Assessing the excess health service utilisation and direct medical costs of injuries.

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Summary

This study was undertaken with the aim to develop improved measures of health service utilisation (HSU) and direct medical costs following an index injury, utilising large scale datasets linked via anonymous patient identifiers.

A cohort of anonymous injury patients resident in Swansea and attending an emergency department (ED) or admitted to hospital between 01/04/2005 and 31/03/2007 were identified and tracked as they progressed through various treatment stages following their index injury, incorporating ED attendances, inpatient stay and outpatient contacts. To determine the extent of the subsequent HSU and direct medical costs associated with the index injury a unique model was developed whereby the numbers, lengths and treatment costs of health service contacts observed amongst the cohort of injured individuals during the follow-up period were compared with the equivalent figures expected in the absence of an injury.

On average each index injury was found to lead to an excess of 0.12 (95% CI 0.11, 0.13) ED attendances, 0.07 (95% CI 0.06, 0.08) inpatient admissions, 1.00 (95% CI 0.78, 1.23) inpatient bed days and 0.55 (95% CI 0.52, 0.58) outpatient contacts being estimated over the follow-up period. Moreover, every index injury resulted in mean excess ED, inpatient and outpatient treatment costs of £12.05 (95% CI £11.05, £13.05), £492.43 (95% CI £415.66, £569.21) and £73.30 (95% CI £68.44, £78.17), respectively, equating to a combined figure of £577.79 (95% CI £500.32, £655.26). Across the entire injured cohort this amounts to an overall excess direct medical cost total of £17.6 million being incurred, with the equivalent figure for the whole of Wales potentially being as high as £306.4 million.

Together with signifying the magnitude of the HSU and direct medical costs resulting from injury, this study has introduced and implemented improved methods for estimating these outcome measures based on the use of anonymous patient record linkage.

Declaration

This work has not previously been accepted in substance for any degree and is not being concurrently submitted in candidature for any degree.

Signed .. ..

Date ......10/06/2011...................................

Statement 1

This study is the result of my own investigations, except where otherwise stated. Where correction services have been used, the extent and nature of the correction is clearly marked in a footnote(s).

Other sources are acknowledged by footnotes giving explicit references. A bibliography is appended.

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Statement 2

I hereby give consent for my thesis, if accepted, to be available for photocopying and for inter-library loan, and for the title and summary to be made available to outside organisations.

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List of Abbreviations

A&E	Accident and Emergency
ALF_E	Anonymised Linking Field (Encrypted)
AWISS	All Wales Injury Surveillance System
CI	Confidence Interval
CoI	Cost of Illness
DALY	Disability adjusted life year
DH	Department of Health
ECOSA	European Consumer Safety Association
ED	Emergency Department
EU	European Union
FCE	Finished consultant episode
GBDI	Global Burden of Disease and Injury
GIS	Geographical Information Systems
GP	General Practice
HES	Hospital Episode Statistics
HIRU	Health Information Research Unit
HMDS	Hospital Morbidity Data System
HRG	Health Resource Group
HSU	Health service utilisation
ICD-10-CM	International Classification of Diseases, 10th revision, Clinical Modification
IGRP	Information Governance Review Panel
LSOA	Lower Super Output Area
MIU	Minor Injury Unit

NHS	National Health Service
NHSAR	National Health Service Academic Registry
NMCUES	National Medical Care Utilization and Expenditure Survey
NRES	National Research Ethics Service
NTSCI	Non-traumatic spinal cord injury
PEDW	Patient Episode Database for Wales
PLICS	Patient-level information and costing systems
PRL	Probability Record Linkage
QALY	Quality adjusted life year
QoL	Quality of life
RTA	Road Traffic Accident
SAIL	Secure Anonymised Information Linkage
SCI	Spinal cord injury
TARN	Trauma Audit Research Network
TBI	Traumatic Brain Injury
TFR2	Trust Financial Returns 2
TSCI	Traumatic spinal cord injury
UK	United Kingdom
US	United States of America
WHO	World Health Organisation
YLD	Years lived with disability
YLL	Years of life lost due to premature mortality

Chapter 1 - Introduction

1.1. Definition of injury

Scientifically an injury can be defined as:

> ...a bodily lesion at organic level resulting from acute exposure to energy interacting with the body in amounts or rates that exceed the threshold of physiological tolerance. The energy can be mechanical, thermal, electrical, chemical, or radiant. In some cases an injury results from an insufficiency of any of the vital elements (in drowning, strangulation or freezing) (Baker et al 1984).

In more general terms injuries represent some form of damage or harm done to or suffered by a person, which may be physically and/or psychologically related.

Specifically, an injury incurred by a given individual can be separated into those classed as being unintentionally (accidentally) acquired and those regarded as being the direct consequence of an intentional action or set of actions. To distinguish between these two distinct injury groupings the Accidental Injury Task Force (AITF), established by the Chief Medical Officer (CMO) in response to the national target for England set out in 'Saving Lives: Our Healthier Nation' (Department of Health 1999), describes accidental injury as:

> injury occurring as a result of an unplanned and unexpected event. (Department of Health 2002).

Examples of such unintentional injuries, as defined by a World Health Organisation (WHO) report (Peden 2002), include road traffic injuries, poisoning, falls, fires and drowning. Alternatively, intentional injuries, being the result of a premeditated undertaking, encompass harm that is self-inflicted (e.g. suicide), interpersonal (e.g. homicide) and war related.

The seriousness of any injury incurred can range from relatively minor afflictions that may require little or no treatment to a severe, potentially, life threatening form of physical and/or psychological trauma. In the case of the latter the impact of injury on the person may be acute (early/rapid) and/or chronic (prolonged/sustained).

For the purposes of this study, the operational case definition of injuries is limited to include only those conditions initially in receipt of medical treatment following attendance at an emergency department (ED) or admittance to hospital.

1.2. Brief review of the burden of injury

Simple analyses of routinely collected epidemiological data suggests that the occurrence of injuries represents a major public health issue, accounting for around one in eight male deaths and one in 14 female deaths worldwide in 1990 (Rockett 1998), and more than 20,000 deaths annually in the United Kingdom (UK) alone (Wise 2001). In particular, injuries impose a huge burden on societies and individuals in terms of the human cost of premature death. Indeed, in 1998 over half the deaths of 15-24 year olds in England and Wales were due to injuries (Wise 2001), whilst during the years 2003 and 2005 injuries that occurred within the 27 European Union (EU) member states accounted for around two-thirds of all deaths in the 15-24 age range (Angermann et al. 2007).

Whilst levels of injury related mortality remain high and represent a considerable burden, mortality rates following injury have actually declined in recent years. According to a recent summary report on injuries in the EU, a 20% reduction in the standardised death rate for all injuries has been experienced by the 27 EU member states over the last ten years (Angermann et al. 2007). Suggested reasons to account for this development include the introduction of several new medical advances, particularly in areas such as neurosurgical management and investigative techniques (Servadei et al. 1988), which have resulted in markedly improved survival rates from several serious, previously fatal, types of injury.

A related morbidity by-product associated with this greater probability of surviving major trauma is that a higher proportion of the injured population are now faced with the prospect of living the remainder of their lifetime with more severe, increasingly debilitating, disabilities. According to Stone, Jarvis and Pless (2001, p. 1557) "Increasingly, young people are surviving previously fatal injuries, producing an extra (but largely unrecorded) burden of long term disability". A study undertaken by Thornhill et al. (2000), for instance, found that in Glasgow (population 909,498 in 1995/96) 1,400 young people and adults were still disabled one year after a head injury, whilst in Australia figures from the Australian Bureau of Statistics (1999) indicate that around 16% of the disabilities in Australia are the result of an injury or accident.

Hence, it is clear that injuries impose considerable adverse effects on individuals, in terms of both premature mortality and life changing disability, thereby serving to signify the importance of limiting their occurrence and severity. However, the consequences of injury are wide-ranging and extend far beyond the specific impact on the health status of the injured individual concerned. Evidence suggests that injuries, even relatively minor cases, can also impose a substantial indirect impact on family/friends and wider society (Lyons et al. 2010). The former may suffer from injury patients being absent from work for a sustained period, resulting in no household income being forthcoming, or a continued reliance on 'sick' pay, which is generally paid at a reduced rate compared to the usual 'take-home' salary. Boden and Galizzi (1999), for instance, estimated lost earnings from workplace injuries and illnesses, projected ten years past the observed period, to be over $8,000 per injury. The responsibility often taken on by family members of the injured party to provide informal care at home can also impose a significant financial toll. Indeed, according to Peden and Sminkey (2004, p. 67) "Many families are driven deeper into poverty by the expenses of prolonged medical care, the loss of a family breadwinner, or the added burden of caring for the disabled". Similarly, the occurrence of injuries can have a marked indirect consequence for the economy as a whole, given the decline in productivity that can ensue as a result of injured individuals being unable to fulfil their normal work responsibilities. Injuries sustained in 2000, for instance, caused an estimated $326 billion in productivity losses in the United States (US) (Finkelstein, Corso and Miller 2006).

Together with the consequences of injuries noted above their occurrence additionally serves to place a huge burden on a variety of healthcare services, which are faced with the responsibility of treating and aiding the rehabilitation of injury patients. Such care often takes place over a prolonged period of time, with the overall aim to ensure that the injured not only survive but get to experience a quality of life comparable to that they were familiar with prior to their injury. To achieve this objective considerable resources must be devoted to the healthcare sector in order to ensure service providers are best equipped, in terms of treatment facilities, medical supplies, capital goods and staff resources, to cope and deal effectively with the sizeable health impact imposed by injuries. Hence, quantifying the extent of health service utilisation (HSU) and subsequent direct medical costs incurred by various sectors operating within the healthcare system following injury represents an important component in determining the overall burden of injury.

1.3. Means of assessing the burden of injury

> Effective injury prevention and control policy to reduce the burden of injury requires access to accurate information at each step of the policy cycle (Hendrie and Miller 2004, p. 193).

The short and long term repercussions of injury can be accounted for in several alternative ways. The following burden of injury measures were reported on in a 2004 publication by Hendrie and Miller (2004).

1.3.1. Mortality measures

Worldwide one of the most commonly used means of quantifying the impact of injury on the population is via counts of the absolute numbers of deaths and calculation of mortality rates directly attributable to an injurious event (Larson 1991; Segui-Gomez and MacKenzie 2003; Hendrie and Miller 2004). Mortality measures are relatively simple to formulate; they are easy to understand, serving to provide a clear indication of how severe a specific injury or subset of injuries are; whilst they allow time trends and comparisons across different countries to be performed. In recent years, together with focusing on the number/rate of deaths that occur following injury, fatality studies have additionally considered the extent to which injuries have contributed to premature death, as expressed through the years of life lost (YLL) measure (Murray et al. 2002).

However, whilst informative, analysis of mortality related indices alone can be misleading. Review of the latest fatality statistics, for example, indicates that the actual number of deaths from injury has fallen over the past decade (Angermann et al. 2007). Together with advances in medical techniques being cited as playing an influential role in this development (Servadei et al. 1988) so too have other factors such as improvements in health education, more effective/efficient public health services, and an increased effort to ensure safety on the road and at work (Noland 2000; Loomis, Bena and Bailer 2003). Although the apparent downturn in injury fatalities represents good news it does not necessarily mean that the injury problem has now been solved. Injuries are continuing to occur on too regular a basis and still place a huge demand on the health sector, accounting for around 30 million medical consultations each year in the UK alone (Wise 2001).

> Progress in reducing fatalities, particularly in the road traffic environment, has made it clear that deaths, although important, represent only a part of the overall injury problem (Watson, Ozanne-Smith and Richardsons 2005, p. 227).

Indeed, for every patient dying as a result of a road accident, three survive with long term disability (Albert and Phillips 2003). Put simply, "the majority of injuries are not fatal but do contribute to the loss of healthy life" (Hendrie and Miller 2004, p. 194). Therefore, information from additional data sources must be taken into account and applied to alternative assessment measures in order to acquire a more complete understanding of the extent of the present injury burden.

1.3.2. Morbidity/disability measures

Given the above it is often argued that any attempts to infer the burden of injury should additionally encompass injury events not resulting in death (Hogberg 2006), thereby incorporating both the short- and long-term health consequences suffered by injured individuals.

In fact the majority of injuries tend to be relatively minor that either do not require any medical attention at all, or only warrant attendance at an emergency department (ED), outpatient clinic or general practice (GP) surgery to treat the immediate impact of the injury, without the subsequent need for admission to hospital. In 2004, for instance, of the estimated 33.2 million people in the US who sought medical attention for an injury just 2.8 million (8.4%) were actually hospitalised, whereas 28.1 million people were treated in EDs and 5.2 million visits were made to outpatient facilities (National Safety Council 2006). More serious injuries, however, may require hospitalisation to treat the injury incurred and it is this hospital discharge information, in terms of the number of new/repeat admissions and the length of stay as a hospital inpatient, which is often collected and appraised in order to ascertain the morbidity impact of injury.

> Although hospitalised injuries represent a relatively small proportion of all non-fatal injuries, they are generally more severe, are associated with higher medical and treatment costs than those treated in outpatient clinics, and are widely used to measure the burden of injury (Boufous and Williamson 2003, p. 370).

Severe injuries caused by major traumatic events can impose significant repercussions on the long-term health of the injured individual to such an extent that those affected may require care and attention far beyond the immediate acute treatment provided as an inpatient. Hence, when appraising health service use data as a means of inferring the morbidity impact of injuries the analysis undertaken must additionally encompass the utilisation of resources from other healthcare sectors that deal with the longer term affects of injury, such as the provision of treatment within the outpatient sector, for instance.

Furthermore, following the occurrence of injuries the individual(s) affected may suffer prolonged disabling conditions that have a major impact on their subsequent quality of life (QoL). Indeed, assessing the QoL experienced post-injury is increasingly viewed as a priority within the fields of morbidity related research and clinical practice (Holbrook and Hoyt 2004; Vollrath and Landolt 2005). A wide range of different assessment tools can be utilised to ascertain the impact of injury on the QoL of the injured individual. Such measures include instruments to assess the physical impairment and functional limitations associated with an injured individual. Have they, for example, suffered a decline in their mobility and ability to be active following their injury? Moreover, QoL measures additionally encompass a subjective dimension that serve to incorporate the actual feelings, beliefs and observations of the injured individual (May and Warren 2001). For instance, whilst it is clear that sustaining an injury may cause disturbances in body and cognitive functions, the impact upon the ability of those injured to be active in daily life, in terms of self-care, mobility or communication, may additionally serve to inhibit their subsequent enjoyment of life and thereby considerably reduce their QoL in the process.

1.3.3. Composite mortality and morbidity related measures

Mortality and morbidity related analyses can be performed in conjunction with each other in such a way that the burden of injury can be assessed in terms of its impact on "both the quantity and quality of life" (Hendrie and Miller 2004, p.194). Encompassing the YLL measure cited above, along with a corresponding calculation that takes into account the number of years lived with a disability (YLD), Disability Adjusted Life Years (DALYs) are frequently used to infer the specific impact of injury. Established by the World Bank and incorporated into the Global Burden of Disease and Injuries (GBDI) study (Murray 2002), DALYs are extensively used by the World Health Organisation (WHO) for international comparisons of the burden of disease and injury. Moreover, other measures that seek to encompass the impact of a given condition on both morbidity and mortality are also frequently being utilised, such as Quality Adjusted Life Years (QALYs).

DALYs and QALYs are often referred to as health status indices. Based on the repeated assessment of a subset of individuals over time, these measures serve to indicate the extent to which injury imposes an impact on a given individual, in terms of the severity of the disability incurred and the period of time over which this applies. Both DALYs and QALYs can be extrapolated so that it is possible to derive population level estimates of the repercussions of injury on overall health. However, such instruments are not universally regarded as the gold standard for measuring the impact of injuries. Indeed they have attracted a certain degree of criticism in recent years. According to Lyons et al (2007, p.2) "the calculation of DALYs has been subject to a number of different approaches, and there is little evidence relating to their validity, reliability and sensitivity as a measurement instrument".

Furthermore, measures like DALYs and QALYs tend to focus on the health consequences injuries specifically impose on the injured individual. However, the repercussions of injury extend far beyond the immediate impact on the health status of those directly involved in a given injury incident. Indeed, the rigours associated with caring for someone afflicted by an injury for instance, or the resulting fear amongst society that can potentially follow an injury related event, mean other individuals either close to or entirely unconnected with the injured individual may suffer a deterioration in their health over the short- and long-term period after an injury incident. Therefore, it is necessary for burden of injury measures to successfully capture such wide ranging consequences which either directly or indirectly impact upon the health of other individuals.

In addition, injuries do not only have an impact on health, which is essentially the only variable that is accounted for in the mortality and morbidity related indices noted above. The occurrence of injuries can additionally result in wide ranging monetary implications for the injured individual, close family and friends, and the economy as a whole. Such financial repercussions can potentially lead to a subsequent indirect deterioration in the health and/or the QoL of the person(s) affected, due, for example, to the stresses and strains involved in coping with the financial pressures that may ensue following an injury event (Lyons et al. 2010). Furthermore, the treatment and rehabilitation of injuries places a huge demand on the resources of the healthcare sector. Thus, the mortality and morbidity measures already discussed fail to encompass the economic consequences associated with the occurrence of injuries.

1.3.4. Economic measures

Injuries inevitably result in both direct and indirect economic costs. The former refers to "expenditures and damages relating to the occurrence and the prevention of an injury" (Goodchild, Sanderson and Nana 2002, p. 4). A major component of this type of cost includes the consumption of resources used in treating and aiding the rehabilitation of an injured individual, borne primarily by the healthcare sector. These direct 'medical' costs comprise spending on ED and inpatient services, ambulance transport, medical supplies and pharmaceuticals, together with the opportunity costs associated with the necessary capital investment directed towards the upkeep/replacement of facilities, staff training and research. Another type of cost categorised as direct expenditures include 'non-medical' related spending, which despite not contributing to the immediate physical and mental healing of the injured individual, can potentially be vast and encompasses the subsequent, ongoing, expenditure designed to assist rehabilitation following the acute treatment phase after injury. Such direct costs include investment in mobility aids, the provision of attendant care at home and the psychological/emotional assistance afforded to family and friends. Furthermore, incidents involving the occurrence of an injury can often result in direct 'accident' costs associated with the physical property damages to vehicles, buildings and equipment that may ensue following an injury event (Goodchild, Sanderson and Nana 2002).

Indirect costs, by contrast, represent the stream of personal and societal losses implicitly associated with the occurrence of injury. For the injured individual, and their family and friends, such costs can be inferred from estimating the value of future earnings and accompanying fringe benefits which could have been accrued had it not been for the suffering of an injury and any resultant disability or premature death preventing the immediate return to normal working life. Depending on the extent of this worker absenteeism financial repercussions may also be incurred by other workers, companies and the economy as a whole, due to the costs associated with lost productivity. It has been estimated that injuries which occurred in 2000 caused an estimated $326 billion in productivity losses in the US (Finkelstein, Corso and Miller 2006). At times the size of the indirect costs reported following injury will depend on the calculation method adopted. Historically the 'human-capital approach' has been used in cost of injury studies, according to which production losses at a specific age are expressed in terms of the total potential productive value of the injured from that age until the age at which they retire (van Beeck, van Roijen and Mackenbach 1997). This method has attracted criticism in recent years, however, given its assumption that workers who have incurred an injury are essentially irreplaceable. In practice this is frequently not the case given the work responsibilities of an injured party can very often be designated to an existing employee, or allocated to an unemployed member of society instead. The alternative 'friction-costs approach' acknowledges this and thus, it is claimed, takes into account the situation that is most likely to ensue in reality, whereby the firm/economy actually only incurs production losses in the interim period when training is being undertaken and skills are enhanced up to the point when duties can be performed at the pre-injury level (Koopmanschap et al. 1995).

Ultimately, therefore, whereas direct costs refer to 'resources expended', indirect costs amount to 'resources forgone' (Haddix, Teutsch and Corso 2003). A third less common type of cost sometimes calculated to account for the repercussions of injury is called the intangible cost of injury. This particular measure considers the impact of injury on the QoL of the injured individual, attempting to place a monetary value on the extent of the physical and emotional pain/suffering often incurred over the post-injury period. These three types of costs can be aggregated together so that it is possible to arrive at a lifetime cost of injury total.

The use of an economic based measure to assess the consequences of injury is advantageous in several ways. According to Hendrie and Miller (2004, p. 195),

> First, it combines deaths, injuries and the longer term impact of injuries into a single measure. Second, if all cost components are included in the measure, then the full economic impact of injury on the community's well-being is being captured, not only the health related cost. Third, cost as a measure of the burden of injury is easy to understand and can be used to sell safety to the politicians, their constituencies and the media.

However, some of the costs associated with injury, primarily the indirect and intangible components, are extremely difficult to measure and may have to be based on subjective assumptions, serving to reduce their reliability as a burden of injury measure. For example, assigning a monetary value to the physical and emotional pain and suffering incurred by an injured individual and their immediate family in the aftermath of an injury event is extremely difficult in practice. The extent of the harm sustained will inevitably vary depending on the individuals involved and the magnitude of the repercussions sustained at the time. Hence, indirect and intangible cost calculations in this instance are likely to be based on estimates and best guesses, which may serve to introduce inaccuracies into the final results.

1.3.5. Focus and structure of this study

Each of the means of assessing the impact of injury discussed in this section represent an important way of inferring and monitoring the resulting consequences, and ideally all should be incorporated into any investigation setting out to ascertain the overall burden of injury. In practice, however, such a wide ranging study is often not possible given the considerable time and monetary resources necessary in order to undertake this effectively. Therefore, injury based epidemiological investigations that seek to report on the impact of injury within a given geographical area or country tend to focus on just one or two of the assessment measures identified above.

The focus of this study is to explore in greater detail the economic consequences that arise following injury, specifically concentrating on the direct medical cost component of this particular burden of injury measure. Direct medical costs represent a monetary valuation of the healthcare resources consumed during the treatment and rehabilitation stages that take place following injury. Hence, the direct medical cost findings reported as part of this study will be based on the extent of the HSU found to be associated with the injuries incurred over a given period.

The structure of this study is as follows: for the remainder of this chapter the theoretical framework of direct medical cost type investigations will be discussed, accounting for the reasons why they are undertaken and the different costing methodologies that need to be considered, plus the scope that exists for this study will be outlined. Chapter 2 provides a review of the existing literature focusing on the impact of injury on HSU and direct medical costs. Chapter 3 defines the aims and objectives of the investigation, together with describing the research questions to be answered. Chapter 4 presents a methodological overview of the study, providing information on the design/setting and the sample population, together with outlining the way in which excess HSU and direct medical costs will be estimated. The findings presented in this study include a breakdown of the demographic and injury characteristics of the study population, as well as an exploration of their pre-injury health status (Chapter 5), the extent of excess HSU post-injury (Chapter 6) and the size of the excess direct medical costs incurred by the healthcare sector responsible for treating individuals seeking medical attention for their injuries (Chapter 7). Additional miscellaneous analysis is undertaken in Chapter 8, exploring the extent to which the HSU and direct medical cost results change in different circumstances. Chapter 9 addresses in detail the two additional research questions posed as part of this study. Finally, Chapter 10 provides an overall summary of the investigation undertaken, presenting the key findings, evaluating the strengths/weaknesses, and discussing the potential implications of the research undertaken and how it will add value to other injury based epidemiological research that is initiated with the aim to assess the burden of injury.

1.4. Theoretical framework

In this section the direct medical cost burden of injury measure will be discussed in greater detail, focusing on the advantages to be gained from adopting this approach to determining the burden of injury, together with discussing the methodological considerations associated with its calculation.

1.4.1. Reasons for direct medical cost of injury studies

Better knowledge of the extent of the direct medical cost impact of illness and injury on the healthcare sector, accounting for various phases of the treatment process, has widely been recognised as an important consideration. Indeed, according to the Department of Health (DH) (2006, p. 2) in the UK, a governmental body responsible for introducing macro-level policy initiatives designed to safeguard and improve the health of the population, "Accurate and timely data on cost is fundamental to the provision of effective, efficient and equitable healthcare.".

Investigations seeking to estimate the extent of direct medical costs specifically serve to provide much needed information, which can assist in understanding the nature and extent of the injury problem and thereby help to reduce the wide ranging negative consequences associated with the occurrence of injuries.

- Allocation of resources

The findings deduced from direct medical cost related research are likely to prove beneficial from a practical and planning perspective, greatly helping policy makers and healthcare professionals to effectively manage scarce health funds.

Aggregated direct medical costs associated with injuries can be utilised to determine the incidence, prevalence and severity of injuries, translating the burden of injury into easily comprehended monetary terms. In this way the collection of direct medical cost based figures serve to facilitate the complex decision making process, involving the appropriate resourcing of research and interventions, which must be forthcoming in any attempt to effectively manage the injury problem. If, for example, analysis was confined purely to fatality statistics then it is likely injuries arising from road traffic accidents (RTAs) will attract far more attention, and thus funding, than injuries resulting from falls, given the increased death rate associated with the former (Krug, Sharma and Lozano 2000). However, with regards to the actual consumption of health resources, as indicated by the direct medical cost of injury calculation, any difference between these alternative causes of injury is likely to be nowhere near as marked and may even be reversed due to falls representing a major cause of hospitalisations. In 2003, for example, the number of inpatient events that occurred in Wales due to RTAs totalled 1,996 whilst the figure associated with falls equalled 19,326. Furthermore, many fall related events may result in potential long-term disability requiring ongoing rehabilitation and possible home social care, especially amongst older aged individuals. Given the above, the total direct medical costs associated with fall related injuries may very well exceed the equivalent figure applicable to injuries resulting from RTAs. Hence, analysis of costs in this instance has made it possible to view the burden of injury from another perspective, serving to raise the importance of fall injuries in relation to RTAs, thereby adding to the pool of information from which decisions can be made and assisting governmental/central authority attempts to achieve allocative efficiency in the process. Shiell et al. (2002, p. 85) state "Allocative efficiency in healthcare is achieved when it is not possible to increase the overall benefits produced by the health system by reallocating resources between programmes".

- Intervention/Prevention strategies

The majority of direct medical cost of injury studies that have been undertaken cite their research as an essential means of identifying high risk injury groups, either in terms of the personal characteristics of injury patients, the types of injuries incurred or the causes of injurious events (Kopjar, Guldvog and Wiik 1996; van Beeck, van Roijen and Mackenbach 1997). As indicated above, with respect to the allocation of resources, consideration of direct medical costs may signify the importance of injury categories that would otherwise be neglected if injury incidence and/or morbidity/mortality statistics were the only parameters of interest. In this way direct medical cost of injury figures assist the process of priority setting (Shiell et al. 2002).

For instance, knowledge that a certain type of injury frequently sustained by a particular demographic subgroup of the population imposes a huge drain on healthcare resources and funds will make it easier for policy makers and healthcare professionals to more specifically target intervention and prevention strategies at these areas. This particular decision making process is increasingly important at times when the funds devoted to healthcare are reduced making it essential that no form of healthcare expenditure is wasted.

- Estimating the burden of injury

Determining the total burden of injury represents a complicated process since the repercussions are numerous and widespread. In a publication that devised a conceptual framework aimed at measuring the overall burden of injury, Lyons et al (2010) present evidence to suggest that there can potentially be 20 negative consequences following an injurious event. The burden of injury in this publication is discussed in terms of the impact on the individual (Death; Pain and discomfort; Reduced short-term physical activity/disability; Long-term physical disability; Psychological disability; Concomitant diseases; Development of secondary conditions; Behavioural changes and secondary health loss; Fear of repeated injury; Tangible costs; Intangible costs; Diminished quality of life); the impact on family, close friends and carers (Observer consequences for close relatives; Carer consequences; Dependent consequences); and the impact on society (Societal fear of injuries; Psychological consequences in observers; Copycat events; Direct medical costs of immediate and long-term treatment; Indirect costs: immediate and long-term). Hence, studies initiated with the aim of estimating the direct medical costs associated with the occurrence of injury deal with a specific component of the total burden of injury, namely by providing an estimate of the monetary costs incurred by the healthcare sector during the treatment and rehabilitation stages following the sustaining of an injury.

Moreover, the results presented in direct medical cost studies can be used to provide information on certain areas of interest which cannot be adequately addressed by alternative burden of injury measures due to the inability to access the types of data necessary to undertake mortality and/or morbidity related analyses. This is possible since it has been reported that given the assumption healthcare costs are correlated to the severity of the injury incurred and the medical need thereafter, the economic burden imposed by injuries is correlated to their health burden. According to Meerding, Mulder and van Beeck (2006, p. 276) "Cost estimates can as such be regarded a summary measure of population health similar to disability adjusted life years (DALY), and are particularly useful when data on the burden of injury are not available".

1.4.2. Costing methodology considerations

Henriksson and Jönson (1998) state that when attempting to capture the cost of illness (CoI) it is important for three methodological questions to be answered: (1) should economic calculations be based on the prevalence or incidence of a given condition?; (2) should a 'top-down' or 'bottom-up' approach be adopted when analysing the data?; (3) what types of costs are to be measured during the cost calculations? In the remainder of this section each of these questions will be discussed in turn.

- Prevalence versus incidence approach

A decision which has to be made prior to estimating the costs associated with the occurrence of a given condition, including injuries, concerns whether the study should focus on the prevalence or incidence of the condition in question (Goodchild, Sanderson and Nana 2002). The former involves capturing health expenditures that are applicable to all cases of illness/injury, assigned specifically to the years in which they occur. According to Tarricone (2006, p. 53) "The underlying rationale of the prevalence approach is that disease costs should be assigned to the years in which they are borne or are directly associated". In contrast, whereby prevalence reflects the subset of the population possessing a condition within a specific period, incidence represents a subset of the population who, initially free from the condition, serve to develop it over a certain period (Silvia et al. 2004). The incidence based approach, therefore, seeks to focus only on new cases of a condition which first materialise within a given interval (Tarricone 2006).

Whether any difference is observed between the prevalence and incidence based approaches to calculating the cost of illnesses/injuries will ultimately depend on the types of conditions under investigation and specifically their impact on the health of individuals over the long-term. When focus is directed on illnesses/injuries with a limited duration the year in which the costs are borne will typically be the same as the year in which these costs are initiated (Havelaar 2007). However, as the average duration over which a given condition has an impact lengthens an increasing distinction can be drawn between the prevalence and incidence approaches, given the latter calculates costs in terms of present values (Tarricone 2006).

- 'Top-down' versus 'bottom-up' approach

Another important issue that must be considered prior to conducting a cost of illness/injury type investigation concerns the methods chosen to estimate the economic costs associated with a given condition. The cost accounting approach adopted can either be based on a 'top-down' or 'bottom-up' orientated analysis. The former involves known, pre-existing, total costs being attributed to certain categories of patients/diseases according to their respective share of prevalence/frequency. Brunetti, Pagano and Garattini (1998, p. 117) state "The top-down strategy is based on aggregate figures and implies an allocation of the total data among diseases". Alternatively, the bottom-up approach is based on the actual consumption of resources associated with a defined subpopulation during their stages of treatment/care/rehabilitation, with the estimated costs incurred then often extrapolated so that they are representative of the population as a whole (Henriksson and Jönson 1998).

Tarricone (2006, p. 53) cites two steps fundamental to the estimation of costs using a bottom-up methodology "The first step is to estimate the quantity of health inputs used and the second step is to estimate the unit costs of the inputs used". To achieve this, input data acquired during the undertaking of an investigation in which costs are estimated from the bottom-up must be sufficiently detailed so that it is possible for the actual healthcare contacts and associated costs at the specific patient level to be identified. This level of detail, however, is not required as part of a top-down type analysis given national health expenditures already calculated can be used instead. This distinction between the two types of cost accounting procedures represents an important factor in determining the most appropriate methodology to adopt for a particular cost of illness/injury study. This is due to the fact that any decision made is ultimately dependent on the data sources available to be scrutinized as part of the investigation. In reference to the top-down and bottom-up methodologies Brunetti, Pagano and Garattini (1998, p. 117) state,

> The two alternatives are strictly related to the sources available: national databases and surveys are suitable for the top-down method, while direct monitoring of a patient sample during a fixed period is better for bottom-up CoI studies....The tools of the bottom-up approach are usually medical records, clinical trials, questionnaires to patients, expert panels, and statistical surveys. The top-down method mainly uses national records or third payers' databases, e.g. public and private insurances.

The advantages of the top-down method of estimating costs include the ability to present the total healthcare costs attributable to the whole of the population of interest without the need to rely on extrapolation techniques. Moreover, since costs do not have to be measured at the very detailed patient level the potential for the double counting of the resources consumed over a certain period is eliminated.

> ..... by allocating total national expenditures among the major diagnostic categories, one can avoid the risk that the sum of treatment costs of individual diseases – estimated through the bottom-up approach – is greater than total healthcare expenditure in a given country (Tarricone 2006, p. 54).

However, whilst this reduced level of detail is beneficial in this specific respect it is a considerable drawback of the top-down approach if the aim is to estimate costs at pre-determined stages of the treatment and rehabilitation process. According to Potter-Forbes (2002, p. 73) "In the 'bottom-up' methodology, the 'decision-points' that affect costs can be identified, and a 'sensitivity analysis' can be conducted in economic evaluation and services planning processes". In order for these noted gains associated with the bottom-up method to be fully exploited though the data sources to be analysed within the investigation have to be sufficiently detailed, as suggested above, which can prove to be problematic in practice. Consequently, the bottom-up cost accounting approach often represents an infeasible alternative for many health related research investigations (Potter-Forbes 2002).

- Cost of injury components

The third and final methodological issue to consider during the planning of a cost based analysis involves how to quantify the resource consumption associated with the treatment/care/rehabilitation of the condition under investigation. As described in section 1.3.4 of this chapter, expenditures may be categorised into direct, indirect or intangible related costs. Very often the resources available to a given investigation will not permit it to estimate the size of every single cost component, meaning choices frequently have to be made about the type of costs the study will focus on. Furthermore, following a decision to report the direct medical costs of a condition it is then necessary to select the specific components of this particular cost measure. Should the expenditures reported include spending on medication, hospital food, healthcare staffing, and so on?

1.5. Scope of this study

In recent years two developments have taken place that have served to alter the scale of the HSU and direct medical costs resulting from injury and how these particular outcome measures are captured. Such developments include changes in the levels/types of HSU taking place during the post-injury period and advances in record linkage techniques.

1.5.1. Development 1: Changes in HSU post-injury

The provision of healthcare is continually changing and improving meaning an increasingly important component of any direct medical cost of injury study that is undertaken is the health sector coverage incorporated within the investigation. Statistics on inpatient utilisation in terms of the number of emergency hospital admissions and the length of in-patient stay, as determined through analysis of national inpatient datasets, such as Hospital Episode Statistics (HES) and Patient

Episode Database for Wales (PEDW) in England and Wales respectively, are very often scrutinized in an attempt to ascertain the extent of HSU that ensues following the occurrence of injury. However, very often inpatient figures alone represent an inadequate means of assessing the overall burden of injury. One major reason for this concerns developments in the delivery of care post-injury.

Evidence suggests that survival from major injury has been steadily increasing over the past couple of decades. For example, Roberts et al. (1996) estimate that over the seven year period 1989-95 the odds of death after severe injury amongst children and young adults fell by 16% a year. Indeed, several previously fatal injury related conditions are now survived on an increasingly regular basis. Winslow and Rozovsky (2003), for instance, report on how advances in the care of spinal cord injury patients have significantly reduced acute and long-term mortality rates. Similarly, Poli de Figueiredo et al (2001) and Noland and Quddus (2004) identify a reduction in traffic related fatalities as part of their investigations, due to developments in medical technologies in Great Britain, and the imposition of increases in fines and licence withdrawal in Brazil, respectively. Other factors that may also have had an impact on the mortality associated with road traffic crashes include an increase in the usage of seat belts and the more widespread adoption of air bags within vehicles.

However, whilst representing good news the increase in the number of survivors following a major traumatic injury has also meant an associated greater frequency of life changing disabilities being incurred by injured individuals, which in turn has served to initiate a change in the role assumed by the healthcare sector. According to O'Donnell et al. (2005, p.1328) "As trauma care systems become increasingly sophisticated the goal of acute intervention is not only to prevent death but to return the person to their pre-injury level of functioning". Moreover, the development of non-invasive surgical and non-surgical procedures has culminated in a shifting in the settings in which treatment is now provided. "Procedures that once were performed only on an inpatient basis are increasingly performed in a variety of outpatient and ambulatory care settings" (Bernstein et al 2003, p.36).

Consequently, the increased survival rate following major trauma, together with an increasing number of operations being performed in alternative settings, means hospital in-patient treatment very often represents only the very beginning of an increasingly long programme of treatment and rehabilitation for an injured individual. Thus, if research into the consequences of injury is limited to the acute treatment phase, primarily based within a hospital setting, then it is unlikely to provide a true reflection of the full repercussions of injuries and will thereby fail to give a realistic representation of the total healthcare resources consumed in the restoration of an injured individual to their former state of health. Indeed, according to Bishai and Gielen (2001, p. 72) "From a population perspective, hospitalization for injury is the tip of an iceberg".

The European Consumer Safety Association (ECOSA) working group places particular emphasis on two subsequent stages of healing following the acute treatment phase based at hospital (van Beeck et al. 2005):

Rehabilitation phase - Rehabilitation involves an injured individual's attempts to increase their personal capacity towards their pre-injury level of functioning. The medical rehabilitation schedule is very often a lengthy process comprising a variety of different services and incorporating the combined skills of several healthcare professionals including doctors, nurses, remedial therapists, clinical psychologists and social workers. Whilst rehabilitation treatment may be undertaken in hospital it is increasingly being provided in outpatient settings as part of residential and community based programmes (Pentland 1990).

Adaptation phase – In certain circumstances it is necessary for injured individuals unable to return to their original, pre-injury, level of functioning to adjust to their surroundings and find a balance between their personal capacity and environmental demands. Frequently, this stage following injury will require numerous improvements and adaptations to an injured individual's home, which are necessary to enable them to continue to live independently. Additionally, personal care from social services may be required to assist with the day to day running of a home and to aid mobility. In contrast to acute care and forms of rehabilitative services, this phase of recovery is primarily designed to prevent further deterioration in the health of the recipient and to assist them in socially adjusting to their new life circumstances, without there necessarily being an expectation that the recipient's health will improve in any way (Bernstein et al. 2003).

Due to a higher proportion of individuals now being able to survive a major injury incident the treatment and rehabilitation stages noted above have become markedly more important and increasingly common over the last decade. In the EU, for instance, it is estimated that for every injury fatality 75 injury patients receive other, out-of-hospital, medical treatment, equating to over 18 million individuals in total (Angermann et al. 2007). Similarly, in a 2001 study undertaken by Bishai and Gielen, with the aim of estimating the average number of outpatient visits, ED visits, and hospitalisations for injured patients, the investigators found

> Statistically, the average injury...is unlikely to result in contact with a hospital. Overall only four hospitalizations are required for every 100 injury conditions. Only 23 emergency department visits are required for every 100 injury conditions. Office based and outpatient care accounts for most of the treatment of injury with 254 visits required for every 100 injured patients (Bishai and Gielen 2001, p. 71).

leading them to conclude:

> Policy makers interested in the cost of injury should account for the extensive outpatient utilization of injured patients (Bishai and Gielen 2001, p. 72).

1.5.1.1. Implications for injury research

Changes in healthcare needs following injury has major implications for research studies aimed at determining the direct medical costs of injury. More than ever a simple calculation of the sum of the resource costs incurred during the acute treatment phase, through the sole analysis of multiple hospital inpatient datasets, is unlikely to provide an accurate deduction of the total health resources consumed by an injured individual. Instead the rehabilitation and adaptation phases must also be incorporated into any attempt to assess the full impact of injury, additionally encompassing outpatient attendances and nursing care if possible. This point is recognised by Polinder et al (2005, p. 1288) in a study of the inpatient costs associated with injury as they advise "Further development of the model should include long-term consumption of outpatient care, rehabilitation, and/or nursing home treatment".

1.5.2. Development 2: Advances in record linkage techniques

Given recent changes in the extent of HSU following injury a variety of health data must now be accessed in order to conduct a thoroughly detailed investigation. Increasingly, the linking together of data records is being adopted as part of health related research, with the aim to acquire information about injury patients treated by multiple different, but associated, healthcare providers (Boufous and Finch 2006).

1.5.2.1. Definition of record linkage

In general the record linking process involves attempts to ascertain whether records originating from the same, or two or more different, datasets refer to the same individual or event. To find equivalent records an algorithm is often devised using deterministic or probabilistic matching in order to correctly align two sets of records. The former utilises a set of rules to determine an 'exact' match, with this exercise most regularly used to populate live clinical systems, where the cost of a false match is potentially high. However, due to the imperfections that tend to exist in many routinely collected data systems and the likelihood of missing and/or incorrect data records, probabilistic record linkage (PRL) must often be implemented. In this case a prospective match between a pair of records is allowable even if one or more of the identifying items are not directly comparable. A match score above or below a predefined threshold level determines whether a pair of records are accepted or rejected as true matches. Frequently used linking variables include name, gender, date of birth, address and/or postcode.

1.5.2.2. Problems of confidentiality constraints

In recent years advocacies of record linkage have grown in number. According to Clark (2004, p. 186) "The frequency of early fatality and transient nature of trauma care mean that a single database will rarely suffice for population based injury research". Similarly in the opinion of Runge (2000, p. 614) "To use retrospective data to define the epidemiology of injury, it is necessary to use data encompassing the whole of the defined population, and to link data from different databases so that individual records within them can be matched among them". However, despite calls for its use, the introduction of record linkage within health research has far from been widespread. One reason for this concerns the presence of confidentiality constraints borne from an inherent fear that joining multiple datasets together will serve to make it easier to identify individual patients.

Record linkage still requires the ability to access the data sources of interest, which in turn can be extremely complicated given the need to comply with various legal and ethical requirements. Such restrictions often mean that the scope of health research that is allowed to be undertaken can, at times, be severely limited (Cameron et al. 2007). As a consequence of patient confidentiality issues and the responsibility to ensure that individuals involved in a given incident are not identified against their wishes, guidelines on the use and protection of patient information are enforced. An example of this includes the recommendations set out in the 2003 National Health Service (NHS) Confidentiality Code of Practice (Department of Health 2003) in the UK. Unfortunately, such measures frequently act as an obstacle to effective research, since in an attempt to ensure they are not violated authorities rigorously oversee the flow of health data. This often results in the imposition of various directives and restrictions that refuse to allow data records relating to different but associated health sectors to be held within one large linked database, or to be maintained by a single provider. This is due to the widely held belief that preventing the storage of large amounts of identifiable and clinical data in one place reduces the risk of identifying individual patients and thus breaching confidentiality rules (Peto, Fletcher and Gilham 2004).

Such caution subsequently serves to make it extremely difficult for researchers to gain access to the multiple data sources which need to be analysed in order for them to accomplish their investigation goals as desired (O'Grady and Nolan 2004). Moreover, there appears to be an increasing concern within the health research community that the measures imposed to restrict access to health related data are to a large extent adversely affecting the quality and effectiveness of research that is currently being undertaken.

> Non-representative access threatens a study's validity, resulting in poorly informed interventions, policy and funding decisions. The situation may now have progressed beyond reasonable trade-offs between the public good and individual privacy to the point where important research cannot be done at all, and the opportunity for advances in health is lost (O'Grady and Nolan 2004, p. 307).

Similarly, in reference to the problems inherent within UK health research Peto et al state "...the pointless obstacles that bona fide researchers, particularly epidemiologists, face when they seek access to individual medical records are now causing serious damage" (Peto, Fletcher and Gilham 2004, p. 1029).

If authorities refuse to remove the restrictions which prevent health data from flowing freely this raises the question of whether researchers will ever be able to acquire access to the multiple, and varied, data sources necessary for them to achieve their desired investigation goals and, specifically, report on the comprehensive costs incurred by the healthcare sector as a whole during the treatment/rehabilitation of the entire injured population.

1.5.2.3. Opportunities provided by anonymous record linkage

A possible means of overcoming the patient identifiable issues cited above that serve to hinder the effectiveness of injury investigations which can be undertaken at present involves the utilisation of anonymised record linkage techniques. This is in contrast to the more standard approaches where all identifiable data are held in the one place or organisation.

In 2002 Kelman, Bass and Holman devised a best practice protocol for inter-agency record linkage with the underlying principles to:

> maximise the protection of individual privacy; provide linked data files only to nominated researchers involved in specific, approved research projects; provide researchers with no more than the datasets required for their specific project; and assure data custodians that those data which are their responsibility will be used appropriately and that security obligations will be met (Kelman, Bass and Holman 2002, p. 252).

In abiding by the above principles unidentifiable record linkage can be performed allowing several databases to be scrutinized simultaneously without contravening confidentiality guidelines. This is achieved through the use of an anonymous linking identifier. Created by specialist technicians, who play no part in the analysis of the final linked subset, the linking field is generated from the encryption of a number unique to a given patient within the healthcare system. A fundamental component of this entire process involves the linking of the datasets of interest being performed completely independently from the extraction of the health records used during the subsequent analysis. According to Kelman, Bass and Holman (2002, p. 252) "A crucial feature of this approach is that personal identifiers are separated from actual health data and their use is confined to the initial linkage stage".

Given an individual analyst only has access to this anonymous patient identifier and their associated health/clinical data, excluding any personal, identifiable, demographic information (e.g. name, address, etc) which is only used and seen by the technicians in the initial linking phase and later destroyed, no means exists of ascertaining who each record actually belongs to. In this way record linkage essentially mirrors the situation which would ensue were all health data maintained within one large database but without the risk of violating confidentiality rules. Consequently, the task of acquiring access to multiple data sources held and maintained by a variety of different individuals and organisations is made easier by the creation and utilisation of a single anonymous linking identifier as part of a comprehensive, transparent, process that is in accordance with accepted guidelines.

1.5.2.4. Implications for injury research

Due to the inherent difficulties involved in accessing multiple data sources from several different data providers current injury related research very often tends to be focused on a single database, or involves the simultaneous analysis of several mutually exclusive datasets in parallel. Inevitably such analyses tend to be limited, due to the inability of researchers to access the necessary information relating to the whole of the population of interest, leading to gaps in the picture regarding the overall impact of injuries. However, in adhering to the principles of anonymous record linkage outlined above the opportunity now exists for several different but associated patient registries/datasets originating from multiple healthcare sectors to be analysed simultaneously. In this way the ease and effectiveness of injury research that can be undertaken is markedly enhanced.

1.5.3. Ability of this study to exploit these developments

Given 'Development 1' it is increasingly necessary for any study seeking to determine the scale of HSU and direct medical costs following injury to be able to track the patient care journey across several healthcare sectors over a prolonged period of time. This approach is made much easier and far more accurate by the emergence of 'Development 2', whereby multiple datasets can be linked together via the use of anonymous patient level identifiers without contravening confidentiality rules. However, as will be indicated in Chapter 2 of this study during which a detailed review of the current literature is undertaken, very few past studies have been able to successfully exploit these developments when reporting on the extent of injury related HSU and direct medical costs. This is due to the fact that the ability to track healthcare contacts at a patient level across potentially numerous stages of treatment and rehabilitation is very resource intensive, requiring the sufficient IT infrastructure necessary to search hundreds of thousands of records at any given time. In addition, the requests for the identifiable information, such as patient names, date of births and addresses, necessary in order to create anonymous patient level identifiers, are frequently blocked by ethics committees, despite the data protection assurances given.

Hence, whilst the developments of changes in HSU and advances in record linkage clearly need to be exploited in theory, it is very often not possible for studies to achieve this in practice.

This study will seek to reverse this trend by utilising the multiple data sources incorporated within the Secure Anonymised Information Linkage (SAIL) project (Lyons et al 2009; Ford et al 2009) initiated by the Health Information Research Unit (HIRU) based at Swansea University. Stored within an IBM supercomputer that allows many millions of records to be searched in the space of seconds, the SAIL databank includes ED, inpatient and outpatient healthcare registries, allowing the resources consumed during the treatment and rehabilitation stages of injury to be counted and costed. Furthermore, with ethical approval obtained by HIRU the SAIL databank additionally integrates a unique, anonymous, patient level identifier within each of its datasets thereby allowing them to be linked and the full patient care pathway to be longitudinally followed. Consequently, through utilising the SAIL administrative and healthcare datasets made available by HIRU this study will retrospectively track injury patients both before and after their index injury event in order to produce accurate and reliable estimates of the HSU and direct medical costs resulting from the occurrence of an index injury.

1.6. Chapter summary

The wide ranging consequences of injuries, in terms of their potentially devastating impact on the health of the individual(s) involved in a given incident, the indirect effects on family, friends and the economy as a whole, together with the subsequent resource utilisation of the healthcare sector responsible for treating injured individuals, have been briefly reviewed in this chapter. Several alternative means currently exist to determine the extent to which injuries impose this impact, including mortality and/or morbidity related measures. Calculating the economic costs associated with injuries and specifically ascertaining the direct medical costs incurred by the healthcare sector, in both the immediate and long-term periods post-injury, represents another outcome measure and is the one focused on in this study. Direct medical cost estimates of the burden of injury allow resources to be allocated efficiently and assist the attempts of national/local governments to choose the most appropriate intervention and prevention strategies aimed at limiting the detrimental impact of injury. Several alternative means exist relating to how best to determine the cost of injury, involving varying approaches to answering specific methodological questions. These have been described in this chapter as has the scope that exists for this study in terms of the opportunities provided by developments in the use of healthcare post-injury and technical advances in the anonymous linking of datasets.

Chapter 2 – Review of Literature

In order to identify and evaluate available evidence on the topic of injuries and the subsequent resource and direct medical cost burden imposed on the healthcare sector, a review of the existing literature was undertaken in two separate stages. Together with scrutinizing the methods of, and results inferred from, measuring the healthcare costs of injury (Stage1), an additional appraisal of past studies that focused specifically on the methodology of long-term HSU post-injury (Stage 2) was performed. This latter stage provided evidence of how previous investigations have gone about following-up large population based cohorts over several years post-injury as a means to capture the long-term HSU during the post-injury period. Furthermore, throughout both stages particular emphasis was placed on identifying and evaluating the use or not of data linkage techniques as part of the articles appraised, due to the linking together of datasets comprising such a major component of this study.

The primary electronic reference source searched as part of the literature review process was PubMed. Developed by the National Centre for Biotechnology Information at the National Library of Medicine, PubMed is a free search engine offering access to the Medline database of citations and abstracts of biomedical research articles, covering the period 1966 to the present day. Additional reference sources also searched included Web of Science and the NHS Economic Evaluation database. Furthermore, in order to ensure as comprehensive a coverage as possible the above searches of electronic reference sources were supplemented with hand searching of 'grey literature' and conference proceedings, together with the utilisation of the internet, as a means of acquiring information about completed and ongoing research not formally published.

2.1. Stage 1: Measuring the direct medical costs of injury

2.1.1. Searching techniques and criteria

Initially articles were extracted for further investigation using a search strategy encompassing the MeSH terms '*Wounds and Injuries*' and '*Healthcare Costs*':

((explode '*Wounds and Injuries*') AND (explode '*Healthcare Costs*')), resulting in 1,147 studies in total. The abstract of each article was then reviewed and considered in terms of the following inclusion/exclusion criteria:

All articles must have focused primarily on injuries and incorporated the impact of the occurrence of injuries on the direct medical costs incurred by the healthcare sector. Hence, investigations assessing the treatment expenditures of diseases/illnesses (excluding injury), or those that measured the long-term consequences of injury in terms of mortality and disability alone, and thus failing to incorporate an economic appraisal of the burden of injury, were disregarded. So too were the studies that only focused on the indirect economic repercussions injuries impose on wider society, employers or the insurance sector, thereby not accounting for the health service treatment costs at all.

Only cost analysis studies reporting on the direct medical costs associated with the occurrence of injuries were of relevance in this literature review meaning investigations aimed largely at inferring or comparing the cost-effectiveness of certain injury related medical treatments/surgical procedures, or assessing the costs-benefits of particular injury related intervention/prevention strategies, were ignored.

An international approach was adopted for this literature review meaning the investigations acceptable for further appraisal could originate from any country and were not confined to UK based studies. This was to ensure that the cost analysis studies surveyed encompassed the burden injury imposed on different healthcare systems, which have alternative methods of treatment/care and contrasting population demographics. However, only articles written in the English language were evaluated as part of this literature review.

The choice of outcome measures represented the final consideration in the screening process. Following adoption of the inclusion/exclusion criteria mentioned above the initial number of 1,147 potentially relevant articles was reduced to 129. A considerable number of these studies (n = 112) however focused only on health sector costs relating to the treatment of a single type/external cause of injury, or a particular demographic subset of the population. Given these articles effectively disregarded a large number of the injured population, thereby making it difficult to infer a population based estimate of aggregated costs, they were excluded from further appraisal.

A flow diagram signifying the study selection process is illustrated in Figure 2.1.

2.1.2. Characteristics of Stage 1 studies

Table 2.1 summarises the characteristics of the studies appraised as part of Stage 1 of the literature review.

2.1.3. Methodology of Stage 1 studies

Each of the studies included in the final evaluation stage were appraised in detail in order to acquire methodological information relating to the study design, the use of data linkage, the calculation of direct medical costs, the inclusion of a control cohort or comparison group, and the consideration of pre-injury/post-injury study periods.

Figure 2.1: Stage 1 study selection process

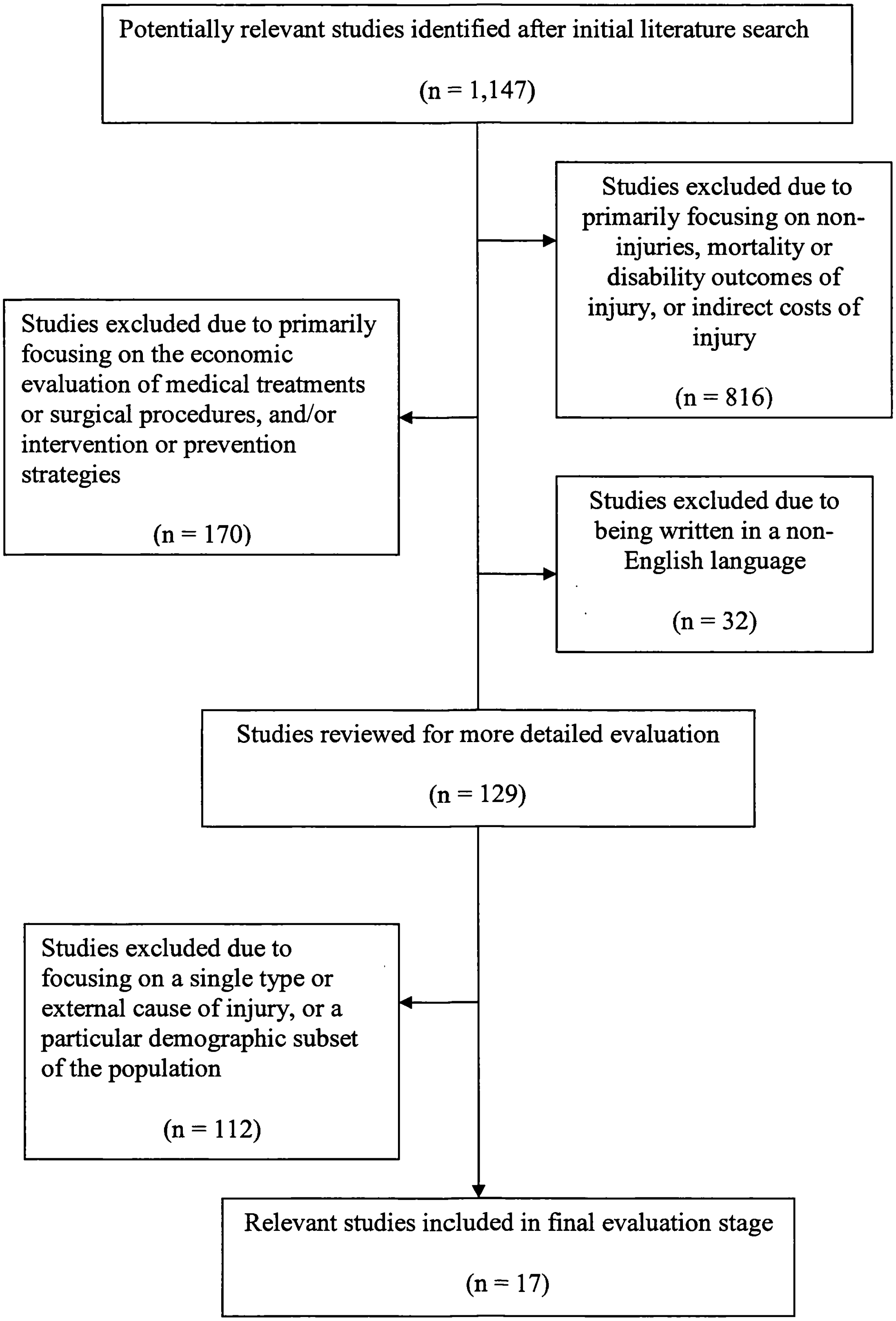


Table 2.1: Summary characteristics of Stage 1 studies

Study	Injury type/severity	Setting	Sample size	Data sources	Health sector coverage
Lindqvist 2002	All injury and severity types	Motala district, Sweden	4,926 injury cases	Medical records of hospital casualty department and 3 health centres	Inpatient; Outpatient (including Primary healthcare)
Harlan, Harlan and Parsons 1990	All injury and severity types	United States	17,123 injured/uninjured individuals	1980 National Medical Care Utilization and Expenditure Survey (NMCUES)	Inpatient; Outpatient; Physician and allied health services; Pharmaceuticals
Corso et al. 2006	All injury and severity types	United States	Approx. 50 million injury cases	2000 National Vital Statistics System (fatal cases); Medical Expenditure Panel Survey (non-ED/non-hospitalised cases); 2000 Healthcare Cost and Utilization Project-Nationwide Inpatient Sample (hospitalised cases); 2001 National Electronic Injury Surveillance System – All Injury Program (ED cases)	ED; Inpatient; Outpatient (office based and hospital outpatient visits)
van Beeck, van Roijen and Mackenbach 1997	All injury and severity types	Netherlands	Approx. 15 million injured/uninjured individuals	National Medical Registry (hospitalised cases) plus additional healthcare registers; Population survey data	Inpatient; General Practitioner (GP); Nursing home; Domestic help; Physiotherapy
Schuster et al. 1995	All injury and severity types	Massachusetts, United States	1.4 million injury cases	Discharges from non-Federal acute care hospitals; National Health Interview Survey	Inpatient; Outpatient (physician); Nursing home; Physiotherapy; Pharmaceuticals
Unwin and Codde 1998	All injury and severity types	Western Australia	152,621 injured individuals; 176,923 injury cases	Hospital Discharge Register	Inpatient
Meerding, Mulder and van Beeck 2006	All injury and severity types	Netherlands	Approx 1.1. million injured individuals; 5,755 injured individuals in follow-up sample	Dutch Injury Surveillance System (non-hospitalised cases); Hospital Discharge Register (hospitalised cases)	ED; Inpatient; Outpatient; Rehabilitation; GP; Nursing home; Physiotherapy; Pharmaceuticals
Miller and	All injury and	United States	Approx. 35,000	National Medical Expenditure	ED; Inpatient; Outpatient; Physician and allied

Study	Injury type/severity	Setting	Sample size	Data sources	Health sector coverage
Lestina 1996	severity types		injured/uninjured individuals; 6,590 injury cases	Survey	health services; Pharmaceuticals
Polinder et al. 2005	All injury and severity types	Austria, Denmark, England, Greece, Ireland, Italy, Netherlands, Norway, Spain, Wales	2,462,387 injury cases	ED sample-based surveillance systems; Hospital Discharge Registers	ED; Inpatient
Mathers and Penm 1999	All injury and severity types	Australia	No information provided	Hospital Discharge Registers; Survey of Morbidity and Treatment in General Practice; Australian Bureau of Statistics National Health Survey	ED; Inpatient; Outpatient; GP; Allied health services; Nursing home; Dentist; Pharmaceuticals
Chandler and Berger 2002	All injury and severity types	Alaska, United States	511 injury cases	Hospital Discharge Register; healthcare database – computerised patient information system	Inpatient
Curtis et al. 2009	Trauma injuries	Australia	206 trauma patients	Hospital Discharge Register; Trendstar Decision Support System – containing financial information extracted from the hospital's general ledger	Inpatient – Trauma centre
Lutge and Muirhead 2005	Trauma injuries arising from assault, gunshot or motor vehicle accidents	Durban, South Africa	517 injury cases and 850 orthopaedic operations	Trauma records	Inpatient – Trauma centre, orthopaedic department
Sikand et al. 2005	Polytrauma injuries	Nottingham, United Kingdom	171 trauma patients	Trauma Audit Research Network (TARN)	Inpatient
Dueck, Poenaru	Trauma	Canada	221 trauma patients	Trauma records	Inpatient

Study	Injury type/severity	Setting	Sample size	Data sources	Health sector coverage
and Pichora 2001	injuries				
Davis et al. 2007	Blunt and penetrating trauma	United States	12,615 trauma patients	Database of medical and pharmacy claims, laboratory results and health plan enrolment details	Inpatient; Outpatient; Ancillary services; Pharmaceuticals
Haeusler et al. 2006	Major trauma	Switzerland	63 trauma patients	Insurance records; hospital and emergency services medical records	Emergency services; Inpatient; Outpatient; Rehabilitation

- Study design

Of the 17 studies appraised seven based their injury incidence and direct medical cost findings on a search of the medical records of the injured individuals within their study population (Unwin and Codde 1998; Dueck, Poenaru, D. and Pichora 2001; Lindqvist 2002; Chandler and Berger 2002; Polinder et al. 2005; Lutge and Muirhead 2005; Sikand et al. 2005). In the study by Davis et al. (2007) information relating to the study population was collected via searches of a health care insurance claims database. Two of the studies solely derived their injury incidence and medical cost figures from the National Medical Expenditure Survey (Harlan, Harlan and Parsons 1990; Miller and Lestina 1996). The remaining seven studies combined the searching of electronic healthcare records with the use of surveys (Schuster et al. 1995; van Beeck, van Roijen and Mackenbach 1997; Mathers and Penm 1999; Corso et al. 2006; Meerding, Mulder and van Beeck 2006; Haeusler et al. 2006; Curtis et al. 2009). In the case of Schuster et al. (1995), for instance, whereas the incidence of hospitalisations due to injury was determined from hospital discharge data, the National Health Interview Survey was used to estimate the number of non-hospitalised injuries. Similarly, Meerding, Mulder and van Beeck (2006) extracted ED injury cases from the Dutch Injury Surveillance System and inpatient injury cases from hospital discharge registers but then subsequently sent postal questionnaires to a sample of their study cohort 2, 5 and 9 months after injury in order to determine long-term direct medical costs.

- Use of data linkage

Only four studies incorporated patient level data linkage into their investigations (Unwin and Codde 1998; Chandler and Berger 2002; Davis et al. 2007; Curtis et al. 2009). Unwin and Codde (1998) made use of linked records from the Western Australian Hospital Morbidity Data System (HMDS), a database containing records linked by a unique patient identifier, thereby allowing a given patient's history of healthcare to be followed. As part of the study by Chandler and Berger (2002) payments made for certain medical services, such as ambulance transport and emergency room visits, were inferred by linking a hospital discharge register to a patient information system using patient names and social security number. Individual payments were then linked to injury hospitalisations by date of service and relation to the type of injury. In order to calculate the cost of each patient's admission Curtis et al. (2009) linked the list of patient medical records of individuals eligible for the study to a separate costing tool. Davies et al. (2007) merged trauma designations to the hospital claims data by matching observations of facility names and addresses to determine the trauma level of the admitting trauma facility.

- <u>Calculation of direct medical costs</u>

<u>(i) Cost components included</u>

Each of the studies accounted for the clinical costs incurred during the treatment of injury within the inpatient sector, such as the cost of medical procedures performed during the hospital stay. The inclusion of longer-term care costs varied across the investigations, however. Expenditures relating to rehabilitation and/or outpatient care were incorporated into the studies by Harlan, Harlan and Parsons (1990), Schuster et al. (1995), Miller and Lestina (1996), Mathers and Penm (1999), Lindqvist (2002), Chandler and Berger (2002), Sikand et al. (2005), Meerding, Mulder and van Beeck (2006), Haeusler et al. (2006) and Davis et al. (2007). Nursing and/or home care formed part of the medical costs reported by Schuster et al. (1995), van Beeck, van Roijen and Mackenbach (1997), Mathers and Penm (1999), Corso et al (2006), Meerding, Mulder and van Beeck (2006). Injury related costs incurred by GP, physician and other allied health services were additionally accounted for by Harlan, Harlan and Parsons (1990), Schuster et al. (1995), Miller and Lestina (1996), van Beeck, van Roijen and Mackenbach (1997), Mathers and Penm (1999), Chandler and Berger (2002), Meerding, Mulder and van Beeck (2006), Davis et al. (2007) and Curtis et al. (2009).

Several studies refer to the exclusion of certain types of expenditures from their direct medical cost calculations. Van Beeck, van Roijen and Mackenbach (1997) and Lindqvist (2002), for instance, specifically mention not considering patient transportation costs as part of their studies, whilst Dueck, Poenaru and Pichora (2001) excluded the food and medication expenses incurred by members of their study population. Polinder et al. (2005) and Curtis. (2009) both refer to staffing expenses forming part of their cost calculations, whereas the salary costs of medical personnel were not reported on in the study by Sikand et al. (2005).

(ii) Prevalence versus incidence approach

The majority of studies adopted an incidence based approach to calculating direct medical costs, with just four investigations (Harlan, Harlan and Parsons 1990; Miller and Lestina 1996; van Beeck, van Roijen and Mackenbach 1997; Mathers and Penm 1999) reporting costs formulated following implementation of a prevalence based methodology.

(iii) 'Top-down' versus 'bottom-up'

In terms of the cost accounting approach adopted 13 studies conducted a 'bottom-up' orientated analysis. Of the remaining four investigations Schuster et al. (1995), van Beeck, van Roijen and Mackenbach (1997), and Mathers and Penm (1999) each applied a 'top-down' type approach to calculating costs, whilst for comparison purposes Lutge and Muirhead (2005) estimated costs in their study using both the 'top-down' and 'bottom-up' methodologies.

- Inclusion of control cohort or comparison group

None of the studies surveyed during Stage 1 of the literature review incorporated a matched non-injured control cohort, or made comparisons with a subset of 'healthy' individuals or the general population. The investigation by Davis et al (2007), however, did stratify the injured study population into three separate cohorts based on the diagnosis or combinations of diagnoses observed during the index hospitalization:

isolated traumatic brain injury (TBI); blunt or penetrating trauma with TBI; blunt or penetrating trauma without TBI.

- Consideration of pre-injury/post-injury study periods

The pre-injury period was only accounted for in the study by Davis et al. (2007). To ensure the index injury represented the first injury related hospitalisation and not a readmission, patients were required to have at least 6 months prior health plan enrolment without evidence of a hospital admission related to trauma. Also as part of the investigation by Davis et al. (2007) the healthcare charges incurred during the 6 month period before the initial injury were compared to those incurred during the 6 month period after the initial injury, in an attempt to determine the incremental financial impact of blunt and penetrating trauma.

With regards to the long-term follow-up of patients during the post-index injury period just four of the 17 studies appraised during the literature review performed this type of analysis. Meerding, Mulder and van Beeck (2006) conducted a patient follow-up among a sample of their injury patients, with postal questionnaires being sent out to participants 2, 5 and 9 months after the injury event. In determining the extent of HSU resulting from injury in their study, Miller and Lestina (1996) recorded the number of follow-up visits per injury case. As indicated above, Davis et al. (2007) calculated healthcare charges incurred 6 months after the index injury, which were subsequently compared with the equivalent charges generated during the 6 month pre-injury period. Direct medical costs were assessed 5 years post-trauma as part of the investigation by Haeusler et al. (2006).

2.1.4. Incidence and direct medical cost results from Stage 1 studies

Each of the studies included in the final evaluation stage were appraised in detail in order to acquire information relating to the variation in the incidence of, and direct medical costs resulting from, the occurrence of injuries due to the age/gender/socioeconomic status of the study population, the diagnostic injury type/external cause/intent associated with the injuries incurred, whether the injury required hospitalisation or not, the injury related healthcare costs as a proportion of all healthcare costs, and injury related costs by healthcare sector.

- Injury incidence by gender and age

Consistently males were reported as accounting for a higher share of injury incidence than females. In the study by Corso et al. (2006), for instance, the overall rate of injury was found to be 20% higher among males than it was for females, whilst the incidence rate of fatal injuries for males was more than 2.4 times greater than the female equivalent. Schuster et al. (1995) report the same fatal injury rate difference between males and females as Corso et al. (2006), and additionally report an injury rate amongst males 1.2 times higher than females for hospitalised injuries and 1.4 times higher for non-hospitalised injuries. Similarly, male individuals within the injured cohort investigated by Unwin and Codde (1998) had a higher age standardised rate of hospital admissions than females (25.5 versus 17.5), whilst males represented the majority of the injury cases investigated by Lutge and Muirhead (2005), Haeusler et al. (2006) and Curtis et al. (2009). The high incidence of injury amongst males can at least in part be explained by the increased risk taking behaviour amongst this gender group (Unwin and Codde 1998; Byrnes, Miller and Schafer 1999).

Several studies report a varying impact of gender on injury incidence according to the age group of the injured cohort. Specifically, the occurrence of injury is found to be higher amongst males at the young and middle-aged age groups, with female injuries more frequent at older ages. Corso et al. (2006) find males younger than 24 are around 30% more likely to suffer an injury than females of the same age group, whereas females older than 75 are around 40% more likely to incur an injury than their male counterparts of the same age. In turn, focusing on the 20-60 age group van Beeck, van Roijen and Mackenbach (1997) also report a much higher incidence of injury amongst males, whilst in the studies by Haeusler et al (2006) and Curtis et al (2009), in which the injury cases were predominantly male, the average age of the injured cohorts were 41 and 34, respectively. The inclination for young males to take part in activities where the resulting risk of injury is relatively high again explains the increased injury rate amongst this demographic group (Unwin and Codde, 1998; Byrnes, Miller and Schafer 1999). A good example of this is the tendency for young males to indulge in high speed driving which often leads to motor vehicle crashes amongst these individuals (Turner and McClure 2003). In the case of the incidence of injury consistently being reported as high amongst older females, this finding reflects the increased tendency of this particular demographic group to fall more often, and also suffer from the condition of osteoporosis which itself means an increased likelihood of sustaining an injury following a fall (Unwin and Codde 1998).

A slight difference in the findings relating to the variation of injury incidence by age group is evident when comparing the studies by Schuster et al. (1995) and Unwin and Codde (1998). In the latter investigation the highest admission rates for injury were among those aged 75 and above, whereas Schuster et al. (1995) found the highest overall injury rate to be associated with adolescents and young adults 15 to 24 years old. The likely explanation for this difference concerns the definition of an injury case, which is vital when comparing injury incidence across studies (Lyons et al 2006). In contrast to the investigation undertaken by Unwin and Codde (1998), which focused solely on injury admissions to hospital, the study by Schuster et al. (1995) incorporated fatal injuries and non-hospitalised injuries, together with hospitalised injuries, into their overall injury rate. Unfortunately, Schuster et al. (1995) do not report the rate of hospitalised injuries separately by age group meaning determining whether there is any difference between these studies in terms of the incidence rate of hospitalised injuries specifically is not possible.

- Direct medical costs by gender and age

Of the studies reporting on the size of the direct medical costs of injuries at different age groups, older individuals are found to be the most costly to treat. Total direct costs correlated significantly with age in the study by Dueck, Poenaru and Pichora (2001), whilst Polinder et al. (2005) found the >65 age group accounted for 46% of the total direct costs of injury related hospital admissions in their investigation. Similarly, both Mathers and Penm (1999) and Curtis et al. (2009) found per capita expenditure and the median patient cost respectively, increased with age, whilst the cost per episode was reported to increase with age in the study by Unwin and Codde (1998) and be highest per head of population in those aged 75+. The reasoning behind the increased direct medical costs incurred following injuries sustained by older aged individuals is twofold. This can not only be explained by the type of injuries they are likely to suffer, with there being an increased tendency towards fracture type injuries, resulting from conditions such as osteoporosis, which are more costly to treat than cuts, sprains and strains, but also can be accounted for by their reduced capacity to respond to treatment following injury (Shabot and Johnson 1995; Horan and Little 1998), potentially leading to longer lengths of stay as an inpatient and increased readmissions to hospital and/or outpatient attendances.

There is a discrepancy in the results presented by a few of the studies with regards to the direct cost breakdown by gender. In terms of overall costs Harlan, Harlan and Parsons (1990), Unwin and Codde (1998) and Corso et al. (2006) each report the dominance of male related expenditures. In the study by Corso et al. (2006), for instance, males accounted for 55% of the total injury attributed medical spending. By contrast van Beeck, van Roijen and Mackenbach (1997) report that in their study almost two thirds of the direct medical costs of injuries are a consequence of injuries to females. In relation to direct medical cost findings presented at a more detailed level Meerding, Mulder and van Beeck (2006) found females accounted for 54% of costs per capita and 63% of the calculated costs per patient, whereas Unwin and Codde (1998) report the cost per hospital episode to be higher for males. Interestingly, the two studies reporting higher costs among females were both conducted in the Netherlands which suggest the difference in settings may account for the variation in the results presented by gender. As will be discussed in subsequent sections, the primary cause of injury amongst the study populations in the Dutch studies was falls in the home, which represents a mechanism of injury most prevalent amongst older females, which may account for the high treatment costs associated with females reported in these investigations.

As is the case with injury incidence it is clearly apparent when appraising the studies included in this literature review that the direct cost distribution by gender varies with age. Van Beeck, van Roijen and Mackenbach (1997) report that among males the highest medical costs of injuries occur in early adulthood (15-25 years of age), a finding endorsed by Polinder at al. (2005) who report a peak in costs per capita being observed in 15 to 24 year old males. Meerding, Mulder and van Beeck (2006) find male total healthcare costs reach a peak among the 15-44 age group in their study, whilst the investigation by Unwin and Codde (1998) report males aged between 25 and 44 as having the highest costs for injury related hospital episodes, with this particular age group accumulating costs equating to 28% of the male total. Whereas the direct medical cost of injury amongst males tends to be concentrated around the younger age groups this is generally not the case in terms of injury expenditures associated with females. Meerding, Mulder and van Beeck (2006) observed the highest peak in female costs amongst individuals aged greater than 65. Similarly, Miller and Lestina (1996) report women aged over 65 as having the largest per capita medical spending, whilst in the study by Unwin and Codde (1998) the highest share of total direct medical costs attributed to females resulted following injuries sustained by individuals aged 75 and above. This observed accumulation of direct medical costs amongst young males and older females largely reflects the increased incidence of injury amongst these demographic groups, as explained above. The high healthcare expenditures at these ages and genders are also a result of the seriousness of the injuries sustained. The activities of young men not only lend themselves to a high risk of injury but also an increased tendency to sustain major traumatic injuries. An example of this is the high number of motor vehicle crashes involving young males which can often lead to a major trauma, and very often, a fatal injury related incident (Turner and McClure 2003). In turn, due to their age and reduced capacity to respond to treatment following an injury event, many types of injury which may be relatively minor conditions at younger ages can become serious when sustained by older females (Horan and Little 1998). Major trauma cases incur higher direct medical costs than more minor cases due to the increased length of stay that is likely to be necessary as an inpatient, the increased number of more complex surgical and medical procedures and the increased likelihood of readmissions to hospital and/or the need for outpatient treatment.

- Direct medical costs by socioeconomic status

Of the 17 studies reviewed in detail as part of the literature review process only one took into account the impact of the socioeconomic status of the injured cohort on the overall direct medical cost of injury. In the study by Harlan, Harlan and Parsons (1990) persons with family incomes of less than $5,000 had a greater proportion of medical costs attributed to injury than did those in the other income groups. This lower income group comprised 7% of the total population but their total injury costs accounted for 10% of all injury costs. Thus, the lowest income group had disproportionately greater costs for injury and disproportionately higher health expenditure. The likely reason for this is due to the severity of the injuries sustained. According to Harlan, Harlan and Parsons (1990, p. 457) those with family incomes of less than $5,000 reported "a greater proportion of health care charges attributable to acute injuries and their sequelae than do their counterparts". The more severe the injury case the more costly the resulting healthcare treatment due to the increased length and complexity of the treatment stages post-injury.

- Injury incidence by diagnostic injury groups

There is some variation in the incidence of certain injury groups between studies. Fractures were associated with the highest injury incidence in the studies by Mathers and Penm (1999) and Polinder et al. (2005), whereas superficial injuries (34%) and open wounds (17%) were found to induce by far the highest number of injury cases investigated as part of the study by Meerding, Mulder and van Beeck (2006). This difference most likely reflects variations in the scene of treatment. In both the studies by Mathers and Penm (1999) and Polinder et al. (2005) the incidence of injuries was described in terms of hospital admissions, whilst Meerding, Mulder and van Beeck (2006) included in their injured cohort all patients who attended an ED. Injuries requiring admission to hospital are more likely to be of increased severity, such as fractures, whereas very many of the injuries treated at an ED are likely to be minor cases, like superficial injuries and open wounds, which do not warrant subsequent admission to hospital. Indeed, in the study by Mathers and Penm (1999) when injury incidence was expressed in terms of the number of non-inpatient visits dislocations, sprains and strains were the leading injury cause. Similarly dislocations, back sprains and strains, and other back injuries averaged the highest number of visits per case to physician offices and ancillary care providers according to the study by Miller and Lestina (1996).

- Direct medical costs by diagnostic injury group

Fractures accounted for the largest share of total healthcare injury costs in the majority of studies. According to Harlan, Harlan and Parsons (1990), Mathers and Penm (1999) and Meerding, Mulder and van Beeck (2006), this injury grouping was responsible for 38%, 27% and 51% of the total medical cost of injury respectively, whilst hip fractures specifically had the highest direct injury costs in the investigations by Lutge and Muirhead (2005), Polinder et al (2005) and Meerding, Mulder and van Beeck (2006). The dominance of fractures in terms of healthcare expenditures reflects both their relatively high frequency and high treatment costs compared to many of the other diagnostic injury groups. The treatment costs of fractures, especially to the hip, are high given a relatively long length of stay in hospital is often required, especially amongst older aged individuals, compared to other types of injuries (Kannus et al. 1999; Cummings and Melton 2002). Also fractures may require more rehabilitation to restore the individual to full health relative to other injury types.

In keeping with injury incidence, the size of the direct medical costs incurred was reported to vary depending on the scene of treatment. Whereas lower limb fractures (74%), poisoning (72%) and skull/face/intracranial injuries (66%) were all dominated by hospital expenditures according to Miller and Lestina (1996), emergency room spending was greatest for open wounds (27%) and superficial injuries/contusions (23%). This reflects the more severe injuries being more frequently treated in hospital and the less severe cases more likely to be seen at an ED.

Both Harlan, Harlan and Parsons (1990) and Meerding, Mulder and van Beeck (2006) provide evidence indicating that diagnostic group costs also alternate significantly as a consequence of differences in age. In the study by Meerding, Mulder and van Beeck

(2006) superficial injuries accumulated the largest share of direct medical costs up to the age of 65 (0-14 = 22%, 15-44 = 20%, 45-64 = 12%), after which hip fractures accounted for the highest share of costs (47%). Similarly Harlan, Harlan and Parsons (1990) also found fracture costs were dominated by older individuals within their injured cohort, with fracture related health care expenditure rising from 27% for individuals aged less than 17 years to 43% for those aged greater than 65 years of age. This tendency for fracture type injuries to account for the majority of the costs of healthcare among older aged individuals reflects the increased incidence of falls amongst the old, particularly by females, many of which result in the occurrence of fractures due to the presence of osteoporosis (Cummings and Melton 2002). Moreover, when such individuals sustain fractures, particularly in the case of those to the hip, there is more often than not the need for a lengthy stay in hospital as an inpatient (Kannus et al. 1999; Cummings and Melton 2002).

Along with reporting variations in costs due to age, Harlan, Harlan and Parsons (1990) also found variations in health spending as a consequence of gender. The vast majority of poisoning costs were associated with females, who also reported higher costs associated with fractures compared to males. In contrast, health expenditure on burns, sprains and dislocations were higher in the study conducted by Harlan, Harlan and Parsons (1990) for males relative to females.

Interestingly, in the study by Harlan, Harlan and Parsons (1990) fracture costs for black persons exceeded the equivalent figure for white and other persons (44% compared to 38%). This impact of race on diagnostic group costs is not reported elsewhere in this literature review. It is important to note however that the study by Harlan, Harlan and Parsons (1990) differs from many of the other studies appraised as part of this literature review in that the findings were gathered following a national survey of health expenditures and the use of personal health services. The reliability of the costs reported therefore relies on the accuracy of the self-reporting by the individuals surveyed. The investigators themselves acknowledged the fact that some groups may have underreported their charges to a greater degree than others, citing the potential for persons covered by Medicaid benefits not being informed by the payer of the actual charges, leading to an underestimation of costs incurred. Such self-reporting inaccuracy may explain the observed race difference reported by Harlan,

Harlan and Parsons (1990). The study by Miller and Lestina (1996) made use of a later version of the survey used by Harlan, Harlan and Parsons (1990), but the investigation by Miller and Lestina (1996) did not report on the direct medical costs incurred across different race categories.

- Incidence by external cause category

Some variation across the studies appraised is evident when considering the incidence of injury by external cause category. Several studies cite falls as the leading contributor to the number of injuries. Mathers and Penm (1999) and Chandler and Berger (2002) report accidental falls as accumulating the highest number of hospital admissions amongst the injured cohort followed up as part of their investigations. Similarly, Corso et al. (2006) report falls as being the most dominant external cause sub-category in the US, accounting for 23% of the total number of injuries, whilst in another US based investigation, Schuster et al. (1995) also find falls represent the leading cause of non-fatal injuries (hospitalised and non-hospitalised) amongst their injured cohort. In contrast Dueck, Poenaru and Pichora (2001) and Curtis et al. (2009) report motor vehicle traffic crashes as the chief contributor to the number of injuries in their particular investigations. The reason for this difference concerns the severity of the injuries assessed as part of each study. In the investigations by Schuster et al. (1995), Mathers and Penm (1999), Chandler and Berger (2002) and Corso et al. (2006) the injury incidence findings reported above are either wholly or largely based on the number of hospitalised/non-hospitalised injuries taking place amongst their injured cohort, which can include both major and minor injury cases. In the investigations by Dueck, Poenaru and Pichora (2001) and Curtis et al (2009), however, injury incidence is described solely in terms of the number of presentations to a trauma centre. Traumatic injuries will all be major injury cases, which are more likely to take place following a motor vehicle traffic accident than a fall due to the increased severity of injuries that tend to ensue following the former external cause category. This theory that motor vehicle traffic crashes tend to be the most dominant in terms of incidence when more severe injuries are considered is supported by the fact that in both the investigations by Schuster et al. (1995) and Corso et al. (2006)

motor vehicle traffic crashes were the largest contributor to the number of fatal injuries.

Both the studies by Lindqvist (2002) and Meerding, Mulder and van Beeck (2006) report the incidence of injury by external cause category in a different way, mixing location with activity and focusing on 'home', 'traffic', 'occupational' ('work'), and 'sports' type injuries. In the investigation by the former, home injuries account for the largest number of injuries (35%), followed by sports and exercise injuries (19%), work injuries (14%) and traffic injuries (13%). Similarly, Meerding, Mulder and van Beeck (2006) find injuries incurred in the home are the most frequent (52%), followed by sports (17%), however, their subsequent rankings differ from that of Lindqvist's (2002) as they cite traffic injuries as the third most prominent and occupational injuries least prevalent. This slight difference may reflect the different settings in which the studies were undertaken. The study population investigated by Lindqvist (2002) were drawn from the district of Motala in Sweden, whereas the study by Meerding, Mulder and van Beeck (2006) was based in the Netherlands. When two or more investigations are not performed using the same study population comparisons between them can be difficult, due to differences in demographic characteristics for example (Lyons et al. 2006).

- Direct medical costs by external cause category

Schuster et al (1995), Mathers and Penm (1999) and Corso et al (2006) each cite falls as contributing most to the direct medical costs calculated as part of their investigations, comprising 35%, 31% and 34% respectively of the total. Falls also accounted for the highest overall expenditures in the study undertaken by Chandler and Berger (2002). Motor vehicle traffic crashes, however, represented the leading contributor to the direct medical costs generated in the investigations by Dueck, Poenaru and Pichora (2001) and Curtis et al. (2009). This difference reflects the varying levels of injury incidence associated with these external cause categories. Schuster et al. (1995), Mathers and Penm (1999), Chandler and Berger (2002) and Corso et al. (2006) each report falls as being the main cause of injury incidence in their studies, primarily reflecting the contribution of this external cause category to the number of hospitalised and non-hospitalised injury cases. In contrast, the investigations by Dueck, Poenaru and Pichora (2001) and Curtis et al. (2009) find motor vehicle traffic crashes account for most of the injury incidence, reflecting the greater contribution of this external cause category to the number of traumatic injuries, which represented the focus of these two latter investigations.

In the studies by van Beeck, van Roijen and Mackenbach (1997), Lindqvist (2002), Polinder et al. (2005) and Meerding, Mulder and van Beeck (2006) the external causes of injury are categorised in a different way, mixing location with activity and focusing on 'home', 'traffic', 'occupational' ('work') and 'sports' type injuries. Injuries incurred within the home represent the largest sub-category in terms of the accumulation of overall healthcare expenditures. Lindqvist (2002) and Meerding, Mulder and van Beeck (2006) find traffic injuries to be the second and third most dominant sub-categories, comprising 25% and 19% of direct costs respectively. Interestingly as part of the study by Polinder et al. (2005) the mean hospital costs per admitted patient are reported to be highest for traffic related injuries. This difference largely reflects the fact that per injury case injuries sustained at a 'traffic' location are most costly to treat relative to the 'home', 'occupational' and 'sports' sub-categories due to the likelihood of a more severe injury being incurred. Across all injuries, however, the much higher incidence of 'home' related injuries makes this sub-category accountable for the largest share of overall medical expenditures (Lindqvist 2002; Meerding, Mulder and van Beeck 2006).

The distribution of direct costs by external cause varies depending on the age and gender of the injured individual. A number of studies refer to the large contribution of falls to the health care expenditures associated with older, female members of their injured cohort (Schuster et al. 1995; Mathers and Penm 1999; Corso et al. 2006), whilst van Beeck, van Roijen and Mackenbach (1997) find domestic injuries account for a very large share of direct medical costs incurred during the treatment of older female injury cases. Falls in the home amongst older females generate large direct medical costs due to their high incidence and the tendency for this external cause of injury to lead to admission to hospital, resulting from their inability to respond to treatment following trauma (Shabot and Johnson 1995; Horan and Little 1998). Once hospitalised, members of this demographic group take longer to be treated, culminating in longer lengths of stay in hospital and an increased need for the use of outpatient and nursing home resources. In their investigation Corso et al. (2006) report younger aged males as accounting for a considerably higher share of direct medical costs compared to females of the same age when focusing specifically on the 'motor vehicle/Other road user', 'Struck by/Against', 'Cut/Pierce' and 'Firearm/Gunshot' external cause categories. Similarly, van Beeck, van Roijen and Mackenbach (1997) find the medical costs of injuries associated with males are highest in early adulthood (15 – 24 years of age), resulting from the high costs of traffic injuries, occupational injuries and sports injuries at these ages. Young males are most likely to participate in high risk activities (Byrnes, Miller and Schafer 1999; Turner and McClure 2003) which often lead to injuries categorised within the motor vehicle, struck by, cut, firearm and sport external cause categories. When sustained these types of injury are frequently very serious culminating in high treatment expenditures due to the need for lengthy hospital stays and ongoing rehabilitation both inside and outside the hospital setting.

- <u>Incidence/direct medical costs by intentionality</u>

In terms of injury incidence, Meerding, Mulder and van Beeck (2006) find intentional injuries account for less than 5% of all injuries (it is not reported whether this particular intent category includes self-harm or assault or both). In the study by Mathers and Penm (1999) 89% of the injuries admitted to hospital were unintentionally inflicted, whilst focusing on the incidence of non-inpatient healthcare visits unintentional injuries accounted for 91% of the overall total.

The apparent dominance of unintentional type injuries also holds true with regards to the direct medical costs of injury. Mathers and Penm (1999) find unintentional injuries account for 92% of the costs of injury amongst their injured cohort, whilst the costs of violence and suicide in the study by Polinder et al. (2005) are both less than 1% of the total hospital costs of injury in Europe. The large share of direct medical costs accounted for by unintentional injuries may not only be due to their high incidence compared to injuries resulting from other forms of intent. Polinder et al. (2005), for instance, find the mean hospital costs per admitted patient to be relatively low for violence (€730) and suicide (€670), in comparison to traffic (€2,330) and non-traffic unintentional injuries (€2,140). The investigators cite varying healthcare use within each category as the reason for this difference.

- Incidence/direct medical costs among hospitalised/non-hospitalised injuries

Consistently across the studies reviewed the number of non-hospitalised cases was found to far exceed the number of hospital admissions. In their investigation based in Massachusetts, US, Schuster et al. (1995) report that for every person who dies from an injury, an estimated 17 people are hospitalised and an estimated 535 people suffer an injury but do not go to hospital. Thus, of the total number of injuries Schuster et al. (1995) find just 3% are hospitalised. Meerding, Mulder and van Beeck (2006) found admitted patients within their injury cohort drawn from the Netherlands accounted for approximately 9% of the total incidence of injuries, whilst in the study by Miller and Lestina (1996) there were 424 hospital admissions for every US individual injured compared to 6,166 non-hospitalised cases.

An altogether different outcome is evident when the attention is focused instead upon the breakdown of healthcare costs. Despite only a relatively small proportion of injured individuals being admitted to hospital for treatment the share of total costs that such patients account for is considerable. Schuster et al (1995), Miller and Lestina (1996) and Meerding, Mulder and van Beeck (2006) each report hospitalised cases accounting for the largest share of the direct medical costs of injury (49%, 49% and 66%, respectively) in Massachusetts, the US and the Netherlands, respectively. In comparison to the injuries in receipt of treatment at an ED and outpatient department the injuries that warrant admission to hospital tend to be more severe conditions. As the severity of a given injury increases so too does the cost of treatment owing to more intense medical care, more complex medical and surgical procedures, and the need for a continuous period of care within the one setting.

Interestingly, some variation in the utilisation of other healthcare services tends to depend on whether a given injured individual first receives treatment at hospital or not. For example, in the study by Miller and Lestina (1996) 27% of hospitalised cases required the additional services provided by an outpatients department compared with only 11% of non-hospitalised cases. Furthermore, overall, hospitalised injuries involved 5.2 follow-up visits per case to physicians and ancillary service providers. By comparison non-admitted injuries averaged only 2.3 follow-up visits. The increased need for outpatient treatment and follow-up visits following injuries admitted to hospital reflects the increased severity of hospitalised injuries and the greater need for continued rehabilitation following discharge from hospital to ensure the injured individual is able to return to their pre-injury state of health.

- Direct medical costs as a proportion of all hospital/healthcare costs

In their investigation Unwin and Codde (1998) find that injuries account for nearly 10% of all hospital bed day expenditures, whilst Lutge and Muirhead (2005) cite trauma costs as comprising almost 2% of the total hospital expenditures as part of their study. This difference reflects the fact that Lutge and Muirhead (2005) are only reporting on trauma cases in their cost estimates, whereas Unwin and Codde (1998) have included all injury cases treated at hospital.

The importance of injuries becomes even more apparent when the costs associated with this condition are compared directly to the spending on other illnesses. Van Beeck, van Roijen and Mackenbach (1997) find the total direct medical costs of injury to be almost 5% of the overall healthcare budget in the Netherlands, with this figure being equal to the expenditure related to cancer and about half of the total spending on cardiovascular diseases. Similarly, Harlan, Harlan and Parsons (1990) report that the direct medical costs of injuries in their study comprised the second largest source of expenditure for medical care in the US behind circulatory system diseases, representing 12% of all direct costs. Moreover, when only the working age population (17-64 years of age) is considered full-time or part-time workers had injury and poisoning as their major source of medical costs. This contrasting share of overall healthcare costs associated with the direct medical costs of injury, reported by van Beeck, van Roijen and Mackenbach (1997) and Harlan, Harlan and Parsons (1990), reflects several differences between the studies. These include the contrasting study settings (van Beeck, van Roijen and Mackenbach (1997) – Netherlands; Harlan,

Harlan and Parsons (1990) – US) and, in particular, the alternative healthcare costs incorporated within the investigations. Van Beeck, van Roijen and Mackenbach (1997), for instance, included the cost of nursing home and domestic help, much of which may not be attributable to an injury, which would account for the comparatively lower share of overall healthcare costs associated with injuries reported within their investigation.

- Direct medical costs by healthcare sector

When aggregating together the total health system costs for all injuries Mathers and Penm (1999) find hospitals (including public hospital non-inpatient services and medical services for private patients in hospital) account for 64% of the final figure, with medical services accounting for 15%, allied health for 6%, pharmaceutical prescriptions for 5% and nursing homes for 4%. Similarly, Meerding, Mulder and van Beeck (2006) report that hospital costs dominate total healthcare costs of injury, with a share of about two-thirds, followed by home care (9%), nursing homes (6%) and physical therapy (6%). In turn, when considering all injury categories Miller and Lestina (1996) find that the medical spending percentage for injuries is equal to 49% for hospital inpatients, with ambulatory care accounting for 20%, outpatient care 14%, emergency room care 11% and home healthcare 3%, whilst van Beeck, van Roijen and Mackenbach (1997) report that the majority of medical costs are incurred in the hospital, with the other important sources of the direct medical costs of injury identified in their study being nursing home care and physiotherapy. Hospitalised injuries are often more severe than injuries treated within other healthcare sectors, such as the ED and in outpatients, meaning the intensity and length of treatment required is greater, resulting in an increased cost of treatment.

Meerding, Mulder and van Beeck (2006) find the age of the injured individual has an impact on injury related costs by healthcare sector. For instance, although the hospital admission rate increases with age in their study the share of hospital care among total costs decreases with age due to the importance and prevalence of nursing/home care provided to the elderly. Compared to the percentage of total costs for all ages, the corresponding percentage for the 65 plus age group specifically, increases by 8% for nursing care and 5% for home care, whereas hospital care costs for persons aged above 65 falls by 5% compared to the all ages figure. Very often when an older individual sustains an injury continued care is provided outside of the hospital setting, at care homes for example, thereby allowing the increased provision of one-to-one care.

2.1.5. Summary of the findings from Stage 1 of the literature review

Following the initial identification of 1,147 studies considered potentially relevant to this stage of the literature review, appraisal of each abstract involving the application of several inclusion/exclusion criteria reduced this figure to just 17. The study designs either involved the electronic searching of patient healthcare records, or the use of survey data, or a combination of the two. Only four of the final 17 studies incorporated data linkage techniques into their investigations. In terms of the cost components reported on, all studies incorporated the clinical costs incurred during the treatment of injury within the inpatient sector but the inclusion of longer-term costs tended to vary, whilst certain studies excluded particular types of costs such as patient transportation, food and staffing expenditures. The majority of studies adopted a 'bottom-up', incidence based, approach to calculating the size of the direct medical costs incurred by their injured cohort. With regards to the consideration of pre- and post-index injury costs only one investigation took account of the pre-term healthcare expenditures associated with their study population, whilst just four of the studies followed-up their cohort beyond the initial treatment applicable to the index injury.

Consistently across the studies the incidence and direct medical costs of injury were reported as being highest among young males and older females, reflecting the increased risk taking behaviour of the former and the tendency of the latter to fall more often, suffer from osteoporosis and possess a reduced capacity to respond to treatment following injury-related traumatic events. Only one study reported on the variation of direct medical costs by income group, with their finding that the lower income group of individuals incurred higher injury health expenditures being the result of more acute injuries being sustained by this demographic subgroup. When injury incidence and direct medical costs were reported across diagnostic injury groups hospitalised cases were most frequent among fracture injuries, whereas the largest share of non-hospitalised cases tended to be amongst superficial and open wound type injuries, with this difference reflecting the severity of the injuries sustained and the tendency for certain injuries of a particular severity to be dealt with in alternative treatment settings. This is also the case with regards to the findings reported in terms of external cause grouping. Whereas falls dominate the incidence and healthcare costs of injuries admitted to hospital, injury cases dealt with at trauma centres were primarily caused by motor vehicle crashes. Furthermore, a difference in injury incidence and costs was also consistently observed across studies when focusing on different ages and genders. Motor vehicle type crashes were most frequent and costly amongst young adult males, whilst older females were most likely to be injured and incur the greatest cost following a fall.

The majority of studies reported the highest incidence and direct medical costs of injury following the occurrence of unintentional injury cases. Consistently across the studies non-hospitalised injuries were reported as being more frequent than injuries requiring hospitalisation, however, in the case of the extent of direct medical costs incurred, hospitalised injury cases were found to generate much larger healthcare expenditures. Several studies found the direct medical costs associated with the treatment/care of injuries accounted for a relatively large share of both hospital costs (range 2 – 10%) and overall healthcare expenditure (range 5 – 12%). Furthermore, when comparing the direct medical cost of injuries across multiple healthcare sectors the hospital treatment of injuries were consistently reported as accounting for the largest share of injury related healthcare expenditure.

2.2. Stage 2: Long-term HSU post-injury

2.2.1. Searching techniques and criteria

Initially articles considered to be of potential relevance were identified within PubMed and Web of Science using a search strategy encompassing the MeSH terms '*Health services*' and '*utilization*' and '*Wounds and Injuries*': ((explode '*Health Services*') AND (explode '*utilization*') AND (explode '*Wounds and Injuries*')), resulting in a list of 2,352 articles in total. The abstract of each article was then reviewed and considered in terms of the following inclusion/exclusion criteria:

All articles must have focused primarily on measuring HSU levels following injuries. Hence, investigations measuring HSU following conditions other than injuries, or in the aftermath of the side effects/medical complications of injury, were disregarded. So too were studies that simply reported HSU levels following injury but provided no indication of how these were measured.

Studies were not considered relevant if the utilisation of the health services reported was based on the initial healthcare contact only and not the follow-up of the injured cohort for a pre-specified period post-injury. Furthermore, articles were excluded if they solely focused on the impact on subsequent HSU levels of a given non-injury related factor, such as compensation, a particular intervention/prevention strategy, or specific treatments.

In contrast to Stage 1 of this literature review, together with reporting on the extent of HSU in the long-term post-injury, Stage 2 was also conducted with the aim of evaluating the methodological approaches of previous studies that have been undertaken with the aim of following-up large population based cohorts over several years post-injury. Consequently, studies which focused on selected injuries were not excluded because they were still considered relevant to understanding the process of conducting longitudinal studies of injury outcome.

The articles appraised were not confined to UK based studies. This was to ensure that the HSU reported during the post-injury period encompassed different healthcare systems, which have alternative methods of treatment/care and contrasting population demographics. In addition the inclusion of international studies increased the possibility of reviewing studies that may have adopted varying methodological approaches to measuring HSU post-injury. However, as in Stage 1, only articles written in the English language were evaluated as part of this stage of the literature review.

A flow diagram representing the study selection process is illustrated in Figure 2.2.

2.2.2. Characteristics of Stage 2 studies

Table 2.2 summarises the characteristics of the studies appraised as part of Stage 2 of the literature review.

2.2.3. Methodology of Stage 2 studies

Each of the studies included in Stage 2 of the literature review were appraised in detail in order to acquire methodological information relating to the study design, the use of data linkage, the inclusion of a control cohort or comparison group, and the consideration of pre-injury/post-injury study periods.

- Study design

Of the 21 studies included within the literature review 10 involved a retrospective analysis of computerised administrative and/or healthcare datasets to determine HSU levels amongst their study population (Holmberg and Thorngren 1988; Blose and Holder 1991; Bergman, Brismar and Nordin 1992; Samsa, Landsman and Hamilton 1996; Hansagi et al. 2001; Dryden et al. 2004; Brown et al. 2006; Cameron et al. 2006; Locker et al. 2007; Guilcher et al. 2010). Brown et al. (2006), for instance, used an administrative database encompassing health related data linked to worker compensation claims data, whilst Locker et al. (2007) analysed records taken directly from the ED and Minor Injury Unit (MIU) upon which the study was based.

Figure 2.2: Stage 2 study selection process

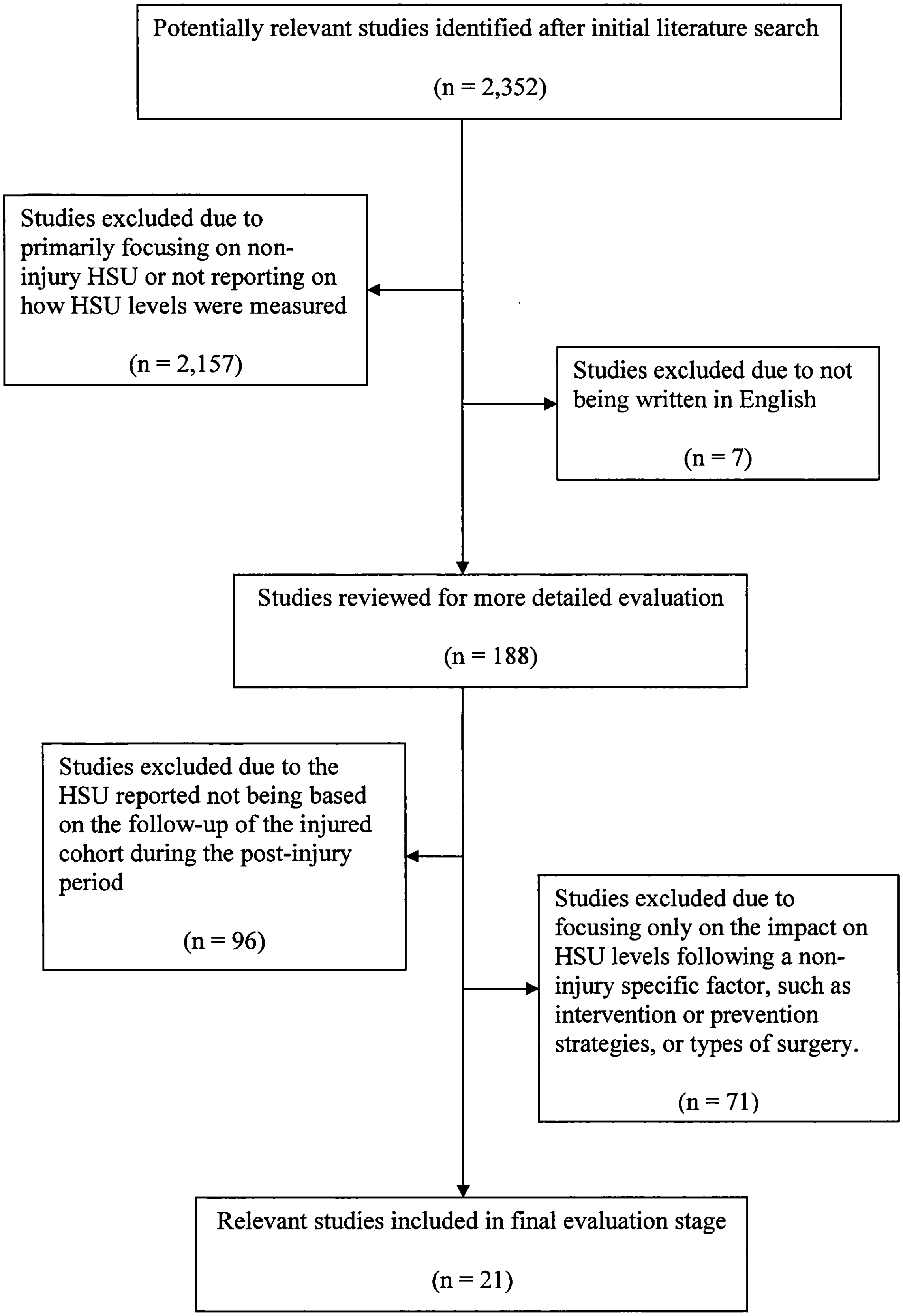


Table 2.2: Summary characteristics of Stage 2 studies

Study	Injury type	Setting	Sample size	Patient characteristics of injured cohort	Length of follow-up	HSU measure
Brown et al. 2006	Workplace injuries	British Columbia, Canada	52,319 injured workers who lost time; 52,319 uninjured workers; 69,142 injured workers who lost no time	Aged 25 or over; mean age 40; mean income decile 5	5 years	GP use; Hospital use; Mental healthcare use
Cameron et al. 2006	Non-fatal injuries	Manitoba, Canada	21,032 injured individuals	64% male; aged 18-64; 54% aged 18-34	10 years	Number of hospitalisations; cumulative length of hospital stay; number of physician claims; number of admissions to care homes
Dryden et al. 2004	Spinal cord injuries	Alberta, Canada	233 injured individuals; 1,165 matched controls	76% male; age range 9-95; median age 34; motor vehicle crash 50% of incidence	6 years	Number of hospitalisations; length of hospital stay; number of physician contacts; intensity of home care services; number of long-term care admissions
Guilcher et al. 2010	Spinal cord injuries	Ontario, Canada	1,562 injury cases	Traumatic spinal cord injury: 75% male; median age 46 Non-traumatic spinal cord injury: 52% male; median age 64	1 year	Outpatient use – number of family physician, specialist and ED visits
Locker et al. 2007	All injuries	United Kingdom	75,141 injured individuals; 98,908 injury cases	Aged 16 or over	1 year	Number of ED and minor injury unit attendances
Bergman, Brismar and Nordin 1992	Domestic violence	Sweden	117 injured individuals	All female; mean age 33	18 years	Use of inpatient medical care
Bishai and Gielen 2001	All injuries	United States	6,320 injury cases	All ages, genders and ethnic backgrounds sampled	2 years	Number of ED, inpatient and outpatient contacts
Blose and Holder 1991	All injuries	United States	Approx. 50,000 injury cases	76% male; average age 39	8 years	Number of ED, inpatient and outpatient contacts

Study	Injury type	Setting	Sample size	Patient characteristics of injured cohort	Length of follow-up	HSU measure
Hodgkinson et al. 2000	Traumatic Brain Injury	Sydney, Australia	119 injured individuals	83% males; mean age at injury 28; mean age at time of study 34; 64% injured in motor vehicle crash	1 year	Number of medical services used
Holmberg and Thorngren 1988	Femoral neck fractures	Stockholm County, Sweden	1,673 injured individuals	75% female - mean age 74 25% male – mean age 70	6 years	Use of hospital and rehabilitation services
Gabbe et al. 2007	Blunt major trauma	Victoria, Australia	243 injured individuals	82% male; median age 33; 43% injured in motor vehicle crash	6 months	Use of physiotherapy, medical/specialist care, occupational therapy, mental health care, home help and hydrotherapy
Safran, Graham and Osberg 1994	Hip fractures	Boston, United States	289 individuals	60% female; 70% aged 65 or over	1 year	Use of outpatient and personal care services
Samsa, Landsman and Hamilton 1996	Spinal cord injuries	United States	1,250 injured individuals	All male; mean age 24 to 25; Motor vehicle crash most common cause of injury	15 years	Patterns of inpatient admissions and length of stay
Miettinen et al 2004	Whiplash	Finland	144 injured individuals	64% female – mean age 39 36% male – mean age 47	3 years	Use of health services including pain medication and physiotherapy
Wiktorowicz et al 2001	Hip fractures	Canada	527 injured individuals	75% female – mean age 82 years 25% male – mean age 76	1 year	Use of hospital, rehabilitation, chronic care, home care, long-term care, informal care
Hansagi et al 2001	All injuries	Stockholm County Sweden	47,349 individuals; 70,700 cases	51% female (frequent visitors to ED)	1 year	Number of ED, physician, outpatient, inpatient and ambulatory visits
Rask et al 1998	All injuries	Georgia, United States	351 individuals; 4,101 cases	51% female; median age 39	2 years	Number of inpatient and outpatient visits
Seematter-Bagnoud et al 2006	Non-injurious fall	Switzerland	690 individuals	61% female; mean age 82	6 months	Number of hospital readmissions and nursing home admissions
Maraste,	Severe road	Sweden	1960s study = 830	1960s study = 428 aged 15+ and	1960s study = 4	1960s study = Inpatient length of

Study	Injury type	Setting	Sample size	Patient characteristics of injured cohort	Length of follow-up	HSU measure
Persson and Berntman 2003	traffic injuries		injured individuals; 1990s study = 476 injured individuals	402 aged 0 – 14; 1990s study = 403 aged 15+ and 73 aged 0 – 14;	years (adults) & 5 years (children); 1990s study = 4 years	stay; 1990s study = Inpatient length of stay, number of visits to doctors and nurses/physiotherapists
Slomine et al 2006	Traumatic brain injuries	United States	330 injured individuals	69% male; mean age 10	1 year	Number of visits to physicians, physical therapists, occupational therapists, respiratory therapists and nursing services
Levi 1997	Hip fractures	Chicago, United States	130 injured individuals	All female aged 65+	6 months	Posthospital institutional days; cumulative sessions of physical and occupational therapy

Five of the investigations acquired HSU related information solely through the use of self-report surveys (Hodgkinson et al. 2000; Bishai and Gielen 2001; Maraste, Persson and Berntman 2003; Miettinen et al. 2004; Gabbe et al. 2007). In the case of Hodgkinson et al. (2000), for instance, members of the study cohort were first asked a series of questions in a personal interview, then provided with a questionnaire to take home, after which they were finally interviewed over the telephone. Gabbe et al. (2007) also used telephone interviews as a means of capturing self-reported HSU as part of their investigation, as did Maraste, Persson and Berntman (2003).

The remaining six studies used a mixture of computerised searching of administrative and healthcare datasets, along with surveys of the study population (Safran, Graham and Osberg 1994; Levi 1997; Rask et al. 1998; Wiktorowicz et al. 2001; Seematter-Bagnoud et al. 2006; Slomine et al. 2006). For example, Wiktorowicz et al. (2001) analysed hospital discharge data to identify initial and subsequent hospitalisations, with telephone interviews of each community dwelling patient or proxy 12-18 months into the study also conducted as a means to determine the frequency of physician visits and the extent of informal care received.

- Use of data linkage

Six studies incorporated data linkage techniques into their investigations (Samsa, Landsman and Hamilton 1996; Rask et al. 1998; Hansagi et al. 2001; Dryden et al. 2004; Brown et al. 2006; Cameron et al. 2006). In several studies non-health specific datasets were joined together with healthcare registers. Brown et al. (2006), for instance, linked Worker Compensation Board records to healthcare datasets in their study and achieved a 97% matched injury rate. Similarly, a population registry of those eligible for healthcare cover was linked to databases of claims made by health providers for reimbursement of services during the investigation undertaken by Cameron et al. (2006). As part of their study the investigators used a unique identification field to join together the datasets of interest. This was also the case when data linkage was performed by Rask et al. (1998), Hansagi et al. (2001) and Dryden et al. (2004). Furthermore, in the study by Samsa, Landsman and Hamilton (1996) HSU was determined by merging a list of veterans with service connected traumatic spinal cord injury (TSCI) together with the VA's Patient Treatment File, through the use of a social security number.

- Inclusion of control cohort or comparison group

In five studies the HSU results were additionally reported amongst a matched control cohort of individuals not suffering from the case condition under investigation (Blose and Holder 1991; Bergman, Brismar and Nordin 1992; Dryden et al. 2004; Brown et al. 2006; Cameron et al. 2006). Common matching variables used included gender, age and place of residence. In each of the studies, controls were either selected from population registries or the remainder of the study population. In contrast to the other investigations Dryden et al. (2004) matched each spinal cord injury (SCI) case to five controls. In comparing HSU levels applicable to their injured cohort with the HSU associated with a matched control cohort the studies mentioned above have attempted to obtain a better understanding of the relative utilisation of healthcare services, as opposed to simply reporting the absolute HSU levels observed amongst their injured cohort.

A further two studies did not match their case cohort under investigation with controls but did report on differences in HSU observed amongst their cases relative to an unmatched comparison group of individuals. Guilcher et al. (2010), for instance, made comparisons in HSU during follow-up between those individuals who had sustained a TSCI and those who had incurred a non-traumatic spinal cord injury (NTSCI), whilst in the study by Seematter-Bagnoud et al. (2006) the case cohort of individuals hospitalised with a non-injurious fall were contrasted with individuals also hospitalised but for a condition other than a non-injurious fall.

- <u>Comparison in HSU between pre- and post-follow-up periods for the same individual</u>

Only two of the studies reported on the change in HSU observed when moving from the pre-injury period applicable to a member of the study population to the post-injury period for that same individual. As part of their investigation Brown et al. (2006) measured the percentage change in the mean value of each outcome measure before and after injury relative to the mean in the year before injury, whilst Wiktorowicz et al. (2001) compared the length of informal care received per week prior to the occurrence of hip fracture amongst their cohort of community dwelling patients with the 2, and 3 to 12 month periods post-hip fracture.

Some of the other investigations did consider the extent of HSU during the pre-follow-up period in some form but did not make any direct comparisons with the scale of HSU observed during follow-up. For instance, in the study by Cameron et al. (2006) pre-injury HSU was simply identified and then controlled for during analysis. Both Dryden et al. (2004) and Guilcher et al. (2010) excluded patients from their final cohorts if they were associated with certain healthcare visits prior to follow-up, whilst in their investigation, Bergman, Brismar and Nordin (1992) included the HSU observed during the period before the domestic violence event as part of the overall HSU reported.

None of the 21 studies used the levels of HSU observed pre-injury to predict the HSU levels that would be expected during the post-injury period in the absence of any injury taking place. Furthermore, no investigation accounted for the older age of the injured cohort, the presence of any trend in the healthcare registries analysed or the relative length of the follow-up period, when comparing the pre- and post-index injury periods.

2.2.4. HSU results from Stage 2 studies

- HSU levels post-injury

Each of the studies appraised during Stage 2 reported an increase in the extent of HSU during the follow-up period. Cameron et al. (2006), for instance, found that 39% of all post-injury hospital discharges, 69% of all years spent in hospital, 22% of physician claims and 77% of placements in care homes that were observed in the injured cohort after injury could be attributed to being injured. At both 1 year and 5 years after the initial index injury being sustained within the workplace Brown et al. (2006) reported an increase in the number of GP visits, the use of hospital services and the number of physician visits for mental healthcare. Initiating studies that focused specifically on SCI, the investigations by Samsa, Landsman and Hamilton (1996) and Guilcher et al (2010) each identified an intensification of healthcare use post-injury. In the case of the latter study high primary care utilisation during the year after injury was observed amongst both TSCI and NTSCI groups, whilst Samsa, Landsman and Hamilton (1996) reported that 75% of their cohort of veterans was admitted to a specialized SCI centre within 6 weeks following their injury. Interestingly in the study by Gabbe et al. (2007) whilst as many as 94% of individuals who had earlier incurred some form of blunt major trauma returned to live in the community by the 6 month follow-up stage, 69% reported continued use of healthcare services. As part of their investigation Miettinen et al. (2004) found 10-17% of whiplash victims regularly used health services 3 years post-injury.

This consistent finding across each of the studies concerning the increased levels of HSU observed for a sustained period post-injury reflects the seriousness of injuries on health. Whilst an initial increase in healthcare activity to deal with the immediate treatment needs of the injury sustained is expected, the continued use of healthcare services for many months, and in some cases years, after the injurious incident provides a clear indication of how injuries can impose a considerable, and prolonged, burden on the health of the injured individual. What is less clear from the studies appraised during this stage of the literature review however is whether the increased levels of HSU observed post-injury can be directly attributable to the occurrence of a prior injury. Only two of the 21 studies directly compared the HSU associated with a given individual over the course of their pre-injury and post-injury periods. Furthermore, not one study used pre-injury HSU levels as a basis for predicting the levels of HSU most likely to occur post-injury in the absence of any injury taking place, meaning no attempts were made to calculate excess HSU by finding the difference between observed and expected HSU post-injury. This represents a limitation of the studies appraised during this stage of the literature review, which will be discussed in greater detail in section 2.3 of this chapter.

- Comparison in HSU during follow-up by different types/severities of injury sustained and different demographic subgroups of the study population

Only four studies stratified the level of HSU post-injury by the type and/or severity of the injury incurred thereby allowing comparisons to be made (Bishai and Gielen 2001; Brown et al. 2006; Cameron et al. 2006; Guilcher et al. 2010). In the study by Bishai and Gielen (2001), for instance, poisoning was identified as the injury most likely to result in ED visits or inpatient stays. Similarly, Cameron et al. (2006) also found the number of hospitalisations was highest among their poisoning group of patients, although the greatest length of hospital stay was found to be associated with SCI's. The finding that poisoning serves to induce a greater number of hospital events, whereas SCI's result in longer stays within hospital reflects the difference in the severity of these injury types. Whilst being sufficiently serious to warrant admission to hospital poisoning cases often do not require a lengthy rehabilitation period as an inpatient. In contrast, despite being rarer, SCI events require sustained periods of inpatient treatment and rehabilitation due to the seriousness of the injury sustained and the need to avoid the potential for long-term disability (Harris et al. 1980; Timothy, Towns and Girn 2004). Indeed, Cameron et al. (2006) report the length of hospital stay, as well as the number of physician claims and number of admissions to care homes, as being positively related to increases in the severity of injury. A similar finding was reported in the study undertaken by Brown et al. (2006) which found workers with acute injuries (fractures, cuts, lacerations) experienced an increased use of health services than workers suffering from chronic injuries (low back pain, repetitive strain, hearing loss). Guilcher et al. (2010) stratified their cohort of individuals into those who had sustained a NTSCI and TSCI type injury. NTSCI patients had significantly fewer days spent in inpatient rehabilitation compared to TSCI patients. This latter group also had higher mean visits to physiatrists and urologists, whereas NTSCI patients had higher mean visits to internists and family physicians. Again this difference, in particular the increased length of inpatient stay observed amongst TSCI patients, reflects the increased severity of injury sustained by this group of patients.

Focusing on the frequency of ED and MIU attendances at the 1 year follow-up stage Locker et al. (2007) identified frequent users, defined as persons making greater than four attendances per year, as being older. In contrast, Safran, Graham and Osberg (1994) find older patients made use of less rehabilitative care than younger patients in their study reporting on the extent of community based care utilisation amongst rehabilitation patients. It must be noted however that 70% of the cohort investigated by Safran, Graham and Osberg (1994) were aged 65+, meaning the finding cited above does not reflect a difference between a young and old subgroup of patients but instead reflects a difference within the elderly demographic subgroup. Concentrating specifically on injury related medical care utilisation amongst a problem drinking population, Blose and Holder (1991) cite males as being associated with a much higher rate of injury care than females, reflecting the increased risk taking behaviour often exhibited by this demographic subgroup (Byrnes, Miller and Schafer 1999). This reasoning would also account for why the incidence of injury care was also highest for problem drinkers aged 51 or less. Interestingly, the relative risk of receiving care following an injury was found to be higher for both females and individuals older than 51, which, particularly in the case of the latter, is likely to reflect the reduced capacity of these demographic subgroups to recover from sustaining an injury without the need for medical care (Shabot and Johnson 1995; Horan and Little 1998). Gabbe et al. (2007) also reported a difference in HSU across subgroups within their study population, with the investigators reporting the use of health services as being less prevalent amongst non-compensable patients relative to compensable ones. This finding reflects the fact that having to pay for healthcare due to the absence of compensation serves to dissuade individuals who have suffered an injury from seeking medical attention.

- Comparison in HSU during follow-up across alternative healthcare providers

Just four of the studies reported on the extent of HSU during follow-up applicable to a single healthcare sector (Holmberg and Thorngren 1988; Bergman, Brismar and Nordin 1992; Samsa, Landsman and Hamilton 1996; Locker et al. 2007). Amongst the others, Brown et al. (2006) found that workers within their cohort who had lost time due to injury increased GP use to a larger degree relative to the use of hospital and physician services. Visits to the former healthcare sector, for instance, were higher among 52% of workers 1 year after injury, whilst just 7% and 12% of these individuals experienced an increase in the number of days spent in hospital and the number of visits to physicians for mental healthcare, respectively. Wiktorowicz et al. (2001) also found that in the year following hip fracture community dwelling patients in their study received on average four GP visits compared to just one specialist visit. In contrast to the above two studies, 55% of 4,101 ambulatory care visits identified as part of the study by Rask et al. (1998) were to ED, with 38% taking place in appointment clinics outside primary care, meaning only 8% of visits occurred within the primary care clinic. This difference observed between the studies by Wiktorowicz et al. (2001) and Brown et al. (2006), and the investigation by Rask et al. (1998) in terms of the frequency of GP use amongst their study populations, reflects the challenges in directly comparing the results across studies (Lyons et al. 2006). The investigations by Wiktorowicz et al. (2001) and Brown et al. (2006) were both set in Canada, whereas the study by Rask et al. (1998) was based in the US. Alternative settings for studies, together with contrasting study populations and different injury types under investigation, can often lead to contradictory results.

Cameron et al. (2006) identified the utilisation of care homes as being most prevalent in their investigation. Relative to the comparison cohort the injured group of individuals followed up 10 years post-injury were associated with 4.4 times the rate of placements in care homes, whereas the equivalent rates for the number of post-injury hospital discharges, the number of days spent in hospital and the number of physician claims were just 1.6, 3.2 and 1.3 respectively. In contrast to the study by Cameron et al. (2006), which reported the number of physicians visits as being the least frequent amongst their injury cohort, both the NTSCI and TSCI patients followed-up as part of the investigation undertaken by Guilcher et al (2010) experienced a higher mean number of physician visits compared to visits to any other form of healthcare, such as the EDs and specialist clinics. These two studies are not directly comparable however given the alternative HSU outcome measures focused on as part of the investigations. Cameron et al. (2006) compared physician visits to placements in care homes and the number/length of hospitalisations, whereas Guilcher et al. (2010) compared physician visits to the number of attendances at an ED and specialist clinics.

Comparing directly the number of ED, inpatient and outpatient contacts resulting from a given injury episode Bishai and Gielen (2001) found that for every 100 injury conditions there were 254 outpatient visits, compared to just 23 ED attendances and only four hospitalisations. Similarly, in the study by Blose and Holder (1991), for both cohort members with and without a chronic drinking problem the number of outpatient events exceeded the number of emergency room contacts and inpatient admissions. In contrast, in their investigation aimed at determining whether frequent use of the ED is indicative of high use of other healthcare services, Hansagi et al. (2001) found that only 59% of frequent ED users made an outpatient visit over the course of the 1 year follow-up period compared to 80% and 72% of these individuals in the case of hospital admissions and primary care visits, respectively. This difference may reflect the fact that in the study by Hansagi et al. (2001) HSU is measured solely for individuals first attending an ED, whereas the investigations undertaken by Blose and Holder (1991) and Bishai and Gielen (2001) account for all injured individuals in receipt of medical attention.

Of the 69% of cohort members living in the community and reporting continued use of healthcare services 6 months after sustaining some form of blunt major trauma, Gabbe et al. (2007) identified physiotherapy as the primary service provider, followed by medical/specialist care. In addition physiotherapeutic treatment was most prevalent 3 years after whiplash injury in the study by Miettinen et al. (2004). These two findings indicate the long-term burden that injury can impose on health, and additionally suggest that as the length of time increases from the initial injury incident, rehabilitative services as opposed to treatment care, often represents the most utilised medical service.

2.2.5. Summary of the findings from Stage 2 of the literature review

Following the initial identification of 2,352 studies considered potentially relevant to this stage of the literature review, appraisal of each abstract involving the application of several inclusion/exclusion criteria reduced this figure to 21. Together with the electronic searching of medical records, the use of sample surveys via postal questionnaires and telephone interviews represented a prominent means of collecting HSU related information in several of the studies surveyed. Data linkage was incorporated into six studies, thereby allowing population and healthcare registries to be joined together. A quarter of the studies compared the HSU results applicable to their injured cohort with matched controls in an attempt to determine the level of relative HSU within their investigations. Another way to determine relative HSU is to account for the utilisation of health services associated with the study population during the pre-injury period; however, this represented a feature of just two of the 21 studies appraised. In terms of the HSU levels observed, each of the studies reported a rise during the follow-up period, reflecting the burden injury imposes on the long-term health of individuals. Several studies found post-injury HSU varied according to the type/severity of the injury incurred, specific demographic subgroups of the study population and the healthcare sector providing treatment.

2.3. Limitations of studies appraised during Stages 1 and 2 of the literature review

- Limited coverage

The search strategy performed as part of Stage 1 of the literature review originally resulted in the identification of 1,147 research articles in total. Following an appraisal of each abstract only 129 were considered potentially relevant to this study in that they focused on the direct medical costs associated with at least one type of injury (Figure 2.1). However, the scope of many of these investigations was often very limited, frequently being restricted to a single type/external cause of injury, a particular demographic subset of the population or a specific health service sector. Such a limited coverage meant that it was very often not possible to determine the full direct medical cost burden of injury in a way which successfully encompassed the extent of the resources used and the magnitude of the costs incurred by the healthcare sector as a whole following the treatment/rehabilitation of injuries in a given period.

Table 2.3 below provides a breakdown of the different categories of injury, subsets of the population and health service sectors focused on by the 129 studies identified as having a limited coverage.

Table 2.3: Number of Stage 1 studies with a limited scope, stratified by injury type/external cause, population/demographic group and healthcare sector

Category	**Number of Stage 1 studies**
1. Injury type/external cause	1. Injury type/severity
a. Hip fracture	a. 16
b. Firearm	b. 12
c. Motor vehicle traffic accident	c. 10
d. Spinal cord injury	d. 9
e. Occupational	e. 8
f. Falls	f. 6
g. Traumatic brain injury	g. 6
h. Dental	h. 4
i. Burns/Scalds	i. 4
j. Hand injury	j. 3
k. Head injury	k. 3
l. Eye injury	l. 3
m. Wound injury	m. 2
n. Submersion/Drowning	n. 2
o. War	o. 2
p. Facial fracture	p. 2
q. Tendon injury	q. 2
r. Violence	r. 2
s. Agricultural	s. 2
t. Ankle fracture	t. 1
u. Electric saw	u. 1
v. Foreign body	v. 1
w. Knee injury	w. 1
x. Repetitive strain injury	x. 1

Category	Number of Stage 1 studies
2. Population/demographic group a. Paediatric b. Old c. Female d. Adult	2. Population/demographic group a. 16 b. 13 c. 3 d. 2
3. Healthcare sector a. Inpatient b. Rehabilitation c. Tertiary referral centres d. Nursing	3. Healthcare sector a. 31 b. 2 c. 1 d. 1

It is apparent from Table 2.3 that many of the research articles identified as reporting on the treatment expenditures associated with the occurrence of injuries (n = 129) either focused on a single type of injury (e.g. hip fracture: n = 16), accounted for a particular subset of the population (e.g. Old: n = 13), or limited their investigation to a specific health service sector (e.g. inpatient: n= 31). In fact only 17* of the 129 studies extended the scope of their investigations to encompass all injury types, incurred throughout the entire population and which were treated/cared for by more than one sector within the healthcare system.

(*These 17 research articles were appraised in detail in Stage 1 of the literature review).

The fact this literature review reveals that there are only a small number of existing studies which report the healthcare related costs of injury amongst the entire injured population within a certain area/region/country means there is a gap in the current knowledge concerning the extent to which injuries impose an economic burden on the healthcare sector as a whole. For example, injury based epidemiological studies that report on the economic consequences associated with spinal cord or traumatic brain related injuries will assist in providing a greater understanding of the impact these particular injuries impose on a given healthcare system. However, the intensity and magnitude of the resources consumed in the treatment and rehabilitation of spinal cord or brain injuries specifically, will not be the same as the reserves devoted to attempts to treat/care for individuals suffering other types of injury. Similarly, the demand for healthcare services following a given injury sustained by an older aged individual will differ considerably when compared to the needs of children/adolescents, whilst explicit focus on the cost of inpatient treatment after injury ignores the spending directed at the provision of outpatient treatment, for example.

- Small sample sizes

Of the 38 studies appraised in detail as part of Stages 1 and 2 of this literature review 18 based their findings on a sample size of below 1,000 injury cases/injured individuals. This lack of a large sample size was a particular feature of the 21 Stage 2 studies reviewed (Table 2.4), of which over a half (n = 12) incorporated an injured cohort ranging from just 1 to 1,000 cases/individuals in number (Bergman, Brismar and Nordin 1992; Safran, Graham and Osberg 1994; Levi 1997; Rask et al. 1998; Hodgkinson et al. 2000; Wiktorowicz et al. 2001; Maraste, Persson and Berntman 2003; Miettinen et al. 2004; Dryden et al. 2004; Seematter-Bagnoud et al. 2006; Slomine et al. 2006; Gabbe et al. 2007).

Table 2.4: Number of Stage 2 studies stratified by sample size

Sample size (number of injury cases/injured individuals within study cohort)	Number of Stage 2 studies
1 to 100	0
101 to 1,000	12
1,001 to 5,000	4
5,001 to 10,000	1
10,001 to 50,000	2
50,001 to 100,000	2
>100,000	0

Although studies that incorporate a relatively small number of cases into their investigations generally possess the ability to perform a more detailed follow-up of their sample cohort, thereby increasing the potential validity of their conclusions in this respect, the overall findings reported from such studies may additionally suffer from a limited statistical power and reduced reliability, given the increased possibility of chance findings significantly skewing the final results, together with leading to uncertainty over effect sizes. This may potentially culminate in misleading conclusions and recommendations being inferred from the investigation (Bower et al. 2003).

One means to determine whether the results and conclusions presented as part of an investigation involving a relatively small sample size are likely to be accurate and reliable is to compare what is reported with the equivalent findings advanced by similar studies which have successfully incorporated far larger cohorts of cases/individuals (n >10,000). However, as Table 2.4 indicates there is a lack of these latter types of studies that are able to act as a reliability gauge to smaller cohort investigations. Indeed, just four of the 21 studies that were reviewed in Stage 2 based their results on sample cohorts encompassing more than 10,000 cases/individuals (Brown et al. 2006; Cameron et al. 2006; Locker et al. 2007; Hansagi et al. 2001). Hence, a greater understanding of the long-term HSU applicable to the follow-up of a large cohort (n > 10,000) is necessary.

- <u>Too great a focus on the short-term consequences of injury</u>

Together with their immediate (acute) and short-term impact, injuries can impose a huge burden on injured individuals, society and the healthcare sector over a considerable, long-term, period post-injury. However, for the most part, the research articles reviewed in this study considered only the initial repercussions of injury. Indeed, 10 of the 21 articles surveyed in Stage 2 (Safran, Graham and Osberg 1994; Levi 1997; Hodgkinson et al. 2000; Wiktorowicz et al. 2001; Hansagi et al. 2001; Seematter-Bagnoud et al. 2006; Slomine et al. 2006; Gabbe et al. 2007; Locker et al. 2007; Guilcher et al. 2010) confined their follow-up periods to a single year or less post-injury, despite only those investigations initiated with the aim to assess the long-term HSU following injury being appraised as part of this literature review. Furthermore, just four (Miller and Lestina 1996; Meerding, Mulder and van Beeck

2006; Haeusler et al. 2006; Davis et al. 2007) of the 17 studies reviewed in detail as part of Stage 1 of this literature review followed-up their injured cohorts beyond the treatment/care of the index injury and reported the long-term costs of injury incurred during the post-index injury period.

- Limited research focusing on the relationship between linked injury events

None of the research articles appraised during the literature review undertaken as part of this study commented on the difficulties involved in distinguishing between repeat and new injury related healthcare events. Furthermore, not one of the studies proposed an empirically substantiated number of days that can reasonably be allowed between the end of one injury related ED attendance or hospitalisation and the start of another before the latter can justifiably be classed as an entirely new healthcare event. However, determining the relationship between past, present and future injury related healthcare events can have a major bearing on how the incidence of injuries, together with their subsequent direct medical costs, is calculated. In addition, advances in data linkage (section 1.5.2, Chapter 1) mean that the ability to ascertain this information does now exist.

- Too great a focus on healthcare events coded as injury

The studies reviewed tended to specifically focus on counting and costing healthcare events assigned an injury diagnosis code. However, certain injury related conditions, especially psychological sequelae, may very well not be coded as injury. Hence, by focusing purely on injury coded healthcare events certain repercussions of the injury are being missed.

- <u>Lack of knowledge as to whether record linkage has any impact on the eventual HSU and direct medical costs reported</u>

Whilst some of the investigations appraised as part of this literature review have used data linkage to join together related records in multiple databases, thereby providing a valuable insight into how this process has been performed, what is less clear is whether the ability or inability to link health related datasets in this way has any bearing on the scale of the HSU and direct medical costs reported following the occurrence of injuries. That is, no existing study has directly compared the injury related HSU and/or direct medical cost results of an investigation incorporating data linkage with the equivalent results of an investigation incorporating no data linkage.

- <u>Too great a focus on reporting the absolute levels of HSU and direct medical costs post-injury</u>

As opposed to simply reporting on the absolute levels of HSU and direct medical costs observed amongst an injured cohort over the post-index injury period, an alternative means of reporting these outcome measures is to compare them with the average or baseline levels expected in the absence of an injury. The expected levels of HSU and costs can be based on the levels observed amongst the general population during the post-index injury period, or the levels observed amongst a non-injured control cohort during the post-index injury period, or the levels observed amongst the injured cohort during the pre-index injury period. By reporting HSU and costs compared to the expected average/baseline equivalent it is possible to determine the relative impact of injury on these outcome measures. Failure to do this assumes that all of the HSU and direct medical costs observed amongst the injured cohort following an index injury are associated with, and hence repercussions of, the index injury itself. This may not be the case, however, given certain healthcare contacts observed and accounted for during the post-index injury period may have in fact taken place irrespective of whether the index injury had been sustained or not. According to

McGuire et al (2001, p.371) "…it may be misleading to identify only recorded cases of the disease for the purposes of a cost-of-illness analysis".

Despite the potential for misleading results associated with reporting solely on the absolute and not the relative levels of HSU and direct medical costs post-injury, this represented a feature of 29 of the 38 studies appraised during Stages 1 and 2 of the literature review, with just nine studies reporting on the relative impact of injury on HSU and direct medical costs via comparison with a matched/unmatched control cohort and/or the pre-index injury period (Blose and Holder 1991; Bergman, Brismar and Nordin 1992; Wiktorowicz et al. 2001; Dryden et al. 2004; Brown et al. 2006; Cameron et al. 2006; Seematter-Bagnoud et al. 2006; Davis et al. 2007; Guilcher et al. 2010).

- <u>Lack of comparison with the pre-injury period when determining the relative impact of injury</u>

Of the 38 studies appraised in detail as part of this literature review only three (Wiktorowicz et al. 2001; Brown et al. 2006; Davis et al. 2007) directly compared the levels of HSU and direct medical costs observed during the post-index injury period with the levels of these outcome measures observed during the pre-index injury period. Instead, each of the remaining studies that reported on the relative impact of injury compared the HSU and direct medical costs applicable to their injured cohort during the post-index injury period with the HSU and direct medical costs applicable to either a matched or unmatched control cohort over the same period (Blose and Holder 1991; Bergman, Brismar and Nordin 1992; Dryden et al. 2004; Cameron et al. 2006; Seematter-Bagnoud et al. 2006; Guilcher et al. 2010). One obvious drawback associated with this practice concerns the fact that even when cases and controls are matched on a one-to-one basis, involving several demographic and pre-index injury variables, the comparison undertaken is still not exactly like for like given the same individuals are not being compared. Hence, the potential for selection bias always exists (Pauly et al. 2008), the presence of which would mean any difference observed amongst the cases and controls over the post-index injury period could reflect differences between the individuals being compared that are not connected to the index injury itself.

In population based studies incorporating large cohorts of individuals it is frequently not possible to identify for certain which of the subsequent healthcare contacts taking place relate to the index injury and which do not. This may only be categorically determined through a one-to-one follow-up of injured patients who can be asked specifically whether the healthcare events in question are related to an earlier index injury. Despite this, any attempt to ascertain whether injury contacts during a certain period are effectively new cases or old ones part of a series that would have occurred anyway, can be assisted by comparing the pre-and post-index injury periods. For example, certain individuals may exhibit high healthcare use over the course of the post-index injury period due to the presence of co-morbidities or their lifestyle choices, meaning the size of the HSU and direct medical costs observed may not solely be caused by an injury being sustained. A better understanding of the actual impact of the injury could be acquired however by observing the HSU and direct medical cost levels amongst these individuals prior to the index injury event taking place, when the impact of co-morbidities or lifestyle choice on HSU and direct medical costs would also be present. Indeed, it has been shown that both past patterns of HSU and cost are strong predictors of future levels of these outcome measures (Bertsimas et al. 2008; Tripp et al. 2008).

This lack of a comparison with the pre-follow-up period when determining the relative impact of a given condition on the utilisation and cost of healthcare is not solely confined to injury based research. Together with this representing a feature of the injury specific investigations appraised during Stages 1 and 2 of the literature review undertaken as part of this study, the failure to consider the pre-follow-up period additionally represents a feature of numerous other past studies that have reported on the relative impact on HSU and costs of other types of non-injury related conditions. For instance, searching PubMed using the search terms *Costs and Cost Analysis* [MeSH] AND *Excess*, resulted in 1,061 studies in total. In the majority of the studies identified, excess costs were determined by comparing the observed cost figures amongst cases with the observed cost figures amongst matched controls. Examples include the investigations conducted by Stewart et al. (2003), Burns et al.

(2010) and Bohl et al. (2010). In studies where a matched control cohort was not used the cost figures observed amongst the case cohorts instead tended to be compared with an expected baseline cost figure derived from the general population. Cuijpers et al. (2007), for instance, defined excess costs as those over and above the base rate, with the base rate consisting of costs generated annually by every person on average. Similarly, in the investigation by Jacobs et al. (2000) excess costs were calculated by subtracting expected costs from observed costs, where expected costs were derived from the general population. Indeed, none of the 1,061 studies identified using the above PubMed search terms, plus none of the 404 studies identified using the PubMed search terms *Health services* [MeSH] AND *utilization* [MeSH subheading] AND *Excess*, reported the relative impact of a given condition by considering the pre-follow-up period as part of their investigations.

- Failure to combine past HSU and direct medical cost levels with demographic and clinical variables to predict future HSU and direct medical costs

Whilst the studies by Wiktorowicz et al. (2001), Brown et al. (2006) and Davis et al. (2007) do consider the levels of HSU and direct medical costs observed during the pre-index injury period when determining the relative impact of injury on these outcome measures, none of these studies use these pre-index injury figures alongside additional demographic and clinical data to predict future HSU and cost levels. This represents a limitation of these studies given future HSU and costs will not only be influenced by the co-morbidities and lifestyle choices associated with the injured cohort, variables that are largely accounted for by considering the pre-follow-up period. Instead, future HSU and costs will also be influenced by the injured cohort increasing in age, an underlying trend in the healthcare datasets analysed and by the varying lengths of the pre- and post-index injury periods investigated, which are variables not accounted for by solely considering the pre-follow-up period. Hence, failure to incorporate these factors means that any increase or decrease in HSU/costs observed amongst the injured cohort over the follow-up period relative to the pre-follow-up period may not be due to the index injury itself. Instead the change may be due, for example, to the older age of the injured individuals, a rising trend in the number and/or costs of healthcare activity inherent within the healthcare registries scrutinized (due to changing insurance status or higher unit costs), or a longer length of follow-up period. The impact of omitting these additional demographic and clinical variables will be more marked in studies with a very long follow-up period and when there is a considerable gap between the start of the follow-up period and the end of the pre-follow-up period, owing perhaps to a long length of stay associated with the index condition under investigation.

- <u>Reliance on patient self-report</u>

The studies by Harlan, Harlan and Parsons (1990), and Miller and Lestina (1996) appraised during Stage 1, together with the investigations by Hodgkinson et al. (2000), Bishai and Gielen (2001), Maraste, Persson and Berntman (2003), Miettinen et al. (2004) and Gabbe et al. (2007) reviewed as part of Stage 2, based their findings on the self-report of survey respondents, through the use of patient questionnaires and/or interviews. Whilst this approach is advantageous in several ways, including the opportunity to determine the impact of injury from the individual patient's viewpoint, the use of patient self-report has a number of drawbacks also. For instance, the recall of healthcare use by patient's is subjective and relies on the ability of respondents to accurately recollect events that may have taken place many weeks or months previously (Coughlin 1990). Patient recall may be additionally misleading due to a concept known as response shift (Howard et al. 1979), whereby the occurrence of a traumatic event, such as an injury, possesses the potential to alter the way in which the individuals involved recall past, present and future events.

Moreover, studies that solely adopt a patient self-report approach often suffer from the limitations associated with a small sample size given the difficulty in initially enrolling patients into these types of study and the loss to follow-up likely to take place over the course of the investigation. Indeed, of the 7 studies cited above that based their findings on patient recall four (Hodgkinson et al. 2000; Maraste, Persson and Berntman 2003; Miettinen et al. 2004; Gabbe et al. 2007) incorporated cohorts numbering less than 1,000 individuals.

2.4. Knowledge gained from literature review

The undertaking of this literature review, involving the appraisal of the methodologies, findings and limitations of a variety of different studies, has served to inform the design and implementation of this study in many ways.

- Sample size

Due to the increased statistical power and reliability of findings based on relatively large sample sizes, together with the apparent lack of studies incorporating injured cohorts of such a size within the current literature, the number of injury cases encompassed within this study was chosen to be in excess of 10,000.

- Data collection

The electronic review of administrative and healthcare databases was chosen over patient recall surveys as a means to collect the HSU and direct medical cost related information as part of this study. This decision was based on the tendency for survey specific investigations to require a relatively small sample size, and due to the potential for surveys to suffer from recall bias and high drop-out rates.

- Outcome measures

A consistent limitation of many of the studies initially identified as being relevant to this study concerned their limited coverage in terms of the types/external causes of injury, demographic subgroups and healthcare sectors incorporated within the investigations, which meant it was often not possible to determine the impact of injury on the entire injured population. Hence, to ensure this study was able to report population based measures of the impact of injury on HSU and direct medical costs, all types/external causes of injury, several demographic subsets of the population and multiple healthcare sectors involved in the treatment of injury were included.

- Cost accounting approach

A bottom-up/incidence based approach was adopted for this study given this method tended to be the most frequently used within the current literature as part of investigations undertaken with the aim to monitor a pre-defined patient cohort over a fixed period of time, with the alternative top-down/prevalence based approach commonly cited as unsuitable for investigations with such a study design. Furthermore, the datasets available to be analysed as part of this study were sufficiently detailed, with the presence of patient level records, to allow a bottom-up/incidence based approach to be implemented.

- Comparison of pre- and post-index injury periods to determine the relative impact of injury on HSU and direct medical costs

Review of the current literature has revealed the lack of past studies that have accounted for the relative impact of injury on HSU and direct medical costs, with the majority of the studies appraised during Stages 1 and 2 simply reporting the absolute changes in these outcome measures. However, given the potential for changes in HSU and cost levels following injury to be the result of factors specific to the injured individual, such as the presence of co-morbidities and lifestyle choices, as opposed to being due to the actual injury sustained, the failure to report the relative impact of injury on HSU and costs may lead to inaccurate results. The most common means of reporting the relative impact of injury amongst existing studies involves comparing the levels of HSU and direct medical costs during the post-injury period associated with an injured and non-injured cohort of individuals. Alternatively, though, the relative impact of injury can also be determined by performing a comparison of the pre-injury and post-injury levels of HSU and direct medical costs associated with a given injured individual. In this way the impact of factors such as co-morbidities and lifestyle choices will be accounted for as part of both the pre- and post-follow-up periods. The undertaking of this literature review, however, clearly signifies the limited number of studies that have accounted for both the pre- and post-injury periods as part of their investigations. Indeed, of the 38 studies appraised in detail in Stage 1 and Stage 2 just three directly compared the levels of HSU and direct medical costs observed during the post-index injury period with the levels of these outcome measures observed during the pre-index injury period.

Comparison of the pre- and post-follow-up periods was chosen as the means of determining the relative impact of injury on HSU and cost levels as part of this study, given the advantages of this approach and the limited number of past investigations that have adopted it.

- <u>Inclusion of demographic and clinical factors in the formula to predict future HSU and direct medical costs</u>

Review of the current literature reporting on the levels of HSU and direct medical costs post-index injury has not only shown that consideration of the pre-follow-up period is rare when determining the relative impact of injury, but has also indicated the failure to consider additional demographic and clinical factors that can influence the HSU and direct medical costs observed over the course of the investigative period. For this study it was decided that such factors, including the age of the cohort followed-up, any trends in the frequency and cost of healthcare activity inherent within the datasets appraised, and variations in the length of the follow-up period relative to the length of the pre-follow-up period, should be included as part of any calculations to predict future HSU and cost levels.

- <u>Length of post-injury period</u>

There is a tendency amongst the current literature to focus primarily on the short-term consequences of injury. However, as described in section 1.5.1 of Chapter 1, injuries are increasingly having a detrimental impact on the long-term health of individuals resulting in the continued need for healthcare treatment and rehabilitation many months/years after the initial injury incident. Hence, the potential post-injury follow-up period applicable to this study was chosen to be in excess of one year in order to allow the longer-term repercussions of injury to be measured.

- <u>Data linkage</u>

Review of the existing literature has clearly indicated the importance of utilising data linkage techniques when attempting to follow-up injury cases/injured individuals longitudinally and across multiple large scale electronic administrative/healthcare datasets. Hence, the ability to link patient level data together through the use of unique individual identifiers was essential when deciding on the data sources to be utilised as part of this study.

- <u>Knowledge gaps</u>

Together with providing an insight into the methodologies, findings and limitations of a variety of studies initiated with the aim of reporting the impact of injury on HSU and direct medical costs, the undertaking of this literature review has additionally revealed significant gaps in assumed knowledge amongst the current literature. Specifically, there appears to be little or no information relating to the decision as to the number of days that can reasonably be allowed between the end of one injury related ED attendance or hospitalisation and the start of another before the latter can justifiably be classed as an entirely new healthcare event. Another gap in assumed knowledge is the treatment for psychological sequelae as a result of injury. By focusing only on healthcare events coded within the range of injury specific diagnosis codes not all of the healthcare events associated with an earlier injury are being counted and costed. A further knowledge gap concerns the apparent lack of a direct comparison between the injury related HSU and/or direct medical cost results of an investigation incorporating data linkage and the equivalent results of an investigation incorporating no data linkage. This study was designed in such a way to provide information relating to these gaps in assumed knowledge.

2.5. Chapter summary

A two-stage literature review has been conducted in this chapter with the aim to identify and evaluate existing literature focusing on the impact of injuries on the healthcare sector in terms of HSU and direct medical costs. Stage 1 appraised in detail past studies that have reported on the health treatment costs associated with the occurrence of injuries, whilst Stage 2 considered those investigations concerned with determining the extent to which injuries impact on subsequent HSU levels. As part of both stages the selected studies were reviewed to obtain information relating to the methodologies adopted, results reported and limitations inherent within the investigations, with the knowledge gained then used to inform the design of this study.

Chapter 3 – Aim, objectives and research questions

3.1. Aim

- To develop improved measures of HSU and direct medical costs following the occurrence of an index injury, by utilising large scale anonymised datasets, linked via unique patient level identifiers.

3.2. Objectives

- To develop a model aimed at estimating the extent of long-term excess HSU and direct medical costs across the ED, inpatient and outpatient healthcare sectors following different types/severities of index injury, incorporating all ages/genders of the injured cohort, the treatment and rehabilitation phases following injury, and both the pre- and post-index injury study periods.

- To use the model developed to estimate the size of the excess HSU and direct medical costs per index injury on average, and to use these figures to estimate the overall size of excess HSU and direct medical costs associated with all the index injuries sustained by the injured cohort followed-up as part of this study, as well as the extrapolated number of index injuries applicable to Wales as a whole.

3.3. Additional methodological questions

Together with satisfying the aims and objectives set out above, in light of the limitations identified amongst the current literature and hence the associated gaps in assumed knowledge, the following two methodological questions were posed and answered as part of this study:

- Question 1 – Is it possible to develop a methodology which determines a pre-defined number of days that should be allowed between two injury related ED/inpatient healthcare events before it is reasonable to classify the second case as an entirely new injury healthcare event as opposed to being related to a previous injury healthcare event?

- Question 2: Do the direct medical costs of injury reported as part of an investigation involving the analysis of multiple healthcare datasets linked via anonymous patient identifiers differ from the findings based on the separate parallel analysis of unlinked healthcare datasets?

Chapter 4 – Methodology

4.1. Study design

This study can be described as a retrospective longitudinal cohort study of injured patients, with the extent of excess HSU and direct medical costs following an index injury estimated by utilising data linkage techniques to join together multiple, large scale, computerised health related databases and population based registries.

4.1.1. Ethics

No ethical approval was required for the undertaking of this study given the absence of any identifiable data being used as part of the analysis. This is in line with the most recent National Research Ethics Service (NRES) guidance, which states

> There is no formal requirement for research databases to apply for ethical review under NHS research governance systems, and ethical and other approvals would only be required by legislation if processing identifiable data without consent. Applications for ethical review will therefore normally be made on a voluntary basis (NRES 2010, p.1).

Each of the datasets utilised were fully anonymised and maintained by the HIRU data warehouse based at Swansea University. HIRU has an independent Information Governance Review Panel (IGRP) which judges whether proposals are in the public interest. This panel contains members from NRES, Involving People, Informing Healthcare, the British Medical Association and the National Public Health Service for Wales.

4.2. Setting

The City and County of Swansea formed the setting for this study. Comprising an area of around 378 square kilometres in size, with a population of around 227,100 residents (2006 estimate), Swansea is a largely urban area within Wales. According to the 2001 UK census, a nationwide survey acquiring information on the demographic and lifestyle characteristics of the UK population, the vast majority of Swansea residents describe themselves as of White origin, with around 2 per cent being from ethnic backgrounds other than White.

Following devolution and the passing of the Government of Wales Act in 1998 the powers to oversee the healthcare sector and ensure the delivery of health related services in Wales has been the responsibility of the National Assembly for Wales.

4.3. Data sources

Multiple data sources held and maintained by HIRU and forming part of the SAIL project (Lyons et al 2009; Ford et al 2009), were linked together and analysed as part of this study. These data sources included population based registries as well as health related datasets, and are listed and described below:

- Population registry records

The initial study population, comprising all of the potential participants from which the injured cohort and non-injured comparison group were later selected, was extracted from the Welsh National Health Service Academic Registry (NHS AR), an electronic record system containing the anonymised address and GP practice history relating to all individuals resident in Wales and registered with a Welsh GP. The NHS AR covers the whole of Wales with data refreshed on a daily basis. As part of this study it was possible to access an historic extract of the NHS AR spanning from 01/01/1960 up to 12/11/2007.

As a consequence of encompassing the address details relating to all Welsh residents the NHS AR was used to determine whether individuals had moved into and outside of Swansea during the investigative period.

- ED data

The All Wales Injury Surveillance System (AWISS), a computerised injury surveillance system designed to collect and collate information on injuries treated in EDs across Wales, was analysed to provide data on presentations to the ED. The AWISS dataset was used to identify the presence of index injuries initially in receipt of ED treatment, whilst this dataset also allowed the extent of ED utilisation (for all conditions) during the study period to be inferred.

However, at the time of analysis complete AWISS data was not available for the whole of Wales meaning analysis was confined to the ED records relating to Morriston hospital in Swansea only, covering the period 01/11/1999 to 28/06/2007. The Morriston ED represents the most frequently used emergency treatment facility for Swansea residents and is the only centre which treats factures and more serious injuries. Minor injuries, such as lacerations, bruises, abrasions and sprains could also be treated at the minor injuries units at Singleton or Baglan hospitals.

- Inpatient data

In order to identify the presence of index injuries sustained by the injured cohort that were initially seen as an inpatient, the PEDW dataset was analysed. With coverage available from 01/04/1999 up to 30/09/2007 the PEDW dataset encompasses the demographic information and clinical records associated with all inpatient admissions, elective and emergency, to Welsh hospitals. Finished Consultant Episodes (FCEs) are used as the basis of this patient administration system. Transfers within the same hospital from one consultant to another constitute a new FCE but remain part of a single provider spell, meaning it is possible for this latter unit of activity to be composed of multiple FCEs, with its duration indicating the total period of time spent at a given hospital. When transfers between hospitals materialise an entirely new provider spell begins. Hence, in order to determine the continuous length of treatment for patients across hospitals 'Super spells' need to be considered. Allowing for a gap of two days or less 'Super spells' aggregate together individual provider spells and are thus representative of the entire length of stay of a patient within the inpatient care sector, from first admission to final discharge, accounting for the movements of patients between hospitals (Brophy et al. 2010).

Together with identifying index injuries initially treated within the inpatient sector, the PEDW dataset was additionally used to infer the extent of inpatient utilisation (for all conditions) associated with members of the injured cohort over the study period, whilst it was also used to identify the presence of any co-morbidities amongst the inpatient records of the study population prior to the start of the follow-up period.

- <u>Outpatient data</u>

In an attempt to ascertain the level of outpatient treatment utilisation, outpatient appointment records from across all NHS Trusts in Wales were scrutinized, covering the period 01/04/2004 to 31/05/2007. Unlike the ED (AWISS) and inpatient (PEDW) datasets, the outpatient records were not used to identify the presence of index injuries but instead were used solely to determine the extent of outpatient utilisation (for all conditions) by the injured cohort during the study period.

- <u>GP data</u>

To identify the presence of co-morbidities associated with the study population, GP records from the Swansea area were examined. With coverage dating back from 1993 up to July 2007 the GP system appraised comprised attendance and clinical information for all GP interactions, including data on patient symptoms, investigations, diagnoses and prescribed medication. At the time of analysis GP data could be accessed for 33 out of the 34 GP practices in Swansea.

The GP data were not used to identify the presence of index injuries or to determine the extent of GP utilisation over the study period, but were solely used to infer whether any of the study population had a pre-existing co-morbidity present within their GP records in the period prior to the start of follow-up.

4.3.1. Scrutiny of multiple data sources

Investigating each of these datasets separately would serve to provide useful information on the level of activity within the ED, inpatient, outpatient and GP sectors individually. However, such fragmented analysis would mean that the findings relating to each of the health service sectors would be unconnected with each other, thereby adding little insight into the extent to which a particular injury event impacts upon several different healthcare service providers through the course of the treatment phases post-injury.

Fortunately since all of the data sources referred to above, and utilised as part of this study, formed part of the SAIL project they each included an encrypted Anonymised Linkage Field (ALF_E). This field, uniquely generated from a patient's NHS number, allows multiple datasets to be linked together at a patient level. Hence, individuals attending ED and/or admitted to hospital with an injury could be anonymously tracked as they proceeded through the healthcare system, advancing from ED/inpatient treatment to possible outpatient visits, with the potential to link each identifier back to the population registry (NHS AR) whenever necessary. Moreover, the pre-index injury healthcare histories associated with these individuals could also be inferred thereby, for instance, allowing the presence of pre-existing co-morbidities to be identified within the GP dataset. Consequently, in this way the ability existed to conduct a longitudinal follow-up of individuals on a large scale level.

4.4. Study population

The study population comprised persons (all ages, both sexes) who remained resident within Swansea throughout the investigative period, starting from 01/04/2004 up until the end follow-up date of 31/03/2007. The study population was identified from the

NHS AR, which in including the 'from' and 'to' dates that a given individual lived at a particular address, made it possible to determine whether or not individuals moved out of Swansea for any length of time during the investigative period. Such individuals were subsequently excluded from the final study population, which in total numbered 196,129 individuals.

4.4.1. Injury cohort

The injured cohort comprised individuals within the study population who attended an ED and/or were hospitalised with an injury between 01/04/2005 and 31/03/2007. ED cases over this period were identified from attendances to Morriston ED incorporated within the AWISS dataset, with inpatient cases searched for within the inpatient dataset PEDW. Individuals were only considered eligible for inclusion within the injury cohort provided they were recorded with a primary diagnosis of injury. With regards to inpatient admissions the following International Classification of Diseases, 10th revision, Clinical Modification (ICD-10-CM) diagnoses were classed as injuries: S00 – T73, T75, T78, excluding "*Maltreatment syndromes*" (T74), "*Certain early complications of trauma, not elsewhere classified*" (T79), "*Complications of surgical and medical care, not elsewhere classified*" (T80-T88), "*Sequelae of injuries, of poisoning and of other consequences of external causes*" (T90-98). PEDW records were also not included in the injury subset if they were attributed an External Cause code in the following ICD-10-CM range: Y40-Y84 ("*Complications of medical and surgical care*"). Similarly, in terms of ED attendances injury induced events were identified by searching for the presence of injury related diagnoses within the ED diagnosis codes specific to Morriston ED.

(A full list of the Morriston ED diagnoses codes used to determine an injury event within the ED sector can be viewed in Table A1 in Appendix 1, whilst the implications associated with confining analysis to injuries recorded in the primary position only, together with excluding certain diagnosis and external cause codes, are discussed in detail in section 10.4 of Chapter 10).

In total 30,387 individuals from the study population (15.5% of the total) were included within the injured cohort. For each individual their first occurring injury during the period 01/04/2005 and 31/03/2007 was defined as their index injury, and only the first index injury was included within the analysis. Hence, the injured cohort comprised 30,387 index injuries.

4.4.2. Non-injury comparison group

The non-injured comparison group was subsequently selected from the remaining members of the original study population not included within the injury cohort of individuals. Given none of these individuals were eligible for inclusion within the injured cohort, it followed that not one of the non-injury comparison group attended Morriston ED or were admitted as an inpatient for the treatment/care of an injury during the period of 01/04/2005 to 31/03/2007.

In total the non-injury comparison group comprised 165,742 individuals and were utilised for the purposes of this study as a means to determine how representative the injured cohort were in relation to the study population as a whole. The extent of injury related excess HSU and direct medical costs associated with the non-injured group of individuals could not be calculated as part of this investigation given they had sustained no index injury during the investigative period.

4.5. Outcome measures

The primary outcome measures of interest within this study were the extent of the excess HSU and the size of the excess direct medical costs estimated following the occurrence of an index injury sustained by each member of the injured cohort.

4.5.1. Determining the extent of excess HSU during the follow-up period

A model specifically aimed at determining the extent of excess HSU following the occurrence of an index injury was developed for the purposes of this study. Incorporating the injured cohort of individuals within the study population, excess HSU was calculated by comparing the number/length of ED, inpatient and outpatient healthcare events (for all conditions) observed during the post-index injury period (excluding the healthcare event associated with the initial treatment of the index injury), with the equivalent number/length of these healthcare events expected to have occurred in the absence of an injury. Expected HSU was based on the number/length of the ED, inpatient and outpatient healthcare events (for all conditions) known to have taken place during the pre-index injury period, whilst also accounting for the age of the injured cohort, any inherent trends within the datasets analysed and the length of the follow-up period relative to the pre-follow-up period. In this way excess HSU was determined separately for the ED sector (based on the number of ED attendances observed and expected), the inpatient sector (based on the number of inpatient admissions observed and expected, and the number of inpatient bed-days observed and expected) and the outpatient sector (based on the number of outpatient visits observed and expected).

It is important to note that when determining the activity levels within the inpatient sector a choice had to be made regarding whether to count the number and length of FCEs, provider spells or 'Super spells'. Given the latter represented the only option that avoided double counting inpatient events when patients moved between hospitals it was chosen as the preferred unit of inpatient activity. Hence, for the remainder of this thesis every single inpatient admission relates to a single inpatient 'Super spell'.

4.5.1.1. Length of follow-up

The maximum length of the follow-up period was two years, from 01/04/2005 to 31/03/2007; however, the actual length of this period was specific to each member of the injured cohort and varied according to their individual circumstances.

For all members of the injured cohort the follow-up period began from the end date of their index injury healthcare event (i.e. the end date of their first injury related ED attendance or inpatient admission taking place on or after 01/04/2005). The date at which the follow-up period ended varied depending on whether an injured individual was associated with a subsequent injury event requiring ED or inpatient treatment/care that was considered not to be related to the original index injury event. Determining the relationship between the index injury event and any subsequent ED/inpatient injury event was a multi-step process. Firstly, all of the injury related events (index or otherwise) identified within the ED and inpatient datasets were assigned to a type of injury grouping, according to the classifications outlined in the study by Meerding et al (2004), based on their primary injury diagnosis. Next, depending on the type of index injury sustained, a pre-specified number of days* were added to the end date of each index injury event. If a subsequent ED/inpatient injury event was then identified with a start date within this interval, whilst being assigned an alternative type of injury grouping relative to the index injury, it was considered a new, unrelated, injury, and hence the follow-up period was curtailed at the start date of this subsequent ED/inpatient injury event. In contrast, any subsequent ED/inpatient injury events taking place within the interval that were associated with the same injury type as the index injury, were considered related to the index injury and thus the follow-up period continued. Any subsequent ED/inpatient injury event occurring after the interval, however, was considered to represent a new, unrelated, injury irrespective of the type of injury incurred, meaning in these cases the follow-up period ended at the start date of the subsequent ED/inpatient injury event.

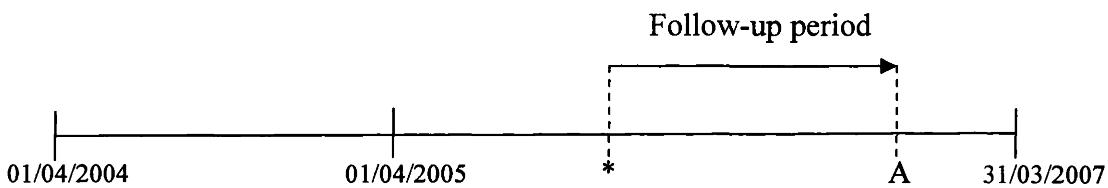
(* Research question 1 answered as part of Chapter 9 lists the specific number of days allowed between the injury related healthcare events and explains how these were determined).

For all individuals within the injured cohort not in receipt of ED or inpatient treatment/care for a new injury event the end date of the follow-up period was 31/03/2007 (i.e. the end of the investigative period). The only exception was for those individuals who died between 01/04/2005 and 31/03/2007 in which case follow-up was curtailed at the date of death.

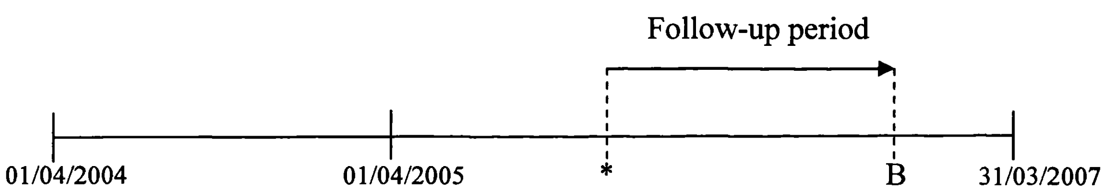
The lengths of follow-ups relating to the alternative scenarios described above are illustrated in Figure 4.1 below.

Figure 4.1: Alternative lengths of follow-up periods

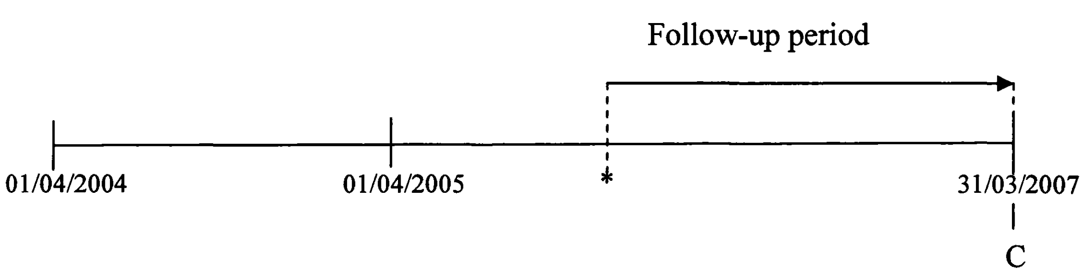
(a) Follow-up period ending due to an individual within the injured cohort being associated with a new injury.



(b) Follow-up period ending due to the death of an individual within the injured cohort.



(c) Follow-up period continuing until the end of the investigative period



As indicated above the follow-up period for the injured cohort began at the end date of the index injury healthcare event (i.e. the end date of the first injury related ED attendance or inpatient admission taking place after 01/04/2005), as signified in Figure 4.1 (a), (b) and (c) by the * symbol.

In Figure 4.1 (a) the follow-up period is terminated at point A, the start date of a subsequent injury event in receipt of medical attention within the ED/inpatient sector for an injury not considered to be related to the index injury event. The number and length of health service contacts are counted during the period spanning from * to B in Figure 4.1 (b), with point B representing the date of death for those individuals within the injured cohort not to have sustained a new injury but who have died prior to the end of the study. In Figure 4.1 (c) the post-injury period continues up to 31/03/2007 as a consequence of no individuals within the injured cohort sustaining what is considered to be a new injury and all individuals surviving beyond the end date of the investigation.

Significantly, all healthcare events (for any condition) connected with a member of the injured cohort that took place outside of their own specific follow-up period were assumed to be associated with a new, unrelated, injury meaning they were excluded from the HSU calculations. Hence, as a consequence of the way in which this follow-up period has been defined the extent of excess HSU reported as part of this model is associated only with the repercussions following a given index injury sustained by a member of the injured cohort. The number of ED attendances, inpatient admissions and outpatient contacts were counted during the period following the end of the index injury (the first injury related ED attendance or inpatient admission between 01/04/2005 and 31/03/2007) up to, but not including, the start date of a subsequent ED attendance or inpatient admission associated with an injury not considered to be related to the index injury. Hence, for each individual within the injured cohort the extent of excess HSU reported only encompassed healthcare events assumed to be directly linked to, and thus a consequence of, the index injury (excluding the healthcare event associated with the treatment of the index injury).

4.5.1.2. Estimating excess HSU

The extent of excess HSU associated with the injury cohort was estimated by finding the difference between the observed number/length of health service contacts known to have taken place amongst these individuals during the follow-up period and the expected number/length of health service contacts predicted to have taken place amongst these individuals during the follow-up period in the absence of an injury.

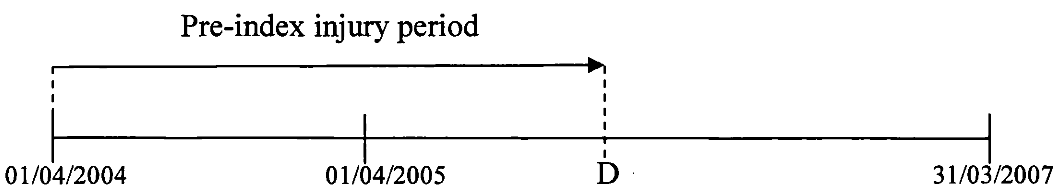
- Observed HSU post-index injury

The extent of HSU observed post-index injury was determined for the ED, inpatient and outpatient sectors separately by counting the number of ED attendances, the number/length of inpatient admissions and the number of outpatient visits, respectively, incurred by each member of the injured cohort between the start and end dates of their own individual follow-up periods. This observed HSU figure did not include the healthcare event associated with the initial treatment of the index injury. If this particular healthcare event was included then it would not be possible to fairly compare the observed and expected HSU totals given the former would always include at least one injury related ED attendance or hospital admission by virtue of the fact that every individual within the injured cohort must have attended an ED or been admitted to hospital due to injury at least once in order to be included within the study.

- Expected HSU post-index injury

In order to determine the extent of HSU expected to have occurred within the ED, inpatient and outpatient sectors over the course of the follow-up period in the absence of an injury it was first necessary to determine the extent of HSU that did actually occur within these sectors during the pre-index injury period. For each member of the injured cohort the pre-index injury period spanned from 01/04/2004 up to but not including the date of the first ED attendance or inpatient admission associated with the treatment of the index injury, as indicated by point D in Figure 4.2 below.

Figure 4.2: Length of pre-index injury period



Hence, pre-index injury HSU was found by counting the number of ED attendances, the number/length of inpatient admissions, and the number of outpatient contacts that took place during the pre-index injury period amongst the injured cohort. To then infer the number/length of health service contacts associated with these individuals expected to have taken place within the ED, inpatient and outpatient sectors throughout the post-index injury period, the pre-index injury figures per individual were multiplied by the specific length of their follow-up period relative to the length of their pre-index injury period. The resulting number/length of health service contacts predicted to have taken place in the post-index injury period were then adjusted to account for the older age of the injured individuals during the post-index injury period and any apparent inflationary/deflationary activity trends in the healthcare datasets appraised during the periods of interest. The formula for determining the expected level of HSU during the post-index injury period is presented below.

$$\text{Post-index injury expected count} = \text{Pre-index injury observed count} \times \frac{\text{Length of post-index injury period}}{\text{Length of pre-index injury period}} \times Y \times Z$$

where Y = age adjustment rate; and Z = dataset trend adjustment rate.

The age adjustment rate was determined separately for each unit of healthcare activity (i.e. ED attendances, inpatient admissions, inpatient bed-days and outpatient visits). Initially the number of healthcare events (for any condition) taking place between 01/04/2005 and 31/03/2007 at each single year of age was identified. The percentage change in the number of each unit of healthcare activity from one age to the next was then determined, with this figure subsequently transformed into a rate ([percent change/100] + 1).

Tables A2.1 – A2.4 in Appendix 2 show the age adjustment rate for each age based on the percentage change in the number of ED attendances, inpatient admissions/bed-days and outpatient visits from one age to the next. It is apparent from Table A2.1 that as an individual increases in age from 10 to 11 the number of ED attendances increase from 1,906 to 2,065, representing a rise of 8%. Hence, based on these figures if an individual aged 10 within the injured cohort was observed as having, for example, 2 ED attendances during the pre-index injury year he/she could be expected to have 2.17 ED attendances (2 x a rate of 1.083) during the post-index injury year, with this increase of 0.17 the result of the individual being a single year older. Age can have an impact on healthcare need due, for example, to changing philosophies towards risk or an increased/a reduced capacity to respond to medical care.

To infer the size of the dataset trend adjustment rate the number of ED attendances, the number and length of inpatient admissions and the number of outpatient visits (for any condition) that were recorded within their respective healthcare datasets during the pre-and post-index injury periods were counted, allowing the percentage change between the two periods to be calculated (Table 4.1). For the purposes of calculating the dataset trend adjustment rate the pre-index injury period spanned from 01/04/2004 to 31/03/2005, with the post-index injury period ranging from 01/04/2005 to 31/03/2007. Given the latter covers two years the number/length of the healthcare events reported for the post-index injury period represented an average figure. For example, in the case of the number of ED attendances, 65,539 were recorded during 01/04/2005 - 31/03/2006, whilst 70,100 were recorded during 01/04/2006 - 31/03/2007, resulting in an average figure of 67,820 ([65,539 + 67,820]/2). As in the case of the age adjustment rate each percentage change figure was then transformed into a rate ([percent change/100] + 1).

Table 4.1: Calculation of the dataset trend adjustment rate based on the percentage change in the number/length of healthcare events recorded within each healthcare dataset during the pre-and post-index injury periods.

Health sector	Pre-index injury period	Post-index injury period	% change	Z
ED	65,504 attendances	67,820 attendances	3.5% increase	1.035
Inpatient	835,658 admissions	856,149 admissions	2.5% increase	1.025
Inpatient	4,192,650 bed days	4,124,287 bed days	1.6% decrease	0.984
Outpatients	3,176,990 visits	3,514,498 visits	10.6% increase	1.106

Table 4.1 above signifies that compared to the total number of ED attendances recorded during the pre-index injury period 3.5% more were observed during the post-index injury period. In order to account for this apparent tendency for the frequency of attendances within the ED dataset to rise throughout the course of the investigative period the expected ED count, based on the number of ED attendances observed pre-index injury multiplied by the length of the post-index injury period relative to the length of the pre-index injury period, was additionally multiplied by 1.035 ([3.5/100] + 1). In contrast, within the whole inpatient dataset 68,363 fewer bed days were recorded during the post-index injury period compared to the pre-index injury period, equating to a drop of 1.6%. Hence, the expected inpatient bed day calculation included a multiplication factor of 0.984 ([-1.6/100] + 1) to reflect a deflationary trend evident within the inpatient dataset in relation to the number of bed days taking place. The inflationary/deflationary trends inherent within the healthcare datasets analysed as part of this study may be due to external factors, such as changes in health insurance status for example, which may encourage/discourage healthcare seeking behaviour.

- Excess HSU post-index injury

Due to excess HSU being determined by finding the difference between the number and length of healthcare contacts observed and expected during the post-index injury period for the same individual, it followed that the injured cohort under investigation as part of this excess HSU model acted as their own controls (like in the study by Davis et al (2007)), assuming the gender, place of residence and co-morbidities of each injured individual remained constant through the investigative period. Hence, with the contrasting lengths of the pre- and post-index injury periods, the age of the injured individual and the inflationary/deflationary activity trend inherent within each healthcare sector all accounted for as part of the expected HSU figure, it was then assumed that the final excess HSU total was solely due to the occurrence of the index injury.

It is important to note that whether this final assumption is true depends on the injured cohort reverting to type and continuing to partake in the same lifestyle choices and suffer from the same type of co-morbidities during the post-index injury period that were a feature of their own respective pre-index injury periods. For instance, if injured subjects have unusually high levels of morbidity or risk (for example through smoking or drinking) during the pre-index injury period, resulting in unusually high HSU levels, then it follows that their expected levels of post-index injury HSU will also be unusually high. Provided these injured subjects though continue to be associated with unusually high levels of morbidity or risk during the post-index injury period then it follows that their observed levels of post-index injury HSU will also be unusually high. In this instance therefore no impact on the estimated excess levels of HSU will result. However, if the co-morbidities or risk behaviours of the injured cohort do not continue through to the post-index injury period then it follows that the estimated excess levels of HSU would be reduced, given the actual observed levels of HSU would not be as high as originally predicted (this point is recognised as a limitation of this study in section 10.4 of Chapter 10).

4.5.2. Determining the extent of excess direct medical costs incurred by the ED, inpatient and outpatient sectors during the follow-up period

4.5.2.1. Choosing the appropriate cost methodology

As discussed in section 1.4.2 of Chapter 1 there are several costing methodologies that have to be considered when deciding on the means of determining the cost of injury.

- Prevalence versus incidence approach

It was decided to base the direct medical cost estimations within this study on the incidence of healthcare events taking place during the investigative period. One major reason for this is due to the incidence based approach focusing on the actual costs of healthcare contacts at a specific patient/index injury level, which are then aggregated together to arrive at the total healthcare cost associated with each patient grouping of interest (Goodchild, Sanderson and Nana 2002). Hence, one problem with the prevalence method of measuring costs, identified by Goodchild, Sanderson and Nana (2002), concerns its ability to only provide estimates of average as opposed to marginal costs. Moreover, the cost results derived following the undertaking of the prevalence approach tend to be confined to a given fixed period, whereas the costs estimated as part of a study focusing on the incidence of a condition encompass "the expected real costs and economic losses for injuries sustained in a given year, calculated to the end point of recovery or death from the injury." (Potter-Forbes 2002, p.73).

A further reason for adopting the incidence approach as opposed to the prevalence alternative concerns the fact that it additionally means that this study will comply with the recent changes in the costing methodology adhered to within the NHS, which has seen a greater emphasis on 'Patient-level information and costing systems' (PLICS). According to the Department of Health (2009)

> Patient-level costing is defined by the ability to measure the resources consumed by individual patients. Resources for inpatients should be measurable for each day or part day from the time of entry and admission to the hospital until the time of discharge. For outpatients and non-admitted A&E attendances, the consumption of resources will be on an occasion of service basis.

It is hoped that a movement towards patient-level costing will allow a better understanding of costs, with the focus being on actual patients as opposed to general averages, which is in keeping with the mandate of this study.

- <u>'Top-down' versus 'bottom-up' approach</u>

The ability to access and scrutinize in detail datasets that encompassed a wealth of patient level data meant that it was possible to adopt the 'bottom up' approach as the means of calculating the direct medical costs reported on in this study. In being able to link the healthcare datasets of interest together via the use of anonymous patient level identifiers it proved possible for the patient journey across several healthcare providers to be approximated, providing knowledge of each healthcare contact taking place and allowing the total cost of treatment/care attributable to injured individuals over a given period of time to be estimated.

- <u>Cost of injury components</u>

Given that the primary aim of this study was to specifically assess the direct medical costs of injury incurred by the healthcare sector, the additional direct economic repercussions of injuries, together with the indirect and intangible type costs, did not feature within the cost of injury calculations. Consequently, the direct incident costs that may arise following injury due to physical property damages to assets, such as vehicles, buildings and equipment, were not investigated. Neither were the direct non-medical costs incurred outside of the healthcare system, like spending on home adaptations and vocational/educational rehabilitation. Moreover, given this study focuses on the extent to which injury imposes costs on the healthcare sector, personal medical cost to the injured individual, who may have to pay for some/all of their own treatment or purchase private medical insurance to cover themselves in the event of an injurious event, were not taken into account.

In addition, indirect costs associated with injury, such as the potentially large financial burden that may arise for a given individual, family or household due to forgone earnings, and for wider society as a consequence of lost productivity resulting from the inability of an injured party to fulfil their normal work responsibilities, were excluded from this study. Furthermore, due to the inherent difficulties involved in its inference, the national economic value of informal, unpaid, care provided by family and friends to injured individuals who are seriously disabled following injury was additionally not taken into account. Neither was any expenditure related to the intangible cost of injury, like pain and suffering.

Instead, the cost of injury results presented in this study were confined to the direct medical costs incurred specifically by the healthcare sector following the treatment and ongoing care provided to injured individuals. The expenditures incorporated into the cost calculations included both variable costs, such as medication and operational procedure expenses, as well as fixed costs, like food and overhead expenses. (The implications of excluding other types of injury related costs from the investigation are discussed in further detail in section 10.4 of Chapter 10).

4.5.2.2. Estimating excess direct medical costs

The excess direct medical costs reported as part of this study were estimated by finding the difference between the observed direct medical costs known to have resulted from the index injuries sustained by the injured cohort during the follow-up period and the expected direct medical costs predicted to have arisen in the absence of an injury being sustained by the injured cohort during the follow-up period.

- Observed direct medical costs post-index injury

The direct medical costs observed post-index injury were estimated separately for the ED, inpatient and outpatient sectors by translating the number of ED attendances, the number/length of inpatient admissions and the number of outpatient contacts known to have taken place amongst the injured cohort during the follow-up period into monetary terms (section 4.5.2.3 provides a description of the unit costs used in this translation process). As in the case of the HSU calculations, the length of the follow-up period varied for each member of the injured cohort depending on their individual circumstances (as described in section 4.5.1.1). Furthermore, the observed direct medical costs figure calculated did not include the treatment costs of the healthcare event associated with the initial treatment of the index injury. This healthcare expenditure was omitted given its inclusion would not allow a fair comparison between the observed and expected direct medical cost levels on the basis that the former would always include the treatment costs of either an injury related ED attendance or a hospital admission. This is due to the fact that each member of the injured cohort must have been in receipt of such treatment in order to be included in the study.

- Expected direct medical costs post-index injury

In order to determine the extent of the direct medical costs predicted to have arisen during the post-index injury period in the absence of an injury being sustained by the injured cohort it was first necessary to estimate the direct medical costs found to be associated with these individuals during the pre-index injury period. This was achieved by translating the number of ED attendances, the number/length of inpatient admissions and the number of outpatient contacts known to have taken place amongst the injured cohort prior to the occurrence of their index injury into monetary terms (section 4.5.2.3 provides a description of the unit costs used in this translation process). To then estimate the direct medical costs expected to have arisen throughout the post-index injury period, the pre-index injury direct medical costs associated with each member of the injured cohort were multiplied by the specific length of their follow-up period relative to the length of their pre-index injury period. The resulting direct medical costs of health service contacts predicted to have taken place in the post-index injury period were then adjusted to account for the older age of the injured individuals during the post-index injury period and any apparent inflationary/deflationary expenditure trends in the healthcare datasets appraised during the periods of interest. The formula for determining the expected direct medical costs during the post-index injury period is presented below.

$$\text{Post-index injury expected direct medical costs} = \text{Pre-index injury observed direct medical costs} \times \frac{\text{Length of post-index injury period}}{\text{Length of pre-index injury period}} \times Y \times Z$$

where Y = age adjustment rate; and Z = dataset trend adjustment rate.

Both the age and dataset trend adjustment rates were determined in the same way as described in section 4.5.1.2. of this chapter when calculating the levels of HSU expected during the post-index injury period, but instead of counting the number of ED attendances, inpatient admissions/bed-days and outpatient visits at each age and across the pre- and post-index injury periods, the direct medical cost of the ED, inpatient and outpatient healthcare events were inferred.

Tables A2.5 – A2.7 in Appendix 2 show the age adjustment factor for each age based on the percentage change in the direct medical cost of ED attendances, inpatient admissions and outpatient visits (for any condition) from one age to the next.

Table 4.2 below shows the overall direct medical costs incurred within the ED, inpatient and outpatient sectors (for any condition) during the pre- and post-index injury periods.

Table 4.2: Calculation of the dataset trend adjustment factor based on the percentage change in the direct medical cost of healthcare events recorded within each healthcare dataset during the pre-and post-index injury periods.

Health sector	Pre-index injury period	Post-index injury period	% change	Z
ED	£6,577,257	£6,809,756	3.5% increase	1.035
Inpatient	£1,874,593,509	£1,904,216,872	1.6% increase	1.016
Outpatients	£401,837,274	£442,875,648	10.2% increase	1.102

It is apparent from Table 4.2 that there is an inflationary trend in the healthcare expenditures observed when moving from the pre-index injury period to the post-index injury period. Potential explanations for this occurrence include an increasing demand for healthcare over the time intervals of interest and/or an increase in the unit costs of the healthcare resources consumed.

- Excess direct medical costs post-index injury

With the extent of excess direct medical costs determined by comparing the observed and expected costs for the same injured individual over the post-index injury period it proved possible for the injury cohort to act as their own control group (like in the study by Davis et al (2007)). Consequently, based on the assumption the gender, place of residence and co-morbidities of each injured individual remained constant through the investigative period, together with the contrasting lengths of the pre- and post-index injury periods, the age of the injured individual and the inflationary/deflationary expenditure trend inherent within each healthcare sector all being accounted for as part of the expected direct medical cost figure, the final excess direct medical cost total could be attributed solely to the occurrence of the index injury. Again whether this final assumption is true depends on the pattern of healthcare usage associated with the injured cohort during the pre-index injury period continuing through to the post-index injury period, as discussed previously in this chapter.

4.5.2.3. Unit costs

The unit costs per component of health service activity used to estimate the excess direct medical costs were acquired from the 2006/2007 Trust Financial Return 2 (TFR2) accounts, published annually by the Welsh NHS (Financial Information Strategy Programme 2007). Generated by each individual healthcare Trust in Wales the TFR2 accounts encompass expenditures relating specifically to ED attendances, inpatient admissions, outpatient follow-up, GP visits and community service provision. In this way they encompass all of the (direct medical) resources consumed during the treatment/care/rehabilitation of patients in receipt of medical attention within the healthcare sector. Furthermore, the costs reported within the TFR2 accounts are fully absorbed costs meaning they include both the costs related to the actual healthcare treatment provided, such as medication and operational procedure expenses, as well as the ongoing running costs so often indirectly associated with healthcare provision, like food and overhead expenses. Unit costs applicable to the 2006/2007 financial year were used given this was the most recent financial year within the investigative period (01/04/2004 – 31/03/2007).

A single unit cost of £100.41 was applied to each ED attendance, with this figure considered to reflect the cost of a new ED presentation on average, as determined by dividing the total expenditure associated with patients using ED services in 2006/2007 by the number of new ED presentations taking place during this period, which according to the 2006/2007 TFR2 accounts equated to £100,328,187 and 999,187 presentations, respectively (£100,328,187 / 999,187 = £100.41).

To estimate the cost of a given inpatient admission a 3-step process was adhered to. Firstly, each FCE of care comprising an inpatient admission was assigned a unit cost from the TFR2 accounts based on the main specialty code of treatment associated with this FCE. The unit cost was then multiplied by the duration of the FCE, thereby allowing the total cost of each FCE to be inferred. Finally, the total cost of all FCEs comprising a given inpatient admission were summed together so as to estimate the overall cost of the inpatient admission. For instance, consider the case where a particular inpatient admission is made up of two FCEs. One of the FCEs, spanning 5 days, has been assigned an 'Orthopaedics' specialty treatment code, whilst for the other FCE with a duration of only 2 days a 'Paediatrics' specialty treatment code is present. Based on the 2006/07 TFR2 accounts the 'Orthopaedics' FCE should be attributed a unit cost per patient day of £496.11, meaning the total cost of this FCE is £2,480.55, since it lasts for 5 days (£496.11 x 5 = £2,480.55). With regards to the 'Paediatrics' FCE the total cost is £1,157.00, as a consequence of it lasting for 2 days and having a unit cost of £578.50 (£578.50 x 2 = £1,157.00). Thus, for this particular inpatient admission the overall direct medical cost is equal to £3,637.55, that is the sum of the total costs applicable to the 'Orthopaedics' FCE and the 'Paediatrics' FCE (£2,480.55 + £1,157.00 = £3,637.55). A special case of the above arises when the duration of a given FCE is 0. In this instance, based on the above calculations the total cost of an FCE will also be 0 irrespective of the main specialty code of treatment that is applicable. However, this cannot be correct given the patient to which this FCE applies has received some form of treatment and hence has imposed a cost on the inpatient sector. Consequently, in cases where an FCE was found to be associated with a duration of 0 days, the equivalent day case unit cost applicable to the specialty associated with that FCE was used, as opposed to the unit cost of a patient day. Hence, in the earlier example if the 'Paediatrics' FCE was associated with a duration of 0 days the unit cost applicable would be £824.49 and not £578.50.

Similar to the direct medical cost of an inpatient admission, the cost of each of the outpatient contacts was estimated by assigning a unit cost from the TFR2 accounts based on the main specialty code of treatment associated with the specific outpatient contact. In the case of an outpatient contact under the speciality of 'Rehabilitation medicine', therefore, a unit cost per attendance of £112.78 would be applicable.

(A full list of the healthcare resource unit costs by specialty used within the final direct medical cost calculations can be viewed in Appendix 3).

It is important to note that there tends to be a wide variation in the unit costs assigned to the healthcare resources that are directly consumed during the treatment of most medical conditions, including injuries. This is largely due to the operation of alternative healthcare systems, which can vary both between and within countries. The lack of consistently applied unit costs in the UK, for instance, has meant that generic monetary valuations have had to be utilised as part of this study which, whilst accounting for the variation in costs applied to the healthcare resources consumed in Wales, represents merely an average of the resource costs borne over a certain period and as such may fail to accurately reflect actual resource utilisation at an individual episode level. Consequently, this potential lack of precision in the unit costs adopted during this investigation must be considered when appraising the eventual findings, especially if attempts are made to generalise the cost results with similar studies conducted elsewhere in the UK and/or other countries worldwide.

Despite the above, the TFR2 accounts are validated annually during the completion of the Welsh Benchmarking Summary (WBS). The WBS compares the activity of an organisation at an all Wales average cost with the average cost calculated by that organisation. This process allows any anomalies in the accounts to be identified, discussed and resolved. Hence, the costing methodologies used are very robust. The TFR2 accounts, however, do not represent the only method for allocating unit costs to healthcare activity. Very often Health Resource Group (HRG) costs are used. In contrast to the TFR2 accounts, whereby unit costs are applied at a specialty level, HRG costs are assigned at a diagnosis level. Both means of attributing costs to healthcare activity are accepted methods within health economics but due to the unavailability of HRG codes within the healthcare datasets appraised at the time of analysis the TFR2 accounts option represented the only viable alternative. Additional research is required in order to determine whether the final direct medical cost results per index injury vary depending on the type of unit costs used.

4.6. Chapter summary

A detailed methodological overview of how this investigation was conducted has been provided within this chapter. This study is based on a longitudinal design, encompassing the scrutiny of multiple, large scale, computerised health related and population based registries. The data sources utilised as part of the study, including ED, inpatient, outpatient and GP records, have been described and it has been shown how these can be linked together through the presence of anonymous patient identifiers. The study population, incorporating all residents of Swansea, has been defined, as has the composition of the injured and non-injured cohorts. The two primary outcome measures apply to the injured cohort within the study population and involve estimating the extent of excess HSU and direct medical costs resulting from an index injury. To achieve this a model has been developed aimed at estimating excess HSU and direct medical costs through finding the difference between the number/length/costs of the healthcare events observed during the follow-up period and the number/length/costs of the healthcare events expected to have taken place over this timeframe in the absence of an injury. The direct medical costs have been calculated on the basis of an incidence, bottom-up, approach incorporating only the unit costs of the healthcare resources consumed during the treatment/care/rehabilitation of each index injury.

Chapter 5 – Results I – Study population/index injury characteristics

5.1. Introduction

This chapter defines the injured cohort of individuals in terms of their main social demographic and pre-index injury health status characteristics, and additionally compares these findings with those applicable to a non-injured comparison group of individuals drawn from the same study population. This latter process was undertaken as a means to determine whether the injured cohort upon whom the excess HSU and direct medical cost results are based is representative of the study population as a whole. Also the types of index injury sustained by the injured cohort will be described in this chapter.

5.2. Classification of results

The results presented as part of this chapter were stratified into several different classifications based on the main social demographic and pre-index injury health status characteristics of the study population (i.e. the injury cohort and the non-injury comparison group), and the type of index injury incurred.

5.2.1. Classification of social demographics and pre-index injury health status

The social demographic and pre-index injury health status characteristics of the injured cohort and the non-injured comparison group were classified as follows:

- Age

The mean and median ages of the injured cohort were calculated as at the date of their index injury, with the mean and median ages of the individuals included within the non-injured comparison group calculated as at 01/04/2005.

- Gender

The gender of the injured cohort and the non-injured comparison group, in terms of the number of males and females, was identified at the date of each index injury and at the fixed date of 01/04/2005, respectively.

- Socio-economic status

The socio-economic status of the study population was described in terms of Townsend deprivation scores (Townsend, Phillimore and Beattie 1988). Specifically, Townsend deprivation quintiles based on unadjusted 2001 Census data standardised for Wales were used to categorise the injured cohort into distinct groupings, ranging from the least deprived quintile to the most deprived quintile. The quintiles were assigned to each Lower Super Output Area (LSOA), a geographical area classification derived by the Office for National Statistics (2004), of residence associated with a member of the injured cohort as at the date of their index injury.

The same Townsend deprivation quintiles were also used to determine the socio-economic status of the non-injured comparison group, based on their LSOA of residence at 01/04/2005.

- Pre-index injury HSU

Both the injured cohort and the non-injured comparison group were stratified into four groups: individuals associated with no healthcare contact (for any condition) in the pre-index injury period; individuals associated with one healthcare contact (for any condition) in the pre-index injury period; individuals associated with between two and four healthcare contacts (for any condition) in the pre-index injury period; individuals associated with five or more healthcare contacts (for any condition) in the pre-index injury period. For ease of comparison the pre-index injury period for each member of the injured cohort and the non-injured comparison group spanned from 01/04/2004 up to 31/03/2005, with healthcare contacts searched for within the ED, hospital and outpatient datasets.

- Co-morbidities

The presence of co-morbidities associated with the injured cohort and the non-injured comparison group were identified by searching for any mention of the co-morbidity within the GP and inpatient datasets during the pre-index injury period, which again for comparison purposes spanned from 01/04/2004 up to 31/03/2005 for all members of the study population. The presence of the following Charlson index co-morbidities (Charlson et al. 1987) were searched for: Myocardial infarction; Congestive heart failure; Peripheral vascular disease; Cerebrovascular disease; Chronic pulmonary disease; Diabetes; Dementia; Rheumatic disease; Peptic ulcer disease; Mild liver disease; Hemiplegia or paraplegia; Renal disease; Any malignancy (including lymphoma and leukaemia, except malignant neoplasm of the skin); Moderate or severe liver disease; Metastatic solid tumor; AIDS/HIV. The range of ICD-10-CM codes used to identify the presence of each co-morbidity within the inpatient dataset was based on the adaptations to the Charlson index provided by Quan et al. (2005). In the case of the Read codes used to identify the presence of the co-morbidities within the GP dataset no pre-existing adaptation to the Charlson index could be located at the time of analysis meaning a list of applicable Read codes had to be devised specifically for this study. More recently a Read code adaptation to the Charlson index has been created by Khan et al. (2010). Additional research is necessary in order to compare the range of Read codes used to identify each co-morbidity utilised as part of this study with the range used by Khan et al.

(Table A4 in Appendix 4 lists the ICD-10-CM and Read version 2 codes used to identify the presence of the co-morbidities within the hospital and GP datasets respectively).

- Distance to ED

Given the large size of the study population it was not possible to obtain self-reported travel distances to the nearest ED and hence the use of straight line distances and geographical information system (GIS) generated distances represented the only viable alternatives. Increasingly studies are reporting estimates of car travel times to health services through the use of GIS network analysis packages (Haynes et al. 2006). Although these have the potential to provide a more accurate representation of real travel times compared to the estimates provided by straight line distances, there is currently little evidence to suggest that a major difference exists between the two methods when analysing the variation in distances between two location points (Haynes et al. 2006). Given the above, straight line distances were considered appropriate for this investigation.

For each member of the injured cohort straight line distances were calculated from the centroid of the LSOA of residence as at the date their index injury to the centroid of the LSOA in which the ED at Morriston Hospital is located. The following four distance ranges were used: 0 – 4,999 metres, 5,000 – 9,999 metres, 10,000 – 14,999 metres and 15,000+ metres. These distance ranges were also used for individuals included within the non-injured comparison group, with the straight line distances in these cases calculated from the centroid of the LSOA of residence as at the date of 01/04/2005 to the centroid of the LSOA in which the ED at Morriston Hospital is located.

5.2.2. Classification of index injury characteristics

The index injuries sustained by individuals within the injured cohort were stratified in terms of the type of injury sustained and the external cause of the injury sustained.

To determine the type of index injury sustained thirteen different groupings were used based on the injury categories created as part of the study by Meerding et al (2004), including ‘Skull-brain injury’, ‘Facial fracture, eye injury’, ‘Spine, vertebrae’, ‘Internal organ injury’, ‘Upper extremity fracture’, ‘Upper extremity, other injury’, 'Hip fracture', 'Lower extremity fracture', 'Lower extremity, other injury', 'Superficial injury, open wounds', 'Burns', 'Poisonings' and 'Other injury'.

(A full list of the ICD-10-CM and Morriston ED diagnosis/anatomical area codes used to classify each index injury into one of the Meerding categories mentioned above can be found in Tables A5.1 and A5.2, respectively, in Appendix 5).

With regards to the external cause associated with each index injury the actual categories presented varied depending on whether the index injury was first treated within the ED or inpatient sector (i.e. whether the index healthcare event involved ED or inpatient treatment). Initially the aim was to report the external cause in terms of the mechanism of injury (i.e. fall, struck by/against, etc), however, although this proved possible in the case of index injuries dealt with first as an inpatient, the ED dataset incorporated within the study did not include this type of information. Hence, for index injuries with their treatment starting at an ED the external cause of injury was described in terms of the place of occurrence (i.e. home, work, etc). This alternative means of reporting the external cause of injury was additionally apparent from the studies appraised when conducting Stage 1 of the literature review undertaken as part of Chapter 2. For certain studies (Schuster et al. 1995; Mathers and Penm 1999; Dueck, Poenaru and Pichora 2001; Chandler and Berger 2002; Corso et al. 2006; Curtis et al. 2009) the external cause of injury was reported in terms of the mechanism of the injury sustained, whilst for others (Lindqvist 2002; Meerding, Mulder and van Beeck 2006) the external cause findings were presented in relation to the place of occurrence of the injury.

5.3. Analytic methods

To determine whether there were any statistical differences between the injured cohort of individuals and the non-injured comparison group, in terms of their social demographic and pre-index injury health status characteristics, independent sample t tests (for continuous variables) and chi-square tests (for categorical variables) were performed at the 95% confidence level.

5.4. Results

5.4.1. Social demographic characteristics and pre-index injury health status of injured cohort and non-injured comparison group

The following table shows the social demographic characteristics and the pre-index injury health status specific to the injured cohort and the non-injured comparison group.

Table 5.1: Social demographics/pre-index injury health status stratified by injured cohort and non-injured comparison group

Social demographics/pre-index injury health status	Injured cohort (n = 30,387)	Non-injured comparison group (n = 165,742)	p-value
Age			
Median	25	44	0.000
Mean	32	43	
Gender	**n (%)**	**n (%)**	
Male	16,637 (55)	81,395 (49)	0.000
Female	13,750 (45)	84,347 (51)	
Socio-economic status*	**n (%)**	**n (%)**	
Least deprived	6,283 (21)	44,049 (27)	0.000
Next least deprived	5,310 (18)	32,098 (19)	
Middle	4,699 (16)	23,819 (14)	
Next most deprived	4,499 (15)	22,415 (14)	
Most deprived	9,588 (32)	43,299 (26)	
Pre-injury HSU	**n (%)**	**n (%)**	
0	14,965 (49)	116,007 (70)	0.000
1	5,353 (18)	17,271 (10)	
2-4	6,454 (21)	21,303 (13)	
5+	3,615 (12)	11,161 (7)	
Co-morbidities	**n (%)**	**n (%)**	
None	28,816 (95)	160,163 (97)	0.000
1 or more	1,571 (5)	5,579 (3)	
Distance from ED*	**n (%)**	**n (%)**	
0 – 4,999 m	11,290 (37)	45,757 (28)	0.000
5,000 – 9,999 m	15,386 (51)	88,746 (54)	
10,000 – 14,999 m	3,276 (11)	26,980 (16)	
15,000+ m	427 (1)	4,197 (3)	

* 8 individuals within the injured cohort and 62 individuals within the non-injury comparison group were not recorded with a resident LSOA code meaning the socio-economic status and distance from ED characteristics could not be determined for these individuals.

Out of the 196,129 individuals that comprised the initial study population 30,387 (16%) received medical treatment for an injury within the ED and/or inpatient sector during the period 01/04/2005 to 31/03/2007, with these individuals forming the injured cohort. As Table 5.1 indicates, given an independent samples t test p-value of below 0.05 there is a statistically significant difference between the injured cohort and the non-injured comparison group of individuals within the study population in terms of age distribution. The former subset of individuals tend to be younger on average with median and mean ages of 25 and 32, respectively, compared to 44 and 43 applicable to the non-injured comparison group. With regards to the gender distribution, the non-injured comparison group is evenly split between males (49%) and females (51%), whilst there is also a relatively even spread in terms of gender within the injured cohort, with this subset of individuals consisting of slightly more males (55%) than females (45%). However, when the injured cohort and non-injured comparison group are compared using a chi-square test the gender distribution within the injured cohort is significantly different from the distribution evident amongst the non-injured comparison group (p-value < 0.05), in terms of the former being composed of more males.

Table 5.1 shows that amongst non-injured individuals the number of residents within the most and least deprived areas of the study setting is more or less equal (26% and 27%, respectively). In contrast, the injured cohort of individuals are concentrated more in the deprived range, with 32% resident in areas considered as being among the most deprived socioeconomic quintile compared to 21% resident in the least deprived areas. This difference is also statistically significant at the 95% confidence level (p-value < 0.05) indicating an increased level of deprivation within the injured cohort of individuals that comprise the study population.

In terms of the extent of HSU observed during the pre-index injury period both the injured cohort and the non-injured comparison group comprise mostly of individuals with no prior healthcare contacts within the ED, inpatient or outpatient sectors. However, whilst this particular category makes up 70% of the non-injured comparison group it constitutes just 49% of the injured cohort, meaning the latter subset of individuals have a greater percentage associated with 1 or more pre-injury healthcare contacts than the non-injured comparison group, with this difference being statistically significant (p-value < 0.05).

Together with determining the extent of HSU pre-index injury, the presence of any co-morbidity was also searched for during this period. The vast majority of the injured cohort and the non-injured comparison group of individuals are associated with no co-morbidity (95% and 97% respectively). Despite this similarity the distribution of individuals within the injured cohort by the presence or otherwise of a co-morbidity is significantly different in statistical terms from the distribution evident amongst the non-injured comparison group, with a higher number of the former being associated with 1 or more co-morbidities.

Finally, distance from Morriston ED was calculated for all members of the study population. Table 5.1 signifies that both the injured cohort and non-injured comparison group are dominated by individuals living between 5,000 and 9,999 metres away from Morriston ED, with this applicable to just over 50% of each subset. A slight difference is apparent however when observing the percentage contribution of the distance ranges 0 – 4,999 and 10,000 – 14,999. For the injured cohort, 37% of individuals live within the former range compared with just 28% of the non-injured comparison group of individuals. Conversely, more of the non-injured group (16%) live within 10,000 – 14,999 metres of Morriston ED than the injured cohort (11%). This indicates a higher number of the non-injured comparison group live further away from their nearest ED compared to members of the injured cohort, with this difference statistically significant based on a chi-square test p-value of below 0.05.

Since statistically significant differences are observed between the injury cohort and the non-injury comparison group, in terms of age, gender, socio-economic status, proximity to an ED, pre-index injury HSU and presence of co-morbidities, the 30,387 injured individuals are not representative of the study population as a whole and are therefore an a priori high risk group for injury. This is to be expected given the individuals that comprise the injured cohort necessarily only include those known to have been in medical receipt for an injury related condition at an ED or within an inpatient setting, and thus they do not represent a random sample of the general population. However, the finding that statistically significant differences are observed between the injured and non-injured members of the study population is an interesting one. It would be useful to perform additional multivariate analysis on the injured group specifically in order to determine whether they continue to conform to the usual picture of those being at risk of injury. Such future analysis would assist in targeting injury prevention measures.

The finding that the injured cohort tends to comprise of more males and younger, more deprived individuals who live closer to an ED and have an increased likelihood of being associated with pre-index injury HSU and co-morbidities relative to the non-injured comparison group should not influence the size of the excess HSU and direct medical costs reported in subsequent chapters. This is due to the fact that each member of the injured cohort acts as their own control, whereby the extent to which the factors listed above impact on the utilisation/cost of healthcare observed during the post-index injury period will be accounted for as part of the utilisation/cost of healthcare expected during the post-index injury period, based on the extent to which these same factors impact on the utilisation/cost of healthcare observed during the pre-index injury period.

5.4.2. Characteristics of the index injury

In Table 5.2 the index injuries sustained by the injured cohort are described in terms of the type of injury incurred, based on the injury categories created as part of the study by Meerding et al. (2004).

Most of the 30,387 injured cohort followed-up as part of this study sustained an index injury within the 'Superficial injury, open wounds' Meerding category, with the 10,174 index injuries (34%) observed in this category over two times greater than the second most prominent category of 'Lower extremity, other injury' (n = 4,687; 15%). Index injuries assigned a primary diagnosis categorised as 'Upper extremity fracture' were also relatively frequent, with just over 4,000 occurrences (13%). Index injuries within the Meerding category of 'Internal organ injury' were least prevalent amongst the injured individuals within the study population, accounting for just 0.1% of all the index injuries sustained. Similarly, index injuries with a primary diagnosis within the categories of 'Skull-brain injury' (0.2%) and 'Burns' (0.2%) were not very frequent amongst the injured cohort.

Table 5.2: Type of index injuries sustained by the injured cohort

Type of index injury	N	%
Skull-brain injury	47	0.2
Facial fracture, eye injury	258	0.8
Spine, vertebrae	1,961	7
Internal organ injury	20	0.1
Upper extremity fracture	4,006	13
Upper extremity, other injury	2,826	9
Hip fracture	317	1
Lower extremity, fracture	2,116	7
Lower extremity, other injury	4,687	15
Superficial injury, open wounds	10,174	34
Burns	68	0.2
Poisonings	594	2
Other injury	3,327	11

Table 5.3: External cause of index injuries sustained by the injured cohort

Mechanism of injury	N	%
Motor Vehicle Traffic Crash	54	4.5
Fall	293	24.2
Burns	45	3.7
Cut/pierce	63	5.2
Struck by/against	94	7.8
Poisoning	258	21.3
Other	404	33.3
Total	1,212	100.0
Location of injury	**N**	**%**
Home	11,002	37.7
Work	2,031	7.0
RTA	1,937	6.6
Sport	76	0.3
Other	14,129	48.4
Total	29,175	100.0

In Table 5.3 above the index injuries sustained by the injured cohort are described in terms of the external cause. For those index injuries initially treated within the inpatient sector (n = 1,212) the most frequent mechanism, excluding the category of 'Other' (33%), was 'Fall' (24%) closely followed by the category of 'Poisoning' (21%). By contrast none of the index injuries incurred by the injured cohort were caused by 'Drowning', whilst just 0.1% were caused by a 'Firearm' related incident. With regards to the index injuries that first sought treatment within the ED (n = 29,175) the most commonly occurring location of index injury amongst the injured cohort, excluding the category of 'Other' (48%), was the category of 'Home' (38%), with the percentage of index injuries associated with this place of occurrence far exceeding the number of index injuries sustained at work (7%) and through a 'RTA' (7%). Interestingly only 0.3% of index injuries were sustained at a sports setting.

5.5. Chapter summary

The purpose of this chapter has been to describe the baseline characteristics of the individuals comprising the injured cohort followed up as part of this study and to compare these findings with those applicable to a non-injury comparison group drawn from the same study population. Furthermore, this chapter has provided information relating to the specific types and external causes of index injury that have been sustained by the injured cohort of individuals.

The injured cohort is primarily dominated by younger aged individuals and has slightly more males than females. Almost a third are resident within the most deprived areas of the study setting, with the vast majority living in a proximity of 9,999 metres from their nearest ED. The injured cohort largely comprises of individuals identified as not being in receipt of healthcare prior to the start of the follow-up period, whilst a very large percentage are found to not be associated with any co-morbidities. In comparison the non-injured group of individuals tend to be older and more evenly split between males and females. They too mostly live within 9,999 metres of their nearest ED but in contrast to the injured cohort are composed of equal numbers of individuals resident in the most and least deprived areas of Swansea. Both the injured cohort and the non-injured comparison group have markedly more individuals without a co-morbidity identified in their health records prior to the start of follow-up than those with a co-morbidity. Whilst the study population as a whole is dominated by individuals found to have experienced no healthcare contact during the pre-index injury period, compared with their non-injured counterparts the injured cohort comprise of more individuals with at least one visit to a healthcare provider during the pre-index injury period. Each of the differences observed between the injured cohort and the non-injured comparison group in terms of age, gender, socio-economic status, proximity to an ED, pre-index injury HSU and presence of co-morbidities are statistically significant at the 95% confidence level. This is to be expected since the 30,387 individuals that comprise the injured cohort followed-up as part of this study have necessarily sustained an injury in receipt of medical attention and thus will not be representative of the study population from which they were extracted, which necessarily have sustained no such injury during the equivalent period.

In terms of the types of index injury incurred by the injured cohort the results presented in this chapter signify that most of the index injuries can be categorised within the 'Superficial injury, open wounds' Meerding category, whereas index injuries within the 'Internal organ injury' category tend to be the least frequent. Excluding the category of 'Other' most of the index injuries treated within the inpatient sector were attributed a 'Fall' mechanism, whilst most of the index injuries in receipt of treatment at an ED occurred at home. The least frequent mechanism and location of index injury incurred by the injured cohort were 'Drowning' and 'Sport', respectively.

Chapter 6 – Results II – Extent of excess HSU

6.1. Introduction

As indicated in section 4.5 of Chapter 4 one of the outcome measures of interest within this study concerns determining the excess number/length of the healthcare events associated with the injured cohort following the occurrence of an index injury. In Chapter 4 a model devised to ascertain the extent of excess HSU taking place during the post-index injury period was described in detail and in this chapter the results acquired following the implementation of this HSU model amongst the injured cohort are presented.

6.2. Classification of results

The excess HSU results presented in section 6.4.2 of this chapter are stratified according to the age, gender and socioeconomic classification of the individuals within the injured cohort as at the date of their index injury, and the type/external cause of the index injury sustained.

6.3. Analytic methods

To determine whether the excess HSU figures reported in section 6.4.2 of this chapter were statistically different from zero, one-sample t tests were used. Based on a test value of zero, p-values were calculated and a 95% confidence interval (CI) constructed, with statistical significance, as indicated by a p-value of less than 0.05 and a 95% CI above zero, suggesting that the occurrence of an index injury always leads to a greater number/length of health service contacts being observed during the follow-up period than would ordinarily be expected in the absence of an injury. By contrast, statistical insignificance signifies that an index injury can sometimes lead to an expected HSU level per index injury which exceeds the observed level, as indicated by a negative value for the mean excess HSU count per index injury. Such occurrences can be considered as resulting in an excess HSU figure that is not statistically different from zero at the 95% CI level. (Multiple tests of statistical significance were not performed as part of this study, however, this process will be initiated as part of any further research that is undertaken).

6.4. Results

6.4.1. Observed, expected and excess HSU

The extent of excess HSU was determined by finding the difference between the observed number/length of health service contacts known to have taken place amongst the injured cohort during the follow-up period after the occurrence of an index injury, and the expected number/length of the health service contacts predicted to have taken place amongst the injured cohort during the follow-up period in the absence of an index injury.

Table 6.1 below indicates the number, and where applicable the length*, of the healthcare events observed during the post-index injury period within the ED, inpatient and outpatient healthcare sectors, excluding the treatment received in relation to the index injury. In terms of ED attendances a total of 12,026 took place amongst the injured cohort. 9,010 inpatient admissions, equating to 62,632 inpatient bed days, were found to have occurred. Finally, the number of outpatient contacts observed amongst the injured cohort during the post-index injury period totalled 50,214.

(*The length of the healthcare events were calculated in terms of the number of bed-days associated with the inpatient admissions during the post-index injury period).

Table 6.1: Count of the number of ED attendances, the number of inpatient admissions, the length of inpatient admissions and the number of outpatient contacts observed during the post-index injury follow-up period

Healthcare sector	Count
ED	12,026 attendances
Inpatient	9,010 admissions; 62,632 bed days
Outpatient	50,214 visits

In order to determine the number and length of the healthcare events expected to have occurred during the post-index injury period it was necessary to multiply the number and length of the healthcare events observed during the pre-index injury period by a pre-defined formula. As described in section 4.5.1.2 of Chapter 4 this formula was based on the length of the post-index injury follow-up period relative to the length of the pre-index injury period, whilst it also included age and dataset trend adjustment factors.

Using this formula the number/length of healthcare contacts observed during the pre-index injury period could be transformed into the number/length of healthcare events expected to have occurred during the post-index injury period (Table 6.2). For instance, if the ratio of ED attendances per member of the injured cohort remained consistent throughout the investigative period in the absence of any injury taking place then the 14,546 ED attendances actually observed pre-index injury would equate to 8,379 ED attendances being expected during the post-index injury period. The lower expected number of ED attendances, inpatient admissions/bed days and outpatient contacts evident from Table 6.2 in the most part reflects the fact that on average each member of the injured cohort was followed up during the post-index injury period for 352 fewer days compared to the length of the pre-index injury monitoring period per individual (Table 6.3).

Table 6.2: Number/length of healthcare events observed during pre-index injury period and number/length of healthcare events expected during post-index injury period

Healthcare sector	Count observed pre-index injury	Count expected post-index injury
ED	14,546 attendances	8,379 attendances
Inpatient	13,986 admissions; 65,494 bed days	6,891 admissions; 32,140 bed days
Outpatient	61,937 visits	33,499 visits

Table 6.3: Length of pre-injury observation period compared to length of post-injury follow-up period

	Pre-index injury observation	Post-index injury follow-up
Entire injury cohort	21,117,485 days	10,414,150 days
Per individual within injury cohort	695 days	343 days

Following derivation of the number/length of healthcare contacts expected to have occurred during the post-index injury period it then proved possible to determine the excess number/length of healthcare contacts within each healthcare sector (Table 6.4). This was achieved by subtracting the expected counts listed in Table 6.2 from the observed counts presented in Table 6.1, as indicated in the table below.

Table 6.4: Excess number/length of healthcare contacts based on the difference between the equivalent counts of events observed and expected during the post-index injury period

Healthcare sector	Count observed post-index injury	Count expected post-index injury	Count of excess healthcare contacts
ED	12,026 attendances	8,379 attendances	3,647 attendances
Inpatient	9,010 admissions; 62,632 bed days	6,891 admissions; 32,140 bed days	2,119 admissions; 30,492 bed days
Outpatient	50,214 visits	33,499 visits	16,715 visits

Hence, as Table 6.4 signifies based on 12,026 ED attendances being observed during the post-index injury period (following the occurrence of an index injury) but only

8,379 ED attendances being expected during the post-index injury period (in the absence of an index injury), the excess number of ED attendances attributable to the index injury equates to 3,647. Similarly, with 6,891 inpatient admissions, 32,140 inpatient bed days and 33,499 outpatient contacts being expected during the follow-up period compared to 9,010 inpatient admissions, 62,632 bed days and 50,214 outpatient contacts actually recorded as having taken place, the index injuries sustained by the injury cohort followed up as part of this investigation can be considered as having induced 2,119, 30,492 and 16,715 excess inpatient admissions, inpatient bed days and outpatient contacts, respectively.

6.4.2. Excess HSU by healthcare sector

Within this section the extent of excess HSU will be reported separately for the ED, inpatient and outpatient sectors in terms of the age and gender of the individuals within the injured cohort, and the type of index injury sustained. For each healthcare sector excess HSU will be presented at a per index injury level, revealing the number/length of excess healthcare contacts taking place on average following an index injury. This is possible since, as indicated in section 4.5.1.1. of Chapter 4, for each individual within the injured cohort the extent of excess HSU reported will only encompass healthcare events assumed to be directly linked to the index injury, with any ED attendances, inpatient admissions and outpatient contacts taking place during the post-index injury period that are not considered related to the initial index injury, based on the findings of research question 1 (section 9.1 of Chapter 9), not being counted.

6.4.2.1. ED sector

With regards to the number of excess ED attendances presented in this section, the total excess count of 3,647 attendances equates to a mean excess ED attendance per index injury of 0.12 (95% CI: 0.11, 0.13; p-value < 0.05), based on the 30,387 index injuries sustained by the injured cohort. That is, each index injury investigated as part of this study culminates in between 0.11 and 0.13 ED attendances taking place in the post-index injury period in addition to the number expected over this timeframe in the absence of an injury. Or equivalently, for every 10,000 index injuries incurred by the injured cohort between 1,100 and 1,300 excess ED attendances are estimated to take place during the follow-up period.

Table 6.5: Mean excess ED attendance count per index injury by age group, gender and socioeconomic classification

	Mean excess ED attendance count per index injury	**95% Confidence Interval**		**p-value**
		Lower limit	**Upper limit**	
Total	0.12	0.11	0.13	0.00
0 – 4	0.10	0.07	0.13	0.00
5 – 9	0.14	0.11	0.17	0.00
10 – 14	0.11	0.08	0.14	0.00
15 – 19	0.16	0.13	0.19	0.00
20 – 24	0.10	0.06	0.14	0.00
25 – 29	0.12	0.08	0.17	0.00
30 – 34	0.10	0.06	0.14	0.00
35 – 39	0.11	0.07	0.14	0.00
40 – 44	0.11	0.08	0.15	0.00
45 – 49	0.08	0.03	0.14	0.00
50 – 54	0.18	0.01	0.34	0.03
55 – 59	0.10	0.05	0.14	0.00
60 – 64	0.08	0.03	0.14	0.00
65 – 69	0.13	0.08	0.18	0.00
70 – 74	0.10	0.06	0.15	0.00
75 – 79	0.13	0.08	0.19	0.00
80 – 84	0.17	0.10	0.24	0.00
85+	0.22	0.15	0.29	0.00
Least deprived	0.10	0.08	0.12	0.00
Next least deprived	0.13	0.11	0.15	0.00
Middle deprived	0.12	0.10	0.14	0.00
Next most deprived	0.12	0.09	0.15	0.00
Most deprived	0.13	0.11	0.15	0.00
Male	0.12	0.11	0.13	0.00
0 – 4	0.12	0.07	0.17	0.00
5 – 9	0.12	0.08	0.16	0.00
10 – 14	0.13	0.09	0.17	0.00
15 – 19	0.17	0.12	0.21	0.00
20 – 24	0.10	0.05	0.14	0.00
25 – 29	0.11	0.05	0.17	0.00
30 – 34	0.10	0.04	0.15	0.00
35 – 39	0.12	0.07	0.17	0.00
40 – 44	0.12	0.07	0.17	0.00
45 – 49	**0.03**	**-0.06**	**0.11**	**0.56**
50 – 54	0.30	0.06	0.53	0.02
55 – 59	0.10	0.03	0.17	0.01
60 – 64	**0.04**	**-0.06**	**0.13**	**0.45**
65 – 69	0.10	0.02	0.18	0.02

	Mean excess ED attendance count per index injury	95% Confidence Interval		p-value
		Lower limit	Upper limit	
70 – 74	0.17	0.09	0.26	0.00
75 – 79	0.17	0.07	0.27	0.00
80 – 84	**0.16**	**-0.02**	**0.34**	**0.08**
85+	0.26	0.14	0.39	0.00
Least deprived	0.09	0.06	0.12	0.00
Next least deprived	0.12	0.09	0.15	0.00
Middle deprived	0.13	0.10	0.17	0.00
Next most deprived	0.11	0.08	0.15	0.00
Most deprived	0.13	0.11	0.16	0.00
Female	0.12	0.11	0.13	0.00
0 – 4	0.07	0.02	0.12	0.00
5 – 9	0.16	0.12	0.20	0.00
10 – 14	0.09	0.04	0.14	0.00
15 – 19	0.15	0.10	0.20	0.00
20 – 24	0.10	0.04	0.16	0.00
25 – 29	0.15	0.09	0.22	0.00
30 – 34	0.10	0.04	0.15	0.00
35 – 39	0.09	0.04	0.14	0.00
40 – 44	0.10	0.05	0.15	0.00
45 – 49	0.14	0.07	0.22	0.00
50 – 54	**0.04**	**-0.18**	**0.26**	**0.71**
55 – 59	0.10	0.04	0.15	0.00
60 – 64	0.12	0.06	0.18	0.00
65 – 69	0.15	0.09	0.21	0.00
70 – 74	0.07	0.01	0.12	0.02
75 – 79	0.12	0.06	0.18	0.00
80 – 84	0.18	0.11	0.25	0.00
85+	0.21	0.12	0.29	0.00
Least deprived	0.10	0.07	0.13	0.00
Next least deprived	0.15	0.12	0.18	0.00
Middle deprived	0.10	0.07	0.14	0.00
Next most deprived	0.13	0.09	0.16	0.00
Most deprived	0.12	0.09	0.15	0.00

Across all ages, the gender of the injured individual has no impact on the size of the mean excess ED attendance count per index injury, with this figure equating to 0.12 for both males and females. Across both genders, all 5 year age groups exhibit a statistically significant (p-value < 0.05) mean excess ED attendance count per index injury, with those aged 85+ having the highest excess of 0.22, and those aged between 45 and 49, together with those aged between 60 and 64, associated with the lowest excess ED figure of 0.08. There is no noticeable trend between the excess ED attendance count and the age of the injured individual, given high mean counts are apparent amongst the young, middle aged and older members of the injured cohort.

When stratifying by both age and gender it is apparent from Table 6.5 that the vast majority of male and female age groups are associated with a statistically significant excess number of ED attendances per index injury, with the exceptions being males aged 45 to 49 (p-value = 0.56), 60 to 64 (p-value = 0.45) and 80 to 84 (p-value = 0.08), and females aged 50 to 54 (p-value = 0.71). As was the case when considering both genders together there does not appear to be any relationship between the statistically significant excess ED attendance counts per index injury on average and the age of the male or female injured.

The lack of any pattern between the number of excess ED attendances per index injury on average and the gender/age of the injured individual indicates that on the whole gender and age are not major predictors of excess ED attendance. This suggests that the types of injury most likely to lead to ED treatment being sought are frequent amongst both gender groups and all ages, and are therefore not concentrated among males or females, or among the young, middle aged or older subgroups of the population.

Each socioeconomic category is associated with a mean excess count of ED attendances that is statistically different from zero at the 95% confidence level (p-value > 0.05). When considering all index injuries the highest mean excess ED attendance count arises following index injuries amongst individuals categorised within the 'Next least deprived' and 'Most deprived' socioeconomic groups (0.13). The lowest mean excess ED attendance count ensues when an index injury is sustained by a member of the injured cohort categorised within the 'Least deprived' grouping (0.10). Index injuries incurred by both males and females separately within this most affluent socioeconomic category also lead to the lowest and joint lowest excess ED attendance counts on average, respectively. Possible explanations for this include the least deprived members of the injured cohort having fewer co-morbidities than the more deprived individuals (Akker et al. 2000; Koster et al. 2004). Although the excess HSU model designed and developed as part of this study accounts for the presence of co-morbidities during both the pre-index and post-index injury periods, meaning that the actual HSU specifically due to the co-morbidities will have no impact on the final excess figures reported, the fact a given individual has other ailments may mean that the occurrence of the index injury leads to additional healthcare treatments being sought compared to someone with no other ailments, due to the co-morbidities making it more difficult to recover from the injury sustained (Koval et al. 1998; Lew et al. 2002). Another potential reason why excess ED costs on average are lowest following index injuries sustained by the least deprived members of the injured cohort concerns the index injuries incurred by these individuals being of less severity. Studies by Hippisley-Cox et al. (2002) and Park et al. (2009) each report findings suggesting injuries amongst the most deprived in society tend to be the most severe. More severe injuries culminate in higher healthcare expenditures due to the need for more complex treatment and an increased amount of healthcare resources being required. As part of this present investigation it was not possible to deduce the level of severity associated with the index injuries sustained meaning further research is required to determine whether varying levels of injury severity represents a viable explanation for differences in excess ED costs across the socioeconomic groups.

Focusing specifically on index injuries sustained by males, the highest mean excess ED attendance count follow index injuries amongst those in the 'Most deprived' and 'Middle' socioeconomic groups (0.13). For females those individuals categorised within the 'Next least deprived' group are associated with the highest mean excess ED attendance count per index injury (0.15).

Table 6.6: Mean excess ED attendance count per index injury by injury type and gender

	Mean excess ED attendance count per index injury	95% Confidence Interval		p-value
		Lower limit	Upper limit	
Total	0.12	0.11	0.13	0.00
Skull-brain injury	0.28	0.07	0.50	0.01
Facial fracture, eye injury	**0.10**	**-0.04**	**0.24**	**0.15**
Spine, vertebrae	0.09	0.05	0.13	0.00
Internal organ injury	**0.19**	**-0.39**	**0.78**	**0.50**
Upper extremity fracture	0.12	0.10	0.15	0.00
Upper extremity, other injury	0.11	0.08	0.15	0.00
Hip fracture	**0.06**	**-0.04**	**0.16**	**0.27**
Lower extremity, fracture	0.12	0.09	0.15	0.00
Lower extremity, other injury	0.11	0.08	0.13	0.00
Superficial injury, open wounds	0.14	0.12	0.16	0.00
Burns	**0.03**	**-0.23**	**0.29**	**0.82**
Poisonings	0.13	0.04	0.22	0.01

	Mean excess ED attendance count per index injury	95% Confidence Interval		p-value
		Lower limit	Upper limit	
Other injury	0.11	0.08	0.14	0.00
Male	0.12	0.11	0.13	0.00
Skull-brain injury	0.30	0.05	0.55	0.02
Facial fracture, eye injury	**0.11**	**-0.05**	**0.26**	**0.17**
Spine, vertebrae	0.07	0.01	0.13	0.02
Internal organ injury	**0.36**	**-0.37**	**1.08**	**0.31**
Upper extremity fracture	0.13	0.10	0.17	0.00
Upper extremity, other injury	0.11	0.05	0.17	0.00
Hip fracture	**0.09**	**-0.09**	**0.26**	**0.33**
Lower extremity, fracture	0.13	0.08	0.17	0.00
Lower extremity, other injury	0.10	0.07	0.14	0.00
Superficial injury, open wounds	0.13	0.11	0.16	0.00
Burns	**0.07**	**-0.27**	**0.42**	**0.68**
Poisonings	**0.14**	**-0.02**	**0.29**	**0.09**
Other injury	0.11	0.07	0.16	0.00
Female	0.12	0.11	0.13	0.00
Skull-brain injury	**0.18**	**-0.27**	**0.63**	**0.38**
Facial fracture, eye injury	**0.08**	**-0.21**	**0.37**	**0.56**
Spine, vertebrae	0.11	0.07	0.16	0.00
Internal organ injury	**-0.29**	**-1.53**	**0.95**	**0.55**
Upper extremity fracture	0.11	0.08	0.15	0.00
Upper extremity, other injury	0.11	0.07	0.16	0.00
Hip fracture	**0.04**	**-0.08**	**0.17**	**0.47**
Lower extremity, fracture	0.12	0.08	0.16	0.00
Lower extremity, other injury	0.11	0.08	0.15	0.00
Superficial injury, open wounds	0.14	0.11	0.17	0.00
Burns	**-0.08**	**-0.41**	**0.26**	**0.63**
Poisonings	0.12	0.01	0.24	0.03
Other injury	0.11	0.07	0.15	0.00

When considering both genders together the injury groupings of 'Skull-brain injury', 'Spine, vertebrae', 'Upper extremity fracture', 'Upper extremity, other injury', 'Lower extremity, fracture', 'Lower extremity, other injury', 'Superficial injury, open wounds', 'Poisonings' and 'Other injury' each exhibit a mean excess ED attendance count per index injury that is statistically significant ($p\text{-value} < 0.05$) at the 95% confidence level. The major reason why the injury groupings of 'Facial fracture, eye injury' (p-value = 0.15), 'Internal organ injury' (p-value = 0.50), 'Hip fracture' (p-value = 0.27) and 'Burns' (p-value = 0.82) are associated with an excess ED attendance count that is not statistically different from zero at the 95% confidence level is due to these types of injury often being admitted straight to hospital. This is especially the case for internal organ injuries and hip fractures, with these injuries largely only treated within inpatient settings (Augenstein et al. 1995; Livingston et al.

1998; Kannus et al. 1999; Cummings and Melton 2002). Amongst the types of injury exhibiting statistical significance the highest and lowest excess ED attendance counts are observed within the 'Skull-brain injury' (0.28) and 'Spine, vertebrae' (0.09) categories, respectively. The high number of excess ED attendances resulting from index injuries within the 'Skull-brain injury' category is likely to reflect the fact that injuries to the head often lead to some form of ED treatment, even for relatively minor conditions, due to the potential for these types of injury to be potentially serious and the need for them to be checked out (Stein and Ross 1992; Shackford et al. 1992; Guerrero, Thurman and Sniezek 2000). The comparatively low number of injuries requiring ED attention from within the 'Spine, vertebrae' category is again most likely a reflection of the fact that a large proportion of injuries to the spine/vertebrae area of the body will be admitted straight to hospital given the seriousness of these types of injuries (Harris et al. 1980; Timothy, Towns and Girn 2004). Injuries to the spine and vertebrae are also relatively uncommon, especially amongst children aged up to 16 (McGrory et al. 1993; Orenstein et al. 1994; Nitecki and Moir 1994; Eleraky et al. 2000).

When focusing on the male and female members of the injured cohort separately, the excess ED attendance count applicable to the injury grouping of 'Poisoning' is no longer statistically different from zero for males (p-value = 0.09), whilst this is the case for the category of 'Skull-brain injury' for females (p-value = 0.38). Of the injury groupings that exhibit a mean excess ED attendance count per index injury that is statistically different from zero, the highest excess figure is associated with the 'Skull-brain injury' category for males (0.30) and the 'Superficial injury, open wounds' category for females (0.14). This apparent difference between the genders most likely reflects the varying types of accident that lead to injuries among males and females. With males being associated with a more high risk attitude (Byrnes, Miller and Schafer 1999) they are often more likely than females to be injured in incidents like motor vehicle crashes (Turner and McClure 2003), which frequently lead to injuries to the skull and brain being sustained (Jagger et al. 1984; Sosin, Sacks and Smith 1989; Cunningham et al. 2002; Slewa-Younan et al. 2004). Hence, this represents the most likely explanation as to why index injuries within the category of 'Skull-brain injury' are associated with the highest statistically significant excess count of ED attendances amongst males, but are associated with an excess ED attendance count amongst females that on average is not statistically different from zero.

Table 6.7: Mean excess ED attendance count per index injury by external cause and gender

	Mean excess ED attendance count per index injury	**95% Confidence Interval**		**p-value**
		Lower limit	**Upper limit**	
Total	0.12	0.11	0.13	0.00
Mechanism of injury				
Motor Vehicle Traffic Crash	**-0.10**	**-0.34**	**0.13**	**0.38**
Fall	**0.07**	**-0.05**	**0.19**	**0.25**
Burns	**-0.07**	**-0.45**	**0.30**	**0.70**
Cut/pierce	**0.03**	**-0.22**	**0.29**	**0.79**
Struck by/against	**-0.08**	**-0.35**	**0.19**	**0.57**
Poisoning	**0.08**	**-0.08**	**0.24**	**0.31**
Other	**-0.08**	**-0.17**	**0.02**	**0.13**
Location of injury				
Home	0.13	0.12	0.15	0.00
Work	0.11	0.08	0.15	0.00
RTA	0.12	0.08	0.15	0.00
Sport	**0.02**	**-0.13**	**0.16**	**0.83**
Other	0.12	0.11	0.14	0.00
Male	0.12	0.11	0.13	0.00
Mechanism of injury				
Motor Vehicle Traffic Crash	**-0.06**	**-0.38**	**0.25**	**0.69**
Fall	**0.11**	**-0.02**	**0.25**	**0.10**
Burns	**-0.02**	**-0.56**	**0.52**	**0.94**
Cut/pierce	**-0.04**	**-0.33**	**0.26**	**0.81**
Struck by/against	**-0.11**	**-0.45**	**0.23**	**0.54**
Poisoning	**0.07**	**-0.23**	**0.35**	**0.66**
Other	**-0.06**	**-0.18**	**0.05**	**0.24**
Location of injury				
Home	0.12	0.09	0.15	0.00
Work	0.11	0.07	0.15	0.00
RTA	0.09	0.03	0.15	0.00
Sport	**0.07**	**-0.13**	**0.26**	**0.51**
Other	0.14	0.12	0.16	0.00
Female	0.12	0.11	0.13	0.00
Mechanism of injury				

	Mean excess ED attendance count per index injury	95% Confidence Interval		p-value
		Lower limit	Upper limit	
Motor Vehicle Traffic Crash	**-0.19**	**-0.53**	**0.16**	**0.28**
Fall	**0.02**	**-0.18**	**0.22**	**0.87**
Burns	**-0.18**	**-0.58**	**0.22**	**0.35**
Cut/pierce	**0.24**	**-0.32**	**0.79**	**0.37**
Struck by/against	**0.01**	**-0.36**	**0.39**	**0.95**
Poisoning	**0.09**	**-0.09**	**0.28**	**0.31**
Other	**-0.10**	**-0.25**	**0.08**	**0.33**
Location of injury				
Home	0.14	0.12	0.16	0.00
Work	0.12	0.05	0.20	0.00
RTA	0.14	0.10	0.19	0.00
Sport	**-0.10**	**-0.25**	**0.05**	**0.19**
Other	0.11	0.08	0.13	0.00

For both genders together, plus males and females individually, none of the mechanism of injury groupings exhibit an excess ED attendance count that is statistically different from zero at the 95% confidence level (p-value > 0.05). This finding reflects the fact that index injuries treated first at an ED could not be categorised into a mechanism of injury grouping due to this type of information not being recorded within the ED dataset analysed as part of this study, meaning only the relatively small number (n = 1,212) of index injuries initially in receipt of inpatient treatment could be stratified according to the mechanism of injury. Furthermore, given injuries requiring admission to hospital are likely to be more serious than injuries requiring only treatment at an ED, it follows that the former are also more likely to need subsequent inpatient and or outpatient medical attention during the post-index injury period than they would need subsequent medical attention provided within the ED.

In terms of the location of injury, the larger number of index injuries (n = 29,175) stratified according to this classification means that all categories are statistically significant except 'Sport' (both genders: p-value = 0.83; males: p-value = 0.51; females: p-value = 0.19). For both genders together, and males and females separately, very few index injuries were sustained at a sport related location (total n = 76; male n = 53; female n = 23) resulting in a statistically insignificant excess ED attendance count. Amongst the other location of injury categories there is no major difference in the mean excess ED attendance count per index injury. Home incidents account for the highest (0.13) and joint highest along with RTA (0.14) when considering all index injuries and those sustained by females, respectively. For males the 'Other' location of injury category is associated with the highest mean excess ED attendance count (0.14) followed closely by 'Home' (0.12) and 'Work' (0.11).

6.4.2.2. Inpatient sector

The extent of excess HSU within the inpatient sector found to be attributable to the index injury will first be presented in terms of the number of excess inpatient admissions (section 6.4.2.2.1.) and will then subsequently be reported in the context of the resulting number of excess inpatient bed-days associated with these inpatient admissions (section 6.4.2.2.2.).

6.4.2.2.1. Inpatient admissions

Given the 30,387 index injuries incurred by the injured cohort that formed part of this investigation and the 2,119 additional inpatient admissions observed after the index injury relative to that expected in the absence of any injury, it follows that each index injury sustained culminates in an excess of 0.07 (95% CI: 0.06, 0.08; p-value < 0.05) inpatient admissions arising over the post-index injury period. That is, for every 10,000 index injuries sustained by the injured cohort between 600 and 800 inpatient admissions are observed in addition to the number expected.

Table 6.8: Mean excess inpatient admission count per index injury by age group, gender and socioeconomic classification

	Mean excess inpatient admission count per index injury	**95% Confidence Interval**		**p-value**
		Lower limit	**Upper limit**	
Total	0.07	0.06	0.08	0.00
0 – 4	**0.03**	**-0.01**	**0.07**	**0.14**

	Mean excess inpatient admission count per index injury	95% Confidence Interval		p-value
		Lower limit	Upper limit	
5 – 9	**0.02**	**-0.02**	**0.05**	**0.43**
10 – 14	0.02	0.00	0.04	0.03
15 – 19	0.04	0.02	0.07	0.00
20 – 24	**0.04**	**-0.00**	**0.08**	**0.06**
25 – 29	**0.04**	**-0.01**	**0.09**	**0.09**
30 – 34	**0.04**	**-0.00**	**0.08**	**0.08**
35 – 39	0.09	0.05	0.13	0.00
40 – 44	0.05	0.00	0.10	0.04
45 – 49	**0.06**	**-0.01**	**0.13**	**0.10**
50 – 54	**0.11**	**-0.07**	**0.29**	**0.21**
55 – 59	**0.07**	**-0.01**	**0.15**	**0.10**
60 – 64	**0.06**	**-0.04**	**0.16**	**0.26**
65 – 69	0.21	0.07	0.35	0.00
70 – 74	0.23	0.14	0.32	0.00
75 – 79	0.27	0.16	0.38	0.00
80 – 84	0.26	0.17	0.36	0.00
85+	0.33	0.24	0.43	0.00
Least deprived	0.06	0.04	0.09	0.00
Next least deprived	0.06	0.03	0.08	0.00
Middle deprived	0.06	0.02	0.09	0.00
Next most deprived	0.08	0.05	0.12	0.00
Most deprived	0.08	0.06	0.11	0.00
Male	0.06	0.05	0.08	0.00
0 – 4	**0.03**	**-0.03**	**0.09**	**0.34**
5 – 9	**0.01**	**-0.06**	**0.07**	**0.79**
10 – 14	0.02	0.00	0.04	0.05
15 – 19	0.04	0.01	0.06	0.00
20 – 24	**0.03**	**-0.00**	**0.06**	**0.08**
25 – 29	0.06	0.03	0.09	0.00
30 – 34	0.06	0.02	0.10	0.00
35 – 39	0.10	0.06	0.15	0.00
40 – 44	**0.05**	**-0.02**	**0.13**	**0.15**
45 – 49	0.12	0.02	0.22	0.02
50 – 54	**0.15**	**-0.06**	**0.35**	**0.16**
55 – 59	0.09	0.01	0.16	0.02
60 – 64	**-0.03**	**-0.20**	**0.14**	**0.76**
65 – 69	**0.29**	**-0.03**	**0.60**	**0.07**
70 – 74	0.28	0.11	0.45	0.00
75 – 79	0.35	0.05	0.66	0.03
80 – 84	0.30	0.08	0.52	0.01
85+	0.39	0.14	0.64	0.00
Least deprived	0.05	0.02	0.08	0.00
Next least deprived	0.06	0.03	0.09	0.00
Middle deprived	**0.02**	**-0.03**	**0.08**	**0.39**
Next most deprived	0.09	0.04	0.13	0.00
Most deprived	0.07	0.04	0.10	0.00
Female	0.08	0.06	0.10	0.00
0 – 4	**0.03**	**-0.02**	**0.08**	**0.20**
5 – 9	**0.02**	**-0.00**	**0.05**	**0.07**
10 – 14	**0.02**	**-0.01**	**0.06**	**0.23**
15 – 19	**0.06**	**-0.00**	**0.11**	**0.06**

	Mean excess inpatient admission count per index injury	95% Confidence Interval		p-value
		Lower limit	Upper limit	
20 – 24	**0.06**	**-0.04**	**0.16**	**0.25**
25 – 29	**0.01**	**-0.11**	**0.14**	**0.84**
30 – 34	**0.00**	**-0.08**	**0.08**	**0.99**
35 – 39	0.08	0.01	0.15	0.03
40 – 44	**0.04**	**-0.01**	**0.10**	**0.09**
45 – 49	**0.00**	**-0.10**	**0.11**	**0.98**
50 – 54	**0.08**	**-0.23**	**0.38**	**0.62**
55 – 59	**0.05**	**-0.08**	**0.19**	**0.45**
60 – 64	0.13	0.02	0.24	0.02
65 – 69	0.15	0.04	0.27	0.01
70 – 74	0.21	0.09	0.32	0.00
75 – 79	0.24	0.13	0.34	0.00
80 – 84	0.25	0.15	0.35	0.00
85+	0.32	0.22	0.41	0.00
Least deprived	0.08	0.04	0.11	0.00
Next least deprived	0.05	0.01	0.09	0.02
Middle deprived	0.10	0.04	0.15	0.00
Next most deprived	0.08	0.03	0.13	0.00
Most deprived	0.09	0.06	0.13	0.00

Across all ages, females (0.08) exhibit a slightly higher mean excess inpatient admission count per index injury than males (0.06), with both excess counts being statistically different from zero at the 95% confidence level. This lack of a marked difference between males and females in terms of the number of excess inpatient admissions associated with a given index injury suggests gender is not a major predictor of subsequent admission to hospital following injury.

When considering both genders together, individuals aged 10 to 19, 35 to 44 and 65+ are associated with a statistically significant mean excess inpatient admission count per index injury. What is most evident from Table 6.8 is that the older individuals within the injured cohort (65+ years of age) have a much higher excess inpatient admission figure than the younger aged individuals, with this finding applicable irrespective of gender. For instance, males aged 65+ are associated with a mean excess inpatient admission count per index injury ranging from 0.28 to 0.39, whereas for males aged less than 65 the highest excess count is 0.15 (50 to 54 year olds). Similarly, in the case of females the excess inpatient count evident amongst those aged 65+ range from 0.15 to 0.32, whilst for females aged less than 65 the mean excess inpatient admission count per index injury tends to be below 0.10 and only rises above this figure for those aged 60 to 64 (0.13).

The increased count of excess admissions to hospital observed amongst the older members of the injured cohort reflects their reduced ability to recover fully from injury without the need to be admitted to hospital (Shabot and Johnson 1995; Horan and Little 1998). Very often a given injury that does not require any medical attention at all or alternatively can be dealt with at an ED when sustained by younger aged individuals will instead require admission to hospital and treatment as an inpatient if sustained by older members of the population, largely due to the presence of a greater number of co-morbidities and increased frailty.

Across all index injuries the mean excess count of inpatient admissions is the same for individuals categorised as amongst the 'Least deprived', 'Next least deprived' and 'Middle deprived' within the injured cohort (0.06). The socioeconomic groupings of 'Next most deprived' and 'Most deprived' exhibit the highest mean excess inpatient admissions count (0.08). These particular categories are also associated with the highest counts following index injuries sustained by males ('Next most deprived' = 0.09; 'Most deprived' = 0.07), whilst the lowest statistically significant count of excess inpatient admissions per index injury on average arise amongst males in the 'Least deprived' socioeconomic category (0.05). More deprived individuals often possess more co-morbidities than the less deprived (Akker et al. 2000; Kosler et al. 2004) and they also frequently sustain more severe injuries (Hippisley-Cox et al. 2002; Park et al. 2009), resulting in the occurrence of a given injury leading to a higher number of inpatient admissions post-index injury than would otherwise be the case. For female members of the injured cohort this pattern is not as marked but still the lowest mean count of excess inpatient admissions is associated with a socioeconomic group of less deprivation than the highest mean count of excess inpatient admissions, whereby index injuries amongst females in the 'Next least deprived' category lead to the lowest count (0.05) and index injuries amongst females in the 'Middle deprived' category lead to the highest count (0.10).

Table 6.9: Mean excess inpatient admission count per index injury by injury type and gender

	Mean excess inpatient admission count per index injury	**95% Confidence Interval**		**p-value**
		Lower limit	**Upper limit**	
Total	0.07	0.06	0.08	0.00
Skull-brain injury	0.35	0.12	0.58	0.00
Facial fracture, eye injury	**0.04**	**-0.07**	**0.16**	**0.43**
Spine, vertebrae	**0.01**	**-0.04**	**0.06**	**0.83**
Internal organ injury	**0.20**	**-0.24**	**0.64**	**0.36**
Upper extremity fracture	0.10	0.07	0.13	0.00
Upper extremity, other injury	0.04	0.01	0.08	0.02
Hip fracture	0.31	0.14	0.48	0.00
Lower extremity, fracture	0.08	0.03	0.14	0.00
Lower extremity, other injury	0.05	0.02	0.08	0.00
Superficial injury, open wounds	0.07	0.05	0.09	0.00
Burns	**0.03**	**-0.11**	**0.18**	**0.67**
Poisonings	**0.11**	**-0.00**	**0.22**	**0.06**
Other injury	0.09	0.04	0.14	0.00
Male	0.06	0.05	0.08	0.00
Skull-brain injury	0.41	0.15	0.67	0.00
Facial fracture, eye injury	**0.03**	**-0.11**	**0.17**	**0.63**
Spine, vertebrae	**0.02**	**-0.04**	**0.07**	**0.57**
Internal organ injury	**0.38**	**-0.17**	**0.93**	**0.16**
Upper extremity fracture	0.10	0.06	0.14	0.00
Upper extremity, other injury	**0.00**	**-0.05**	**0.05**	**1.00**
Hip fracture	0.38	0.06	0.69	0.02
Lower extremity, fracture	**0.08**	**-0.01**	**0.16**	**0.07**
Lower extremity, other injury	0.05	0.02	0.08	0.00
Superficial injury, open wounds	0.05	0.03	0.07	0.00
Burns	**0.03**	**-0.13**	**0.19**	**0.73**
Poisonings	**0.13**	**-0.03**	**0.30**	**0.11**
Other injury	0.09	0.01	0.17	0.04
Female	0.08	0.06	0.10	0.00
Skull-brain injury	**0.08**	**-0.49**	**0.64**	**0.76**
Facial fracture, eye injury	**0.07**	**-0.11**	**0.25**	**0.43**
Spine, vertebrae	**-0.00**	**-0.09**	**0.08**	**0.92**
Internal organ injury	**-0.36**	**-1.00**	**0.28**	**0.20**
Upper extremity fracture	0.10	0.06	0.14	0.00
Upper extremity, other injury	0.09	0.03	0.15	0.01
Hip fracture	0.28	0.08	0.48	0.01
Lower extremity, fracture	0.09	0.01	0.16	0.02
Lower extremity, other injury	**0.05**	**-0.01**	**0.10**	**0.10**
Superficial injury, open wounds	0.09	0.06	0.12	0.00
Burns	**0.04**	**-0.31**	**0.39**	**0.81**
Poisonings	**0.09**	**-0.06**	**0.24**	**0.25**
Other injury	0.10	0.04	0.15	0.00

Across the entire injured cohort 5 of the 13 injury type categories are not statistically different from zero at the 95% confidence level, including 'Facial fracture, eye injury' (p-value = 0.43), 'Spine, vertebrae' (p-value = 0.83), 'Internal organ injury' (p-value = 0.36), 'Burns' (p-value = 0.67) and 'Poisoning' (p-value = 0.06). This finding is largely due to the fact that these types of injury tend to be relatively infrequent. Hence, whilst several of the categories of injury listed above, especially 'Spine, vertebrae' and 'Internal organ injury', are likely to warrant admission to hospital for treatment (Harris et al. 1980; Augenstein et al. 1995; Livingston et al. 1998; Timothy, Towns and Girn 2004) the fact they tend to be uncommon compared to other types of injury (McGrory et al. 1993; Orenstein et al. 1994; Nitecki and Moir 1994; Eleraky et al. 2000; Krige et al. 2005; Burkitt et al. 2007; Povýsil et al. 2009) means they do not exhibit a statistically significant excess count of inpatient admissions. Of those injury groupings that do display statistical significance the highest mean excess inpatient admission count per index injury arises within the 'Skull-brain injury' category (0.35), with the lowest mean excess figure evident within the 'Upper extremity, other injury' category (0.04). The relatively high frequency of excess hospital admissions resulting from injuries within the category of 'Skull-brain injury' reflects the potential seriousness of injuries to the head that not only require treatment at an ED (as described previously in section 6.4.2.1. of this chapter) but also often warrant admission to hospital for continued observation (MacMillan, Strang and Jennett 1979; Sainsbury and Sibert 1984; af Geijerstam, Britton and Mebius 2000).

When focusing specifically on the male members of the injured cohort the injury groupings of 'Upper extremity, other injury' (p-value = 1.00) and 'Lower extremity, fracture' (p-value = 0.07) are no longer statistically different from zero. Whilst these types of injuries tend to be relatively frequent a possible explanation as to why they are not associated with an excess inpatient admission count that is statistically different from zero is that they are increasingly being treated within non-inpatient settings due to the need to free up hospital beds (Hensher et al. 1999; Bernstein et al. 2003). The highest mean excess inpatient admission figure per index injury for males continues to be exhibited within the 'Skull-brain injury' grouping (0.41). The dominance of these types of index injuries among males again reflects the high-risk activities that this gender is associated with.

For females specifically, in addition to the 5 categories not statistically significant across both genders together, the injury groupings of 'Skull-brain injury' (p-value = 0.76) and 'Lower extremity, other injury' (p-value = 0.10) each no longer exhibit an excess inpatient admission count that is statistically different from zero. In the case of the former this reflects the relative infrequency of these types of injuries among females, whilst the statistical insignificance observed within the 'Lower extremity, other injury' grouping is most likely due to these types of injuries increasingly being treated at non-inpatient settings (Hensher et al. 1999; Bernstein et al. 2003). For females by far the highest statistically significant mean excess inpatient admission count per index injury is evident within the 'Hip fracture' category (0.28). Hip fractures represent a very frequent type of injury sustained by older females (Melton 1996; Kannus et al. 1999; Cummings and Melton 2002). Hence, due to their high prevalence among such a vulnerable sub-group of the population it is little surprise that hip fracture type injuries very often require treatment within hospital as an inpatient (Kannus et al. 1999; Cummings and Melton 2002).

Table 6.10: Mean excess inpatient admission count per index injury by external cause and gender

	Mean excess inpatient admission count per index injury	**95% Confidence Interval**		**p-value**
		Lower limit	**Upper limit**	
Total	0.07	0.06	0.08	0.00
Mechanism of injury				
Motor Vehicle Traffic Crash	0.29	0.02	0.57	0.04
Fall	0.20	0.08	0.32	0.00
Burns	**-0.03**	**-0.23**	**0.17**	**0.76**
Cut/pierce	**0.09**	**-0.07**	**0.25**	**0.25**
Struck by/against	0.21	0.02	0.40	0.03
Poisoning	**0.08**	**-0.12**	**0.29**	**0.42**
Other	0.09	0.00	0.19	0.05
Location of injury				
Home	0.07	0.05	0.09	0.00
Work	0.04	0.00	0.07	0.04
RTA	0.06	0.01	0.10	0.01
Sport	**0.11**	**-0.03**	**0.25**	**0.12**
Other	0.07	0.05	0.09	0.00

	Mean excess inpatient admission count per index injury	95% Confidence Interval		p-value
		Lower limit	Upper limit	
Male	0.06	0.05	0.08	0.00
Mechanism of injury				
Motor Vehicle Traffic Crash	0.35	0.09	0.60	0.01
Fall	0.14	0.01	0.27	0.03
Burns	**-0.04**	**-0.26**	**0.18**	**0.71**
Cut/pierce	**0.05**	**-0.12**	**0.22**	**0.55**
Struck by/against	**0.19**	**-0.01**	**0.39**	**0.07**
Poisoning	**0.18**	**-0.18**	**0.55**	**0.32**
Other	**0.07**	**-0.04**	**0.18**	**0.20**
Location of injury				
Home	0.05	0.02	0.09	0.00
Work	0.03	0.00	0.05	0.06
RTA	0.07	0.02	0.11	0.00
Sport	**0.10**	**-0.02**	**0.22**	**0.09**
Other	0.07	0.04	0.09	0.00
Female	0.08	0.06	0.10	0.00
Mechanism of injury				
Motor Vehicle Traffic Crash	**0.19**	**-0.51**	**0.89**	**0.58**
Fall	0.28	0.06	0.49	0.01
Burns	**-0.01**	**-0.44**	**0.42**	**0.97**
Cut/pierce	**0.22**	**-0.21**	**0.65**	**0.30**
Struck by/against	**0.27**	**-0.22**	**0.76**	**0.26**
Poisoning	**0.01**	**-0.23**	**0.26**	**0.91**
Other	**0.13**	**-0.04**	**0.31**	**0.13**
Location of injury				
Home	0.09	0.06	0.12	0.00
Work	**0.07**	**-0.05**	**0.19**	**0.23**
RTA	**0.05**	**-0.04**	**0.13**	**0.27**
Sport	**0.13**	**-0.27**	**0.52**	**0.50**
Other	0.07	0.05	0.10	0.00

Despite the relatively small number of index injuries initially in receipt of treatment as an inpatient (n = 1,212) some of the mechanism of injury categories are associated with a statistically significant count of excess inpatient admissions. When considering both genders together this is the case for the categories of 'Motor Vehicle Traffic Crash' (p-value = 0.04), 'Fall' (p-value = 0.00), 'Struck by/against' (p-value = 0.03) and 'Other' (p-value = 0.05), and is a reflection of the seriousness of injuries that require admission to hospital and which often require subsequent spells of treatment as an inpatient during the post-index injury period.

Amongst the other mechanism of injury categories the most likely reason why 'Burns' (p-value = 0.76) and 'Cut/pierce' (p-value = 0.25) exhibit statistical insignificance is due to injuries resulting from these causes being mostly treated in outpatients and ED settings, respectively. A possible reason for the lack of a statistically significant mean excess inpatient admission count amongst the 'Poisoning' category (p-value = 0.42) concerns the difficulty in attributing the cause of poisoning to a given inpatient injury event. Of the mechanism of injury categories that are associated with statistical significance the highest excess mean inpatient admission count is observed amongst the 'Motor Vehicle Traffic Crash' category for both genders together and males individually (0.29 and 0.35, respectively), with this reflecting the fact that these types of incident frequently lead to injuries to the skull and brain being sustained (Jagger et al. 1984; Sosin, Sacks and Smith 1989; Cunningham et al. 2002; Slewa-Younan et al. 2004), which in turn often warrant admission to hospital for continued observation (MacMillan, Strang and Jennett 1979; Sainsbury and Sibert 1984; af Geijerstam, Britton and Mebius 2000). In contrast, the 'Motor Vehicle Traffic Crash' mechanism of injury grouping exhibits a statistically insignificant mean excess count of inpatient admissions amongst females (p-value = 0.58), with this difference between the genders most likely due to males being associated with a more high risk attitude (Byrnes, Miller and Schafer 1999) and thus being more likely than females to be injured in incidents like motor vehicle crashes (Turner and McClure 2003). For females the highest mean excess count of inpatient admissions arises within the 'Fall' grouping (0.28), owing to these incidents frequently culminating in fractures of the hip, especially amongst older females, and the subsequent need for admission to hospital for treatment (Melton 1996; Kannus et al. 1999; Cummings and Melton 2002).

With regards to the location at which the index injury was sustained it is apparent from Table 6.10 that the category of 'Sport' is associated with a statistically insignificant mean excess count of inpatient admissions across all index injuries (p-value = 0.12), plus those sustained by males (p-value = 0.09) and females (p-value = 0.50) separately, which reflects the relatively small number of index injuries incurred at a sport location (Total n = 76; Male n = 53; Female n = 23). When focusing on index injuries suffered by females the location groupings of 'Work' (p-value = 0.23) and 'RTA' (p-value = 0.27) additionally exhibit statistical insignificance, which is most likely a consequence of fewer females working in dangerous occupations like the construction trades (U.S. Department of Labor, Bureau of Labor Statistics 1998) and females being inclined to take less risks on the road (Turner and McClure 2003) than males, respectively.

Excluding the category of 'Other' the location of injury groupings with the highest statistically significant mean excess count of hospital admissions is the category of 'Home' when considering both genders together (0.07) and females individually (0.09), and the category of 'RTA' (0.07) when considering only index injuries incurred by males. Older females in particular are susceptible to injuries occurring within the home given this is the location where the tendency to fall, a frequent type of incident amongst older females, is most likely, which in turn often culminate in hip fractures and the need for inpatient treatment (Melton 1996; Kannus et al. 1999; Cummings and Melton 2002). Injuries on the road are commonplace amongst males, especially young males, given their general high risk attitude and subsequent likelihood of being injured in motor vehicle crashes (Byrnes, Miller and Schafer 1999; Turner and McClure 2003), which in turn frequently culminate in major trauma injuries that require inpatient treatment.

6.4.2.2.2. Inpatient bed-days

Based on the 30,492 excess inpatient bed-days resulting from the 30,387 index injuries sustained by the injured cohort, it follows that an index injury leads to an extra 1.00 (95% CI: 0.78, 1.23; p-value < 0.05) inpatient bed-days being observed relative to the number expected in the absence of an injury. Or alternatively, for every 10,000 index injuries between 7,800 and 12,300 more inpatient bed-days are observed over expected.

Table 6.11: Mean excess inpatient bed-days count per index injury by age group, gender and socioeconomic classification

	Mean excess inpatient bed-days count per index injury	95% Confidence Interval		p-value
		Lower limit	Upper limit	
Total	1.00	0.78	1.23	0.00
0 – 4	**0.00**	**-0.08**	**0.08**	**0.94**
5 – 9	**-0.00**	**-0.05**	**0.04**	**0.88**
10 – 14	**0.03**	**-0.13**	**0.18**	**0.75**
15 – 19	**0.30**	**-0.07**	**0.68**	**0.11**
20 – 24	0.33	0.08	0.58	0.01
25 – 29	0.49	0.02	0.95	0.04
30 – 34	0.45	0.03	0.86	0.03
35 – 39	0.71	0.29	1.13	0.00
40 – 44	**0.49**	**-0.11**	**1.10**	**0.11**
45 – 49	**0.23**	**-0.10**	**0.55**	**0.17**
50 – 54	**0.40**	**-1.07**	**1.87**	**0.59**
55 – 59	**0.96**	**-0.38**	**2.30**	**0.16**
60 – 64	**-0.04**	**-2.07**	**1.99**	**0.97**
65 – 69	**1.17**	**-0.24**	**2.57**	**0.10**
70 – 74	3.77	2.12	5.41	0.00
75 – 79	7.13	2.93	11.34	0.00
80 – 84	8.71	4.24	13.19	0.00
85+	9.11	5.68	12.55	0.00
Least deprived	0.69	0.21	1.18	0.01
Next least deprived	1.11	0.45	1.77	0.00
Middle deprived	1.03	0.63	1.43	0.00
Next most deprived	1.24	0.65	1.84	0.00
Most deprived	0.99	0.60	1.39	0.00
Male	0.60	0.35	0.85	0.00
0 – 4	**-0.01**	**-0.14**	**0.12**	**0.92**
5 – 9	**-0.03**	**-0.11**	**0.05**	**0.45**
10 – 14	**0.02**	**-0.02**	**0.06**	**0.39**
15 – 19	**0.04**	**-0.07**	**0.14**	**0.51**
20 – 24	0.40	0.06	0.75	0.02
25 – 29	**0.51**	**-0.03**	**1.04**	**0.06**
30 – 34	**0.22**	**-0.14**	**0.58**	**0.23**
35 – 39	0.80	0.14	1.47	0.02
40 – 44	**0.37**	**-0.05**	**0.77**	**0.08**
45 – 49	**0.34**	**-0.17**	**0.85**	**0.19**
50 – 54	**0.94**	**-1.84**	**3.71**	**0.50**
55 – 59	2.90	0.28	5.53	0.03
60 – 64	**-1.15**	**-5.21**	**2.90**	**0.58**
65 – 69	**1.42**	**-0.93**	**3.77**	**0.24**
70 – 74	6.85	3.00	10.70	0.00
75 – 79	**2.91**	**-3.38**	**9.19**	**0.36**
80 – 84	**6.49**	**-2.64**	**15.62**	**0.16**
85+	9.61	1.63	17.58	0.02
Least deprived	**0.46**	**-0.15**	**1.07**	**0.14**
Next least deprived	0.50	0.09	0.91	0.02
Middle deprived	**0.43**	**-0.01**	**0.86**	**0.06**
Next most deprived	0.80	0.25	1.35	0.00
Most deprived	0.73	0.20	1.26	0.01

	Mean excess inpatient bed-days count per index injury	95% Confidence Interval		p-value
		Lower limit	Upper limit	
Female	1.49	1.09	1.89	0.00
0 – 4	**0.02**	**-0.06**	**0.09**	**0.65**
5 – 9	**0.03**	**-0.01**	**0.07**	**0.16**
10 – 14	**0.04**	**-0.36**	**0.43**	**0.86**
15 – 19	**0.75**	**-0.24**	**1.74**	**0.14**
20 – 24	**0.20**	**-0.11**	**0.50**	**0.21**
25 – 29	**0.45**	**-0.43**	**1.32**	**0.32**
30 – 34	**0.77**	**-0.09**	**1.64**	**0.08**
35 – 39	0.59	0.16	1.02	0.01
40 – 44	**0.65**	**-0.59**	**1.89**	**0.30**
45 – 49	**0.12**	**-0.29**	**0.53**	**0.56**
50 – 54	**-0.21**	**-0.62**	**0.19**	**0.30**
55 – 59	**-0.71**	**-1.77**	**0.35**	**0.19**
60 – 64	**0.90**	**-0.64**	**2.44**	**0.25**
65 – 69	**1.00**	**-0.74**	**2.75**	**0.26**
70 – 74	2.19	0.68	3.70	0.01
75 – 79	8.73	3.45	14.03	0.00
80 – 84	9.55	4.42	14.68	0.00
85+	8.98	5.17	12.80	0.00
Least deprived	0.96	0.19	1.73	0.01
Next least deprived	1.83	0.48	3.18	0.01
Middle deprived	1.78	1.06	2.49	0.00
Next most deprived	1.79	0.64	2.95	0.00
Most deprived	1.32	0.73	1.92	0.00

Both male and female members of the injured cohort exhibit a statistically significant mean excess inpatient bed-days count per index injury, with the figure for females (1.49) almost 3 times as large as the equivalent male figure (0.60). This finding is interesting given no major difference between the genders was observed when considering the number of excess inpatient admissions associated with members of the injured cohort. This suggests that whilst the likelihood of admission to hospital is relatively constant among males and females, once admitted as an inpatient the latter require on average longer periods of treatment. To a certain extent this is likely to reflect the high frequency of injuries often sustained by older females (especially hip fractures) and the reduced capacity of this demographic subgroup to regain full health once injured (Shabot and Johnson 1995; Horan and Little 1998).

When considering both genders together the 5 year age groups associated with a mean excess inpatient bed-days count statistically different from zero include individuals aged 20 to 39 and 70+. This finding reflects the potential for more serious injuries to be sustained by individuals within these age groups, which require longer treatment phases within hospital. For instance, individuals aged 20 to 39, especially males, exhibit an increased tendency to partake in activities with a high-risk of serious injury, such as dangerous driving (Byrnes, Miller and Schafer 1999; Turner and McClure 2003). In addition, injuries which tend to be relatively minor when sustained by the young are often more serious when suffered by the old due to their reduced ability to respond successfully to medical care (Shabot and Johnson 1995; Horan and Little 1998).

Injured individuals aged 70+ have by far the highest mean excess count of inpatient bed-days, ranging from 3.77 to 9.11 on average. The finding that older members of the injured cohort are associated with a greater mean excess inpatient bed-day count than that observed amongst younger aged individuals continues when the results are stratified by gender, although a greater difference between the young and old is evident among females. In the case of males, for instance, those aged 70+ are associated with an excess count ranging from 2.91 to 9.61, whilst for females, the mean excess counts of bed-days range from 2.19 to 9.55. This finding that an increased number of hospital bed-days are associated with index injuries sustained by the old mirror the finding that older aged individuals also dominate the number of excess hospital admissions observed per index injury (Table 6.8). The length of hospital stay associated with elderly females, in particular, is often very high due to their reduced capacity to respond to treatment following the occurrence of injury, especially hip fractures (Melton 1996; Kannus et al. 1999; Cummings and Melton 2002). Hence, when this subgroup of the population sustain an injury they are not only frequently admitted to hospital but regularly remain as an inpatient for a prolonged period in order to account for their longer treatment time and increased need for continued observation.

Across all index injuries the lowest mean count of excess inpatient bed-days arises following an index injury sustained by individuals categorised within the 'Least deprived' socioeconomic grouping (0.69). Each of the remaining groups are associated with similar excess counts of inpatient bed-days per index injury on average, ranging from 1.24 for the 'Next most deprived' to 0.99 for the 'Most deprived'. When considering index injuries sustained by male members of the injured cohort the socioeconomic groupings of 'Least deprived', 'Next least deprived' and

'Middle deprived' are each associated with an equally low mean count of excess inpatient bed-days (0.46, 0.50, 0.43 respectively). By contrast, index injuries incurred by males in the socioeconomic categories of 'Next most deprived' and 'Most deprived' lead to a much higher count of excess inpatient bed-days on average (0.80 and 0.73 respectively). The tendency for index injuries amongst the more deprived to lead to higher mean counts of excess inpatient bed-days is less marked amongst females, however it is apparent from Table 6.11 that the lowest count of excess inpatient bed-days follows index injuries amongst females within the 'Least deprived' socioeconomic group (0.96).

The above findings suggest that higher levels of deprivation amongst the injured cohort followed up as part of this thesis lead to higher excess counts of inpatient bed-days. As suggested when discussing this same finding observed when considering the relationship between socioeconomic status and excess ED attendances/inpatient admissions, this is most likely due to the fact that the more deprived within society tend to suffer from more ongoing co-morbidities (Akker et al. 2000; Kosler et al. 2004) which often have the impact of making it more difficult for individuals to respond to treatment, thereby culminating in an increased number and length of healthcare contacts (Koval et al. 1998; Lew et al. 2002). Furthermore, evidence suggests the less affluent have a tendency to sustain more severe injuries (Hippisley-Cox et al. 2002; Park et al. 2009) which are more susceptible to lengthy stays in hospital as an inpatient.

Table 6.12: Mean excess inpatient bed-days count per index injury by injury type and gender

	Mean excess inpatient bed-days count per index injury	**95% Confidence Interval**		**p-value**
		Lower limit	**Upper limit**	
Total	1.00	0.78	1.23	0.00
Skull-brain injury	13.17	0.12	26.22	0.05
Facial fracture, eye injury	**0.20**	**-0.49**	**0.89**	**0.57**
Spine, vertebrae	1.01	0.25	1.76	0.01

	Mean excess inpatient bed-days count per index injury	95% Confidence Interval		p-value
		Lower limit	Upper limit	
Internal organ injury	**4.39**	**-2.38**	**11.16**	**0.19**
Upper extremity fracture	1.08	0.37	1.79	0.00
Upper extremity, other injury	**0.05**	**-0.28**	**0.38**	**0.77**
Hip fracture	13.10	5.86	20.35	0.00
Lower extremity, fracture	1.85	1.02	2.67	0.00
Lower extremity, other injury	0.81	0.35	1.27	0.00
Superficial injury, open wounds	0.63	0.20	1.05	0.00
Burns	**1.04**	**-0.65**	**2.72**	**0.22**
Poisonings	2.27	0.64	3.90	0.01
Other injury	1.09	0.58	1.61	0.00
Male	0.60	0.35	0.85	0.00
Skull-brain injury	**15.50**	**-0.23**	**31.23**	**0.05**
Facial fracture, eye injury	**-0.22**	**-0.67**	**0.23**	**0.33**
Spine, vertebrae	1.69	0.21	3.17	0.03
Internal organ injury	**4.27**	**-4.44**	**12.97**	**0.31**
Upper extremity fracture	**0.36**	**-0.02**	**0.74**	**0.06**
Upper extremity, other injury	**0.01**	**-0.21**	**0.23**	**0.94**
Hip fracture	**8.53**	**-3.05**	**20.10**	**0.15**
Lower extremity, fracture	0.69	0.08	1.30	0.03
Lower extremity, other injury	0.62	0.18	1.06	0.01
Superficial injury, open wounds	**0.29**	**-0.24**	**0.81**	**0.28**
Burns	**1.52**	**-0.80**	**3.83**	**0.19**
Poisonings	2.31	0.23	4.40	0.03
Other injury	0.79	0.28	1.30	0.00
Female	1.49	1.09	1.89	0.00
Skull-brain injury	**1.82**	**-2.00**	**5.64**	**0.30**
Facial fracture, eye injury	**1.29**	**-0.91**	**3.48**	**0.25**
Spine, vertebrae	**0.38**	**-0.14**	**0.88**	**0.15**
Internal organ injury	**4.78**	**-9.33**	**18.87**	**0.40**
Upper extremity fracture	1.92	0.45	3.39	0.01
Upper extremity, other injury	**0.09**	**-0.55**	**0.73**	**0.78**
Hip fracture	14.83	5.82	23.85	0.00
Lower extremity, fracture	3.00	1.47	4.52	0.00
Lower extremity, other injury	1.02	0.18	1.87	0.02
Superficial injury, open wounds	1.11	0.40	1.82	0.00
Burns	**-0.20**	**-1.31**	**0.90**	**0.71**
Poisonings	**2.23**	**-0.21**	**4.68**	**0.07**
Other injury	1.51	0.51	2.52	0.00

In total (both genders) the mean excess inpatient bed-days count per index injury is statistically different from zero at the 95% confidence level for all index injury category types except 'Facial fracture, eye injury' (p-value = 0.57), 'Internal organ injury' (p-value = 0.19), 'Upper extremity, other injury' (p-value = 0.77) and 'Burns' (p-value = 0.22). The most likely explanation for the lack of a statistically significant excess inpatient bed-day count amongst these groupings is the infrequency of certain types of injury, especially injuries to the internal organs (Krige et al. 2005; Burkitt et al. 2007; Povýsil et al. 2009), plus the increased tendency for some types of injuries to be treated in non-inpatient settings, particularly upper extremity injuries (Hensher et al. 1999; Bernstein et al. 2003).

Of the groupings exhibiting statistical significance the highest mean excess inpatient bed-days count is observed amongst the 'Skull-brain injury' category (13.17) closely followed by the 'Hip fracture' category (13.10), with the lowest excess count on average evident amongst the 'Superficial injury, open wounds' grouping of injuries (0.63). The high number of excess inpatient bed-days associated with index injuries within the 'Skull-brain injury' category reflects the seriousness of injuries to the head and the continued need for hospital based observation or intervention (MacMillan, Strang and Jennett 1979; Sainsbury and Sibert 1984; af Geijerstam, Britton and Mebius 2000). The dominance of hip fracture injuries in terms of the excess length of hospital stay reflects the high frequency of these types of injury sustained by older individuals (Melton 1996; Kannus et al. 1999; Cummings and Melton 2002), who regularly require longer-term care as an inpatient in order to be restored to full health (Shabot and Johnson 1995; Horan and Little 1998). By contrast the comparatively low number of excess inpatient bed-days associated with index injuries classified within the 'Superficial injury, open wounds' grouping of injuries reflects the fact that these types of injury are often very minor that can be dealt with at an ED without the need for subsequent admission to hospital, plus when admitted the treatment time associated with these types of injury is often relatively short meaning there is frequently no need for a lengthy hospital stay.

When focusing specifically on index injuries sustained by males, the type of injury associated with the highest statistically significant excess bed-day count figure is 'Poisoning' (2.31). This reflects the fact that when serious enough to warrant admission to hospital poisoning related injuries require longer treatment periods as an inpatient and more lengthy periods of observation. Males in particular may be more susceptible to serious poisoning type injuries than females due to their increased risk of suicide (Nordström, Samuelsson and Asberg 1995; Hawton, Zahl and Weatherall 2003). The majority of poisoning admissions to hospital will be to manage mental health problems and reduce the risk of further self-harm rather than the treatment of the poisoning related condition. With regards to female members of the injured cohort the type of injury associated with by far the highest mean excess count of inpatient bed-days is 'Hip fracture' (14.83). Again, as already discussed, this reflects the reduced capacity of older aged females in particular to respond successfully to treatment following their injury (Shabot and Johnson 1995; Horan and Little 1998), with hip fractures especially prevalent among this demographic subgroup of the population due to the occurrence of falls in the home (Melton 1996; Kannus et al. 1999; Cummings and Melton 2002).

Table 6.13: Mean excess inpatient bed-days count per index injury by external cause and gender

	Mean excess inpatient bed-days count per index injury	95% Confidence Interval		p-value
		Lower limit	Upper limit	
Total	1.00	0.78	1.23	0.00
Mechanism of injury				
Motor Vehicle Traffic Crash	14.12	0.48	27.75	0.04
Fall	4.69	1.49	7.88	0.00
Burns	**0.24**	**-1.21**	**1.68**	**0.74**
Cut/pierce	**0.27**	**-0.14**	**0.69**	**0.19**
Struck by/against	**1.95**	**-0.94**	**4.85**	**0.18**
Poisoning	**2.70**	**-0.65**	**6.06**	**0.11**
Other	**0.46**	**-2.45**	**3.36**	**0.76**
Location of injury				
Home	1.88	1.39	2.37	0.00
Work	0.23	0.09	0.37	0.00
RTA	0.34	0.12	0.56	0.00
Sport	**0.32**	**-0.01**	**0.65**	**0.05**
Other	0.38	0.12	0.65	0.00
Male	0.60	0.35	0.85	0.00
Mechanism of injury				
Motor Vehicle Traffic Crash	20.81	0.44	41.18	0.05
Fall	**3.27**	**-0.12**	**6.65**	**0.06**
Burns	**0.50**	**-1.60**	**2.60**	**0.63**
Cut/pierce	**0.16**	**-0.31**	**0.63**	**0.49**
Struck by/against	**1.15**	**-1.03**	**3.33**	**0.30**
Poisoning	**4.45**	**-0.12**	**9.02**	**0.06**
Other	**-1.12**	**-3.95**	**1.73**	**0.44**
Location of injury				
Home	1.11	0.63	1.59	0.00

	Mean excess inpatient bed-days count per index injury	95% Confidence Interval		p-value
		Lower limit	Upper limit	
Work	0.18	0.06	0.31	0.00
RTA	0.36	0.03	0.69	0.03
Sport	**0.45**	**-0.02**	**0.92**	**0.06**
Other	**0.27**	**-0.09**	**0.64**	**0.14**
Female	1.49	1.09	1.89	0.00
Mechanism of injury				
Motor Vehicle Traffic Crash	**0.73**	**-2.00**	**3.46**	**0.58**
Fall	6.33	0.63	12.03	0.03
Burns	**-0.30**	**-1.73**	**1.13**	**0.66**
Cut/pierce	**0.60**	**-0.35**	**1.56**	**0.20**
Struck by/against	**4.43**	**-5.85**	**14.72**	**0.38**
Poisoning	**1.48**	**-3.27**	**6.24**	**0.54**
Other	**3.19**	**-3.09**	**9.38**	**0.32**
Location of injury				
Home	2.50	1.70	3.30	0.00
Work	**0.36**	**-0.04**	**0.76**	**0.08**
RTA	0.33	0.04	0.62	0.03
Sport	**0.03**	**-0.17**	**0.23**	**0.76**
Other	0.55	0.18	0.92	0.00

Across all index injuries first treated within an inpatient setting, and for which it was possible to categorise by mechanism of injury (n = 1,212), it is evident from Table 6.13 above that only the groupings of 'Motor Vehicle Traffic Crash' (p-value = 0.04) and 'Fall' (p-value = 0.00) are associated with a mean excess count of inpatient bed-days that is statistically different from zero at the 95% confidence level. This finding reflects the high statistically significant mean count of inpatient bed-days observed amongst males with regards to index injuries associated with a 'Motor Vehicle Traffic Crash' mechanism of injury (20.81), and females in relation to index injuries resulting from a 'Fall' mechanism of injury (6.33). As discussed in section 6.4.2.2.1. when considering the number of inpatient admissions, these particular causes of injury are commonplace amongst these particular genders, and due to the likely severity of the resulting injury there is frequently the need for a lengthy stay as an inpatient in hospital in order to treat the resulting injury.

The relatively few number of index injuries sustained within a sports setting means that this location of injury category continues to be associated with a statistically insignificant mean count of excess inpatient bed-days, as was the case for ED attendances and inpatient admissions. The grouping of 'Work' is also not statistically different from zero for females, which most likely reflects the fewer number of females working in dangerous occupations, such as the construction trades, compared to males (U.S. Department of Labor, Bureau of Labor Statistics. 1998). When considering both genders together, plus males and females separately, the location of 'Home' is associated with the highest statistically significant mean excess count of inpatient bed-days (Total = 1.88; Male = 1.11; Female = 2.50). For females this is to be expected given the high number of falls amongst older people within the home leading to a high number of hip fractures that require treatment as an inpatient. The finding, however, that the mean excess count of inpatient bed-days resulting from home based injuries exceed the equivalent figure due to injuries sustained at a road traffic location when focusing on male index injuries is surprising given the high mean excess count of inpatient bed-days amongst males that is associated with a 'Motor Vehicle Traffic Crash' mechanism of injury. A potential explanation for this concerns the location of injury categorisation only being possible for index injuries first treated at an ED. This means that all of the index injuries initially in receipt of inpatient treatment that were sustained at a road location and which were associated with a lengthy stay as an inpatient are being missed.

6.4.2.3. Outpatient sector

The 16,715 excess outpatient contacts calculated as taking place during the post-index injury period following the occurrence of 30,387 index injuries incurred by the injured cohort equates to an average of 0.55 (95% CI: 0.52, 0.58; p-value < 0.05) excess outpatient contacts arising per index injury. That is, for every 10,000 index injuries between 5,200 and 5,800 outpatient contacts are observed in addition to the number expected in the absence of any injury.

Table 6.14: Mean excess outpatient visit count per index injury by age group, gender and socioeconomic classification

	Mean excess outpatient visit count per index injury	95% Confidence Interval		p-value
		Lower limit	Upper limit	
Total	0.55	0.52	0.58	0.00
0 – 4	0.32	0.22	0.42	0.00
5 – 9	0.49	0.39	0.58	0.00
10 – 14	0.43	0.33	0.52	0.00
15 – 19	0.40	0.32	0.48	0.00
20 – 24	0.44	0.34	0.53	0.00
25 – 29	0.44	0.32	0.56	0.00
30 – 34	0.46	0.33	0.58	0.00
35 – 39	0.60	0.48	0.72	0.00
40 – 44	0.48	0.38	0.59	0.00
45 – 49	0.62	0.42	0.82	0.00
50 – 54	0.70	0.14	1.26	0.02
55 – 59	0.71	0.49	0.93	0.00
60 – 64	0.88	0.68	1.08	0.00
65 – 69	0.98	0.75	1.21	0.00
70 – 74	1.03	0.79	1.28	0.00
75 – 79	0.99	0.76	1.23	0.00
80 – 84	0.87	0.60	1.13	0.00
85+	1.10	0.87	1.33	0.00
Least deprived	0.66	0.59	0.73	0.00
Next least deprived	0.50	0.42	0.58	0.00
Middle deprived	0.53	0.44	0.61	0.00
Next most deprived	0.52	0.44	0.61	0.00
Most deprived	0.53	0.48	0.59	0.00
Male	0.54	0.50	0.58	0.00
0 – 4	0.34	0.21	0.47	0.00
5 – 9	0.46	0.32	0.60	0.00
10 – 14	0.47	0.36	0.59	0.00
15 – 19	0.44	0.34	0.53	0.00
20 – 24	0.57	0.46	0.68	0.00
25 – 29	0.47	0.35	0.59	0.00
30 – 34	0.51	0.37	0.64	0.00
35 – 39	0.58	0.44	0.72	0.00
40 – 44	0.50	0.36	0.63	0.00
45 – 49	0.71	0.45	0.98	0.00
50 – 54	0.95	0.22	1.68	0.01
55 – 59	0.69	0.45	0.92	0.00
60 – 64	0.86	0.57	1.16	0.00
65 – 69	0.93	0.58	1.27	0.00
70 – 74	0.69	0.29	1.09	0.00
75 – 79	0.84	0.36	1.32	0.00
80 – 84	1.08	0.54	1.61	0.00
85+	1.35	0.78	1.92	0.00
Least deprived	0.54	0.46	0.63	0.00
Next least deprived	0.58	0.48	0.69	0.00
Middle deprived	0.44	0.35	0.54	0.00
Next most deprived	0.59	0.48	0.69	0.00
Most deprived	0.54	0.47	0.60	0.00

	Mean excess outpatient visit count per index injury	95% Confidence Interval		p-value
		Lower limit	Upper limit	
Female	0.56	0.51	0.62	0.00
0 – 4	0.29	0.15	0.44	0.00
5 – 9	0.52	0.40	0.64	0.00
10 – 14	0.36	0.19	0.53	0.00
15 – 19	0.34	0.19	0.49	0.00
20 – 24	0.18	0.01	0.35	0.04
25 – 29	0.39	0.13	0.65	0.00
30 – 34	0.38	0.15	0.62	0.00
35 – 39	0.62	0.42	0.82	0.00
40 – 44	0.47	0.29	0.65	0.00
45 – 49	0.53	0.24	0.82	0.00
50 – 54	**0.42**	**-0.47**	**1.31**	**0.34**
55 – 59	0.73	0.37	1.09	0.00
60 – 64	0.90	0.63	1.16	0.00
65 – 69	1.01	0.71	1.32	0.00
70 – 74	1.21	0.90	1.52	0.00
75 – 79	1.05	0.78	1.32	0.00
80 – 84	0.79	0.48	1.09	0.00
85+	1.04	0.79	1.29	0.00
Least deprived	0.79	0.69	0.90	0.00
Next least deprived	0.40	0.27	0.53	0.00
Middle deprived	0.63	0.48	0.78	0.00
Next most deprived	0.44	0.31	0.57	0.00
Most deprived	0.53	0.43	0.62	0.00

There is very little difference in the mean excess outpatient visit count per index injury between males (0.54) and females (0.56), with both gender groups associated with an excess count figure statistically different from zero at the 95% confidence level (p-value < 0.05). Interestingly the lack of any marked difference between gender in terms of the number of excess outpatient visits associated with a given index injury suggests that although the reduced capacity to recover from injury amongst females leads to more lengthy excess stays as an inpatient (Table 6.11) it does not culminate in the provision of increased excess outpatient treatment.

When focusing on both genders together every 5 year age group exhibits a statistically significant excess count of outpatient visits on average. There is a positive trend apparent with the excess figures observed increasing with the age of the injured individual. For instance, the mean excess outpatient visit count per index injury ranges from 0.32 to 0.62 for individuals within the injured cohort aged between 0 and 49. In contrast, when the age of the individuals injured rises above 50 the mean excess outpatient visit count per index injury ranges from 0.70 to 1.10. Such a general positive relationship between mean excess outpatient counts and age is additionally evident when focusing specifically on males and females. Moreover, all male age groups exhibit an excess outpatient visit count on average that is statistically different from zero, whilst this is also the case for all female age groups except for the 50 to 54 range (p-value = 0.34).

The finding relating to the number of excess outpatient visits increasing with the age of the injured cohort reflects the fact that older aged individuals require longer stages of treatment in order to deal with their injuries (Shabot and Johnson 1995; Horan and Little 1998). Very often a given injury that does not require any medical attention at all or can be dealt with at an ED or as an inpatient if sustained by younger aged individuals will frequently require ongoing treatment in order to restore older members of the population to their former state of health. Such long-term care regularly takes the form of the provision of treatment at outpatient facilities.

Interestingly, in contrast to the findings observed when considering the relationship between socioeconomic status and the mean excess count of ED attendances, inpatient admissions and inpatient bed-days per index injury, the mean excess count of outpatient contacts per index injury tends to be higher amongst the less deprived members of the injured cohort. For instance, the excess count of outpatient contacts on average is highest amongst the 'Least deprived' socioeconomic grouping when considering both genders together, as well as females separately (0.66 and 0.79 respectively). Whilst although for males the 'Least deprived' category is not associated with the highest mean excess count of outpatient contacts it is still associated with a very high count, with the figure of 0.54 being very close to 0.59, which is the highest count of outpatient contacts per index injury on average ('Next most deprived'), and much higher than the figure of 0.44, which is the lowest count of outpatient contacts per index injury on average ('Middle deprived').

This finding of an inverse relationship between the socioeconomic status of the injured cohort and the number of excess outpatient contacts observed per index injury can potentially be explained by the fact that the least deprived tend to sustain less serious injuries (Hippisley-Cox et al. 2002; Park et al. 2009), which can often be dealt with solely at outpatients. Also given outpatient treatment tends to deal with less serious injuries it means the medical attention required may at times not be essential. In these cases more deprived individuals may choose not to attend outpatient treatment (McClure, Newell and Edwards 1996; Hamilton, Round and Sharp 2002). This may be due to the more deprived not being able to afford to take time off work and/or not being able to afford the transport costs.

Table 6.15: Mean excess outpatient visit count per index injury by injury type and gender

	Mean excess outpatient visit count per index injury	**95% Confidence Interval**		**p-value**
		Lower limit	**Upper limit**	
Total	0.55	0.52	0.58	0.00
Skull-brain injury	1.64	0.76	2.53	0.00
Facial fracture, eye injury	0.69	0.36	1.02	0.00
Spine, vertebrae	**-0.01**	**-0.14**	**0.11**	**0.84**
Internal organ injury	**0.14**	**-3.13**	**3.41**	**0.93**
Upper extremity fracture	2.09	2.00	2.18	0.00
Upper extremity, other injury	0.23	0.15	0.32	0.00
Hip fracture	1.08	0.72	1.44	0.00
Lower extremity, fracture	2.05	1.89	2.20	0.00
Lower extremity, other injury	0.11	0.04	0.18	0.00
Superficial injury, open wounds	0.13	0.07	0.18	0.00
Burns	3.84	2.70	4.97	0.00
Poisonings	0.60	0.30	0.90	0.00
Other injury	0.12	0.03	0.20	0.01
Male	0.54	0.50	0.58	0.00
Skull-brain injury	1.48	0.56	2.40	0.00
Facial fracture, eye injury	0.68	0.30	1.07	0.00
Spine, vertebrae	**0.02**	**-0.11**	**0.14**	**0.79**
Internal organ injury	**-1.17**	**-4.45**	**2.10**	**0.46**
Upper extremity fracture	2.02	1.90	2.13	0.00
Upper extremity, other injury	0.18	0.08	0.29	0.00
Hip fracture	1.96	1.36	2.56	0.00
Lower extremity, fracture	2.26	2.07	2.45	0.00
Lower extremity, other injury	0.16	0.08	0.25	0.00
Superficial injury, open wounds	0.12	0.06	0.19	0.00
Burns	4.02	2.70	5.34	0.00
Poisonings	0.39	0.15	0.63	0.00
Other injury	**0.09**	**-0.02**	**0.20**	**0.11**
Female	0.56	0.51	0.62	0.00
Skull-brain injury	**2.45**	**-0.77**	**5.66**	**0.12**
Facial fracture, eye injury	0.70	0.07	1.34	0.03
Spine, vertebrae	**-0.04**	**-0.25**	**0.17**	**0.71**

	Mean excess outpatient visit count per index injury	95% Confidence Interval		p-value
		Lower limit	Upper limit	
Internal organ injury	**4.08**	**-7.26**	**15.42**	**0.37**
Upper extremity fracture	2.18	2.04	2.32	0.00
Upper extremity, other injury	0.28	0.14	0.42	0.00
Hip fracture	0.75	0.31	1.18	0.00
Lower extremity, fracture	1.84	1.60	2.07	0.00
Lower extremity, other injury	**0.05**	**-0.07**	**0.17**	**0.38**
Superficial injury, open wounds	0.13	0.04	0.21	0.00
Burns	3.37	0.97	5.77	0.010
Poisonings	0.78	0.27	1.29	0.00
Other injury	0.15	0.01	0.30	0.04

When considering both genders together only two injury groupings fail to be statistically significant at the 95% confidence level, with this being the case for the categories of 'Spine, vertebrae' (p-value = 0.84) and 'Internal organ injury' (p-value = 0.93). This is most likely due to the infrequency of these types of injuries (McGrory et al. 1993; Orenstein et al. 1994; Nitecki and Moir 1994; Eleraky et al. 2000; Krige et al. 2005; Burkitt et al. 2007; Povýsil et al. 2009), and the fact that when sustained they are most likely to require treatment within the inpatient sector as opposed to in outpatient settings (Harris et al. 1980; Augenstein et al. 1995; Livingston et al. 1998; Timothy, Towns and Girn 2004).

Of the injury groupings associated with an excess outpatient visit count on average that is statistically different from zero the highest mean excess count is evident for the category of 'Burns' (3.84), with the lowest applicable to the category of 'Lower extremity, other injury' (0.11). For males specifically, individuals within the injured cohort that have sustained a burn related index injury exhibit the highest mean excess outpatient visit count per index injury (4.02), whereas the corresponding lowest statistically significant excess count is evident amongst individuals categorised within the 'Superficial injury, open wounds' grouping (0.12). In terms of the female members of the injured cohort, of the injury groupings that are statistically different from zero at the 95% confidence level the highest and lowest mean excess outpatient visit count per index injury are also associated with the categories of 'Burns' (3.37) and 'Superficial injury, open wounds' (0.13), respectively.

The high number of excess outpatient visits associated with burn related index injuries reflects the fact that these types of injury often require continued treatment for a prolonged period after the initial medical attention is sought, with the treatment provided not sufficiently intense or complicated to demand attendances to an ED or lengthy admissions to hospital. By contrast the comparatively low number of excess outpatient visits that tend to arise following index injuries categorised within the 'Superficial injury, open wounds' injury grouping is a reflection of the fact that these particular types of injury can usually be dealt with fully at an ED or hospital without the need for the provision of continued treatment within outpatient settings. The finding that the index injury category of 'Lower extremity, other injury' is also associated with a relatively low count of excess outpatient visits on average is somewhat surprising given these types of injury tend to be increasingly dealt with in outpatient settings (Hensher et al. 1999; Bernstein et al. 2003). This particular finding therefore may largely reflect the fact that the outpatient visits considered as part of this study relate specifically to outpatient treatment services as opposed to outpatient rehabilitation services. Hence, there is the potential that the transfer of care for injuries within the 'Lower extremity, other injury' grouping is most prevalent between inpatient treatment and outpatient rehabilitation as opposed to inpatient treatment and outpatient treatment (the fact the outpatient data source used within this study may potentially not include all outpatient rehabilitation services provided to injured individuals is identified as a limitation of this dataset listed in section 10.4 of Chapter 10).

Table 6.16: Mean excess outpatient visit count per index injury by external cause and gender

	Mean excess outpatient visit count per index injury	**95% Confidence Interval**		**p-value**
		Lower limit	**Upper limit**	
Total	0.55	0.52	0.58	0.00
Mechanism of injury				
Motor Vehicle Traffic Crash	2.36	1.17	3.54	0.00
Fall	2.04	1.48	2.59	0.00
Burns	4.45	2.82	6.08	0.00

	Mean excess outpatient visit count per index injury	95% Confidence Interval		p-value
		Lower limit	Upper limit	
Cut/pierce	2.32	1.56	3.08	0.00
Struck by/against	1.31	0.68	1.94	0.00
Poisoning	0.90	0.32	1.49	0.00
Other	1.23	0.91	1.54	0.00
Location of injury				
Home	0.49	0.44	0.55	0.00
Work	0.29	0.19	0.39	0.00
RTA	0.15	0.01	0.30	0.03
Sport	0.89	0.33	1.46	0.00
Other	0.60	0.55	0.64	0.00
Male	0.54	0.50	0.58	0.00
Mechanism of injury				
Motor Vehicle Traffic Crash	2.38	0.79	3.97	0.00
Fall	2.05	1.34	2.76	0.00
Burns	4.63	2.55	6.71	0.00
Cut/pierce	2.55	1.80	3.31	0.00
Struck by/against	1.04	0.35	1.73	0.00
Poisoning	0.72	0.28	1.16	0.00
Other	1.40	0.98	1.81	0.00
Location of injury				
Home	0.45	0.38	0.53	0.00
Work	0.27	0.17	0.38	0.00
RTA	0.17	0.00	0.34	0.05
Sport	0.75	0.02	1.49	0.04
Other	0.58	0.53	0.64	0.00
Female	0.56	0.51	0.62	0.00
Mechanism of injury				
Motor Vehicle Traffic Crash	2.30	0.49	4.11	0.02
Fall	2.02	1.13	2.90	0.00
Burns	4.08	1.14	7.01	0.01
Cut/pierce	**1.62**	**-0.58**	**3.83**	**0.14**
Struck by/against	2.13	0.63	3.63	0.01
Poisoning	1.03	0.08	1.98	0.03
Other	0.95	0.43	1.44	0.00
Location of injury				
Home	0.53	0.45	0.60	0.00
Work	0.34	0.12	0.56	0.00
RTA	**0.14**	**-0.09**	**0.37**	**0.23**
Sport	1.22	0.33	2.10	0.01
Other	0.61	0.54	0.69	0.00

It is apparent from Table 6.16 that the vast majority of the mechanism of injury categories are associated with a mean excess count of outpatient contacts that is statistically different from zero at the 95% confidence level. Indeed, only index injuries sustained by females that are assigned a 'Cut/pierce' mechanism of injury exhibit statistical insignificance (p-value = 0.14), which may reflect the increased need for injuries amongst females resulting from this cause to receive inpatient treatment as opposed to outpatient treatment, due to the increased severity of the injuries sustained. When considering both genders together as well as males and females separately the mechanism of injury grouping of 'Burns' is associated with the highest mean excess count of outpatient contacts (Total = 4.45; Males = 4.63; Females = 4.08). This finding supports the results observed in Table 6.15 when the index injuries were stratified according to the type of injury sustained and which also showed that the mean excess count of outpatient contacts was highest following a burn related injury. This is due to burn injuries often requiring continued treatment for a prolonged period after the initial medical attention is sought, with the treatment provided not sufficiently intense or complicated to demand attendances to an ED or lengthy admissions to hospital.

With regards to the location at which each index injury was sustained only the grouping of 'RTA' amongst females is statistically insignificant (p-value = 0.23) reflecting the reduced number of these types of incidents amongst females due to their reduced tendency to partake in risk-taking relative to males. Interestingly, index injuries sustained at a sports setting culminate in the highest mean count of excess outpatient contacts for both males and females. This finding can most likely be explained by the fact that injuries incurred during sport frequently require ongoing treatment in order to return the injured individual to their former state of health. Such injuries, however, are often not serious enough to require ED or inpatient treatment, explaining why index injuries associated with a sports location did not exhibit a statistically significant mean excess count of ED attendances, inpatient admissions or inpatient bed-days (Table 6.7, Table 6.10 and Table 6.13, respectively).

6.5. Chapter summary

The aim of this chapter has been to describe the excess HSU findings resulting from the implementation of the model developed as part of the methodology outlined in Chapter 4. This model sought to find the difference between the number/length of healthcare events observed following the occurrence of index injuries sustained by the injured cohort and the number/length of healthcare events expected to have arisen over this period in the absence of an index injury taking place.

Based on the 30,387 index injuries, a total of 3,647 excess ED attendances; 2,119 excess inpatient admissions; 30,492 excess inpatient bed days and 16,715 excess outpatient contacts were identified over the course of the investigative period. For every index injury these figures equate to an extra 0.12 ED attendances, 0.07 inpatient admissions, 1.00 inpatient bed day and 0.55 outpatient contacts taking place during the post-index injury period relative to the number expected to have occurred over the same timeframe in the absence of an injury. That is, for every 10,000 index injuries sustained by the injured cohort as a whole, an extra 1,200 ED attendances, 700 inpatient admissions, 10,000 inpatient bed-days and 5,500 outpatient contacts are observed in excess of the number expected.

Chapter 7 – Results III – Direct medical costs

7.1. Introduction

The aim of this chapter is to describe how the excess direct medical costs associated with each index injury sustained by the injured cohort were generated, and to report the extent of these treatment costs relating to the ED, inpatient and outpatient sectors specifically, as well as for all three health sectors combined.

7.2. Classification of results

The excess direct medical cost results presented in section 7.4.2 of this chapter are stratified according to the age, gender and socioeconomic status of the individuals within the injured cohort at the time of their index injury, and the type/external cause of the index injury sustained.

7.3. Analytic methods

To determine whether the excess direct medical cost figures reported in section 7.4.2 of this chapter were statistically significant, one-sample t tests were used. Based on a test value of zero, p-values were calculated and a 95% CI constructed, with statistical significance, as indicated by a p-value of less than 0.05 and a 95% CI above zero, suggesting that a greater amount of health care expenditure is always generated following the occurrence of an index injury than would ordinarily be expected in the absence of any injury. By contrast, statistical insignificance would imply that an index injury can at times lead to expected direct medical costs exceeding observed direct medical costs, culminating in a negative value for the mean excess direct medical cost total. Such occurrences should be considered as resulting in an excess direct medical cost figure that is not statistically different from zero. (Multiple tests of statistical significance were not performed as part of this study, however, this process will be initiated as part of any further research that is undertaken).

7.4. Results

7.4.1. Observed, expected and excess direct medical costs

Together with allowing the number of excess health service contacts following a given index injury to be ascertained, the model developed as part of this study made it possible to estimate the excess direct medical costs incurred by the healthcare sectors of interest during this post-index injury period. The extent of this excess expenditure was deduced by finding the difference between the direct medical costs generated following the health service contacts known to have taken place amongst the injured cohort after the occurrence of an index injury, and the direct medical costs predicted to have taken place during the follow-up period in the absence of an injury.

In Table 7.1 an estimate of the direct medical costs incurred by the ED, inpatient and outpatient healthcare sectors as a consequence of the observed health service contacts post-index injury are presented.

Table 7.1: Direct medical costs incurred within the ED, inpatient and outpatient sectors during the post-index injury follow-up period

Health sector	Direct medical costs (£)
ED	1,207,531
Inpatient	29,394,037
Outpatient	6,620,546

Based on the 12,026 ED attendances, 9,010 inpatient admissions, equating to 62,632 inpatient bed days, and 50,214 outpatient contacts observed during the post-index injury period (Table 6.1) the estimated direct medical costs incurred by the ED, inpatient and outpatient sectors during the post-index injury period equate to £1,207,531, £29,394,037 and £6,620,546, respectively (Table 7.1).

To then determine estimates of the direct medical costs predicted as having been accumulated by each health service provider during the follow-up period in the absence of an index injury, the direct medical cost figures associated with the healthcare events observed during the pre-index injury period were multiplied by an extrapolation factor, based on the length of the post-index injury period relative to the length of the pre-index injury period, together with age and dataset expenditure trend adjustment factors. The formula for this extrapolation factor is presented in section 4.5.2.2 of Chapter 4.

Table 7.2: Direct medical costs incurred during the pre-index injury period and direct medical costs expected during the post-index injury period within the ED, inpatient and outpatient sectors

Healthcare sector	**Direct medical costs observed pre-index injury (£)**	**Direct medical costs expected post-index injury (£)**
ED	1,460,564	841,369
Inpatient	28,839,070	14,430,479
Outpatient	8,152,445	4,393,066

Based on the assumption that the extent of the direct medical costs expected during the post-index injury period in the absence of an index injury will mirror the extent of the direct medical costs observed during the pre-index injury period, the estimated direct medical costs within the ED, inpatient and outpatient healthcare sectors which are associated with the former are £841,369, £14,430,479 and £4,393,066, respectively. It is apparent that the size of the predicted direct medical costs is less than that observed pre-index injury and this reflects the fact that on average each member of the injured cohort were followed up during the post-index injury period for 352 fewer days compared to the length of the pre-index injury monitoring period per individual (Table 6.3).

With knowledge of the extent of direct medical costs predicted during the follow-up period in the absence of an index injury, it then proved possible to calculate an estimated excess direct medical costs figure for each healthcare sector by subtracting the expected direct medical cost totals listed in Table 7.2 from the observed direct medical cost totals (Table 7.1).

Table 7.3: Excess direct medical costs based on the difference between the estimated direct medical costs of the healthcare events observed and expected during the post-index injury period

Healthcare sector	Direct medical costs observed post-index injury (£)	Direct medical costs expected post-index injury (£)	Direct medical costs of excess healthcare contacts (£)
ED	1,207,531	841,369	366,161
Inpatient	29,394,037	14,430,479	14,963,558
Outpatient	6,620,546	4,393,066	2,227,480

It follows from Table 7.3 above that the total direct medical costs estimated as having been incurred by the ED sector during the course of the post-index injury period equated to £1,207,531. However, in the absence of an index injury direct medical costs in the region of £841,369 were expected to have been accumulated by the ED sector over the equivalent time period. Hence, the index injuries sustained by the injured cohort followed up as part of this investigation result in an estimated excess direct medical cost outlay of around £366,161 being generated by the ED sector. In the same way the excess direct medical costs incurred by the inpatient and outpatient sectors are estimated to be around £14,963,558 and £2,227,480, respectively, with these excess totals based on observed and expected direct medical costs within the inpatient sector of £29,394,037 and £14,430,479, and within the outpatient sector of £6,620,546 and £4,393,066, respectively.

7.4.2. Excess direct medical costs by healthcare sector

Within this section the excess direct medical cost findings reported above are stratified in terms of the age and gender of the individuals within the injured cohort, and the type of index injury sustained. First this will be undertaken individually for the ED, inpatient and outpatient healthcare sectors, and then in respect to the aggregated excess direct medical costs estimated to have arisen across all three healthcare sectors combined. Throughout this section the excess direct medical costs will be presented at a per index injury level, revealing the average excess direct medical costs following an index injury.

7.4.2.1. ED sector

With the 30,387 index injuries sustained by the injured cohort under investigation as part of this study culminating in total excess ED treatment costs of £366,162, it follows that an index injury can be considered as resulting in an excess direct medical cost of £12.05 (95% CI: £11.05, £13.05; p-value < 0.05) being incurred by the ED sector on average.

Table 7.4: Mean excess ED direct medical costs per index injury by age group, gender and socioeconomic classification

	Mean excess ED direct medical costs per index injury (£)	95% Confidence Interval		p-value
		Lower limit (£)	Upper limit (£)	
Total	12.05	11.05	13.05	0.00
0 – 4	9.97	6.52	13.41	0.00
5 – 9	13.96	11.18	16.75	0.00
10 – 14	11.40	8.46	14.34	0.00
15 – 19	16.01	12.88	19.15	0.00
20 – 24	9.92	6.29	13.55	0.00
25 – 29	12.47	8.03	16.91	0.00
30 – 34	9.64	5.55	13.73	0.00
35 – 39	10.65	6.82	14.48	0.00
40 – 44	11.13	7.67	14.60	0.00
45 – 49	8.45	2.69	14.21	0.00
50 – 54	17.75	1.43	34.06	0.03
55 – 59	9.74	5.32	14.17	0.00
60 – 64	8.28	2.92	13.64	0.00
65 – 69	13.20	8.33	18.08	0.00
70 – 74	10.27	5.59	14.95	0.00
75 – 79	13.29	7.99	18.60	0.00
80 – 84	17.27	10.14	24.41	0.00
85+	21.94	14.73	29.14	0.00
Least deprived	9.74	7.75	11.74	0.00
Next least deprived	13.22	11.04	15.39	0.00
Middle deprived	12.06	9.67	14.45	0.00
Next most deprived	12.00	9.26	14.73	0.00
Most deprived	12.96	11.00	14.92	0.00
Male	12.08	10.67	13.49	0.00
0 – 4	11.88	7.14	16.62	0.00

	Mean excess ED direct medical costs per index injury (£)	95% Confidence Interval		p-value
		Lower limit (£)	Upper limit (£)	
5 – 9	12.19	8.38	16.00	0.00
10 – 14	13.00	9.38	16.61	0.00
15 – 19	16.63	12.50	20.76	0.00
20 – 24	9.88	5.44	14.31	0.00
25 – 29	10.88	4.98	16.78	0.00
30 – 34	9.62	3.93	15.32	0.00
35 – 39	11.93	6.57	17.29	0.00
40 – 44	11.74	6.93	16.55	0.00
45 – 49	**2.61**	**-6.10**	**11.32**	**0.56**
50 – 54	29.73	5.99	53.46	0.02
55 – 59	9.90	2.85	16.96	0.01
60 – 64	**3.66**	**-5.92**	**13.23**	**0.45**
65 – 69	10.00	1.65	18.34	0.02
70 – 74	17.30	8.99	25.60	0.00
75 – 79	16.85	6.87	26.84	0.00
80 – 84	**15.98**	**-1.78**	**33.74**	**0.08**
85+	26.53	13.58	39.48	0.00
Least deprived	9.39	6.47	12.32	0.00
Next least deprived	11.75	8.83	14.67	0.00
Middle deprived	13.47	10.18	16.75	0.00
Next most deprived	11.51	7.73	15.29	0.00
Most deprived	13.55	10.75	16.35	0.00
Female	12.02	10.62	13.42	0.00
0 – 4	7.42	2.46	12.39	0.00
5 – 9	16.08	11.99	20.17	0.00
10 – 14	8.89	3.90	13.88	0.00
15 – 19	14.98	10.23	19.73	0.00
20 – 24	10.01	3.66	16.35	0.00
25 – 29	15.27	8.78	21.76	0.00
30 – 34	9.66	3.98	15.34	0.00
35 – 39	8.93	3.56	14.29	0.00
40 – 44	10.39	5.41	15.38	0.00
45 – 49	14.10	6.53	21.67	0.00
50 – 54	**4.17**	**-18.15**	**26.48**	**0.71**
55 – 59	9.60	4.02	15.18	0.00
60 – 64	12.17	6.46	17.89	0.00
65 – 69	15.29	9.33	21.24	0.00
70 – 74	6.68	1.03	12.34	0.02
75 – 79	11.95	5.68	18.22	0.00
80 – 84	17.76	10.52	25.00	0.00
85+	20.76	12.32	29.20	0.00
Least deprived	10.14	7.48	12.80	0.00
Next least deprived	14.93	11.68	18.18	0.00
Middle deprived	10.33	6.85	13.80	0.00
Next most deprived	12.60	8.64	16.56	0.00
Most deprived	12.22	9.54	14.89	0.00

There is no major difference in the mean excess ED direct medical costs per index injury when comparing male (£12.08) and female (£12.02) members of the injured cohort, with each of these excess totals being statistically different from zero at the 95% level (p-value < 0.05). When considering males and females together, each 5 year age group exhibits a statistically significant excess ED treatment cost on average, with the highest excess costs evident amongst those aged 85+ (£21.94), 50 to 54 (£17.75), 80 to 84 (£17.27) and 15 to 19 (£16.01). In contrast, the lowest mean excess ED costs per index injury are associated with individuals aged 60 to 64 (£8.28) and 45 to 49 (£8.45). When focusing specifically on injured males all age ranges are statistically different from zero except 45 to 49 (p-value = 0.56), 60 to 64 (p-value = 0.45) and 80 to 84 (p-value = 0.08). Of the age ranges associated with a statistically significant excess ED direct medical cost the highest and lowest costs on average are apparent amongst males aged 50 to 54 (£29.73) and 30 to 34 (£9.62), respectively. For females only the 50 to 54 age range produces a mean excess ED cost per index injury that is not statistically different from zero (p-value = 0.71). Amongst the other 5 year age groups the highest excess ED treatment cost on average is applicable to individuals aged 85+ (£20.76), whilst the lowest is evident amongst the members of the injured cohort aged 70 to 74 (£6.68).

The findings concerning the excess cost of ED treatment on average being relatively constant across gender and age is in keeping with the lack of any real gender and age difference observed in terms of the number of excess ED attendances associated with a given index injury (as indicated in section 6.4.2.1. of Chapter 6). These results suggest the ED resources required to treat index injuries do not vary considerably depending on the gender or age of the injured individual.

It is apparent from Table 7.4 that irrespective of gender excess ED costs per index injury on average are lowest following index injuries sustained by members of the injured cohort classified as amongst the 'Least deprived'. This finding can be explained by the fact that the more well off in society tend to suffer from fewer ongoing medical conditions (Akker et al. 2000; Kosler et al. 2004), which means that when they sustain an injury they often respond better to treatment relative to more deprived individuals for whom the presence of co-morbidities is more frequent (Koval et al. 1998; Lew et al. 2002). It also tends to be the case that individuals from a less affluent socioeconomic grouping sustain more serious injuries (Hippisley-Cox et al. 2002; Park et al. 2009), which in turn require more complicated and thus more costly forms of treatment. When considering both genders together, as well as females separately, the highest mean excess ED costs arise when index injuries are sustained by individuals within the 'Next least deprived' socioeconomic group. For index injuries amongst males the highest excess ED costs on average occur amongst those within the 'Most deprived' (£13.55) group closely followed by the 'Middle deprived' group (£13.47).

Table 7.5: Mean excess ED direct medical costs per index injury by injury type and gender

	Mean excess ED direct medical costs per index injury (£)	95% Confidence Interval		p-value
		Lower limit (£)	Upper limit (£)	
Total	12.05	11.05	13.05	0.00
Skull-brain injury	28.44	6.82	50.05	0.01
Facial fracture, eye injury	**10.10**	**-3.62**	**23.82**	**0.15**
Spine, vertebrae	9.12	5.45	12.80	0.00
Internal organ injury	**19.38**	**-39.35**	**78.11**	**0.50**
Upper extremity fracture	12.37	9.75	14.99	0.00
Upper extremity, other injury	11.18	7.64	14.73	0.00
Hip fracture	**5.64**	**-4.34**	**15.63**	**0.27**
Lower extremity, fracture	12.07	8.92	15.23	0.00
Lower extremity, other injury	10.81	8.47	13.15	0.00
Superficial injury, open wounds	13.71	11.90	15.52	0.00
Burns	**3.05**	**-23.35**	**29.45**	**0.82**
Poisonings	12.95	3.57	22.34	0.01
Other injury	11.31	8.37	14.25	0.00
Male	12.08	10.67	13.49	0.00
Skull-brain injury	30.55	5.46	55.64	0.02
Facial fracture, eye injury	**10.73**	**-4.79**	**26.25**	**0.17**
Spine, vertebrae	6.76	0.96	12.56	0.02
Internal organ injury	**35.61**	**-37.39**	**108.61**	**0.31**
Upper extremity fracture	13.18	9.55	16.81	0.00
Upper extremity, other injury	11.06	5.46	16.66	0.00
Hip fracture	**8.80**	**-8.94**	**26.55**	**0.33**
Lower extremity, fracture	12.58	7.74	17.42	0.00
Lower extremity, other injury	10.39	7.15	13.62	0.00
Superficial injury, open wounds	13.49	11.09	15.88	0.00
Burns	**7.29**	**-27.54**	**42.13**	**0.68**
Poisonings	**13.55**	**-1.97**	**29.07**	**0.09**
Other injury	11.44	7.27	15.60	0.00
Female	12.02	10.62	13.42	0.00
Skull-brain injury	**18.14**	**-27.25**	**63.53**	**0.38**
Facial fracture, eye injury	**8.47**	**-20.63**	**37.56**	**0.56**
Spine, vertebrae	11.31	6.69	15.94	0.00

	Mean excess ED direct medical costs per index injury (£)	95% Confidence Interval		p-value
		Lower limit (£)	Upper limit (£)	
Internal organ injury	**-29.31**	**-153.66**	**95.04**	**0.55**
Upper extremity fracture	11.43	7.66	15.21	0.00
Upper extremity, other injury	11.31	7.05	15.57	0.00
Hip fracture	**4.45**	**-7.65**	**16.54**	**0.47**
Lower extremity, fracture	11.57	7.50	15.63	0.00
Lower extremity, other injury	11.28	7.89	14.68	0.00
Superficial injury, open wounds	14.03	11.27	16.80	0.00
Burns	**-7.90**	**-41.53**	**25.73**	**0.63**
Poisonings	12.46	1.00	23.93	0.03
Other injury	11.13	7.16	15.11	0.00

For males and females together the injury groupings that do not result in a mean excess direct medical ED cost per index injury statistically different from zero at the 95% confidence level include 'Facial fracture, eye injury' (p-value = 0.15), 'Internal organ injury' (p-value = 0.50), 'Hip fracture' (p-value = 0.27) and 'Burns' (p-value = 0.82). As discussed in the case of excess ED utilisation within section 6.4.2.1 of Chapter 6, this is due to these types of injury, especially hip fractures and internal organ injuries, bypassing ED treatment and being admitted straight to hospital (Augenstein et al. 1995; Livingston et al. 1998; Kannus et al. 1999; Cummings and Melton 2002). Of the categories that are statistically significant it is most costly on average to treat individuals within the ED sector that have sustained an index injury of 'Skull-brain injury' (£28.44), whilst lowest ED treatment costs are evident amongst the 'Spine, vertebrae' group of index injuries (£9.12).

Along with the four categories of injury already mentioned as not being statistically different from zero this is also the case for the 'Poisoning' grouping (p-value = 0.09) when solely considering male members of the injured cohort. In keeping with the findings observed when not stratifying by gender, the most and least costly of the statistically significant categories of index injuries to treat within the ED sector incurred by males are the 'Skull-brain injury' grouping (£30.55) and the 'Spine, vertebrae' grouping (£6.76), respectively. For females, there are five types of index injury not statistically significant, with this list including the four identified when considering both genders together and also the 'Skull-brain injury' category (p-value = 0.38). Of the injury groupings associated with a mean excess ED direct medical cost statistically different from zero, the highest and lowest treatment expenditures on average are among the 'Superficial injury, open wounds' (£14.03) and the 'Other injury' (£11.13) categories, respectively.

To a large extent the types of index injury that are statistically significant and associated with the most and least excess direct medical ED costs on average mirror those types of index injuries that are statistically significant and associated with the highest and lowest excess mean number of ED attendances per index injury (Table 6.6). That is, the more frequent the ED attendances following a given injury the more costly that injury becomes to treat within the ED sector. For instance, the categories of 'Skull-brain injury' and 'Superficial injury, open wounds', which attract the most excess ED treatment costs on average for males and females respectively, were also the type of index injury groupings associated with the highest mean number of excess ED attendances amongst these particular genders.

Table 7.6: Mean excess ED direct medical costs per index injury by external cause and gender

	Mean excess ED direct medical costs per index injury (£)	**95% Confidence Interval**		**p-value**
		Lower limit	**Upper limit**	
Total	12.05	11.05	13.05	0.00
Mechanism of injury				
Motor Vehicle Traffic Crash	**-10.39**	**-33.82**	**13.05**	**0.38**
Fall	**6.88**	**-4.80**	**18.55**	**0.25**
Burns	**-7.38**	**-45.09**	**30.33**	**0.70**
Cut/pierce	**3.42**	**-22.23**	**29.07**	**0.79**
Struck by/against	**-6.58**	**-33.85**	**20.55**	**0.63**
Poisoning	**7.44**	**-8.35**	**23.41**	**0.35**
Other	**-7.38**	**-16.70**	**2.09**	**0.13**
Location of injury				
Home	13.22	11.52	14.92	0.00
Work	11.34	7.67	15.01	0.00
RTA	11.57	7.74	15.40	0.00
Sport	**1.50**	**-12.71**	**15.70**	**0.83**
Other	12.42	10.97	13.81	0.00
Male	12.08	10.67	13.49	0.00

	Mean excess ED direct medical costs per index injury (£)	95% Confidence Interval		p-value
		Lower limit	Upper limit	
Mechanism of injury				
Motor Vehicle Traffic Crash	**-6.28**	**-37.83**	**25.26**	**0.69**
Fall	**11.42**	**-2.01**	**24.85**	**0.10**
Burns	**-2.02**	**-56.51**	**52.46**	**0.94**
Cut/pierce	**-3.56**	**-33.28**	**26.16**	**0.81**
Struck by/against	**-10.62**	**-44.65**	**23.41**	**0.54**
Poisoning	**8.01**	**-21.32**	**37.64**	**0.58**
Other	**-6.77**	**-18.04**	**4.62**	**0.24**
Location of injury				
Home	12.09	9.31	14.87	0.00
Work	11.05	6.86	15.25	0.00
RTA	9.05	3.04	15.06	0.00
Sport	**6.48**	**-12.93**	**25.89**	**0.51**
Other	13.68	11.80	15.56	0.00
Female	12.02	10.62	13.42	0.00
Mechanism of injury				
Motor Vehicle Traffic Crash	**-18.59**	**-53.67**	**16.48**	**0.28**
Fall	**1.63**	**-18.34**	**21.61**	**0.87**
Burns	**-18.09**	**-58.19**	**22.00**	**0.35**
Cut/pierce	**23.91**	**-31.60**	**79.41**	**0.37**
Struck by/against	**5.89**	**-31.69**	**44.01**	**0.74**
Poisoning	**7.05**	**-10.73**	**24.93**	**0.43**
Other	**-8.43**	**-25.01**	**8.37**	**0.33**
Location of injury				
Home	14.12	12.02	16.23	0.00
Work	12.16	4.57	19.75	0.00
RTA	14.20	9.51	18.89	0.00
Sport	**-9.99**	**-25.35**	**5.38**	**0.19**
Other	10.54	8.30	12.61	0.00

As observed in the case of the mean excess counts of ED attendances (Table 6.7) none of the mechanism of injury categories are associated with a statistical significant mean excess ED cost (p-values > 0.05). This finding is most likely a reflection of the fact that index injuries treated first at an ED could not be categorised into a mechanism of injury grouping due to this type of information not being recorded within the ED dataset analysed as part of this study, meaning only the relatively small number (n = 1,212) of index injuries initially in receipt of inpatient treatment could be stratified according to the mechanism of injury. Furthermore, given injuries requiring admission to hospital are likely to be more serious than injuries requiring only treatment at an ED, it follows that the former are also more likely to need subsequent inpatient and or outpatient medical attention during the post-index injury period than they would need subsequent medical attention provided within the ED.

The location of injury category of 'Sport' exhibits a statistically insignificant mean excess ED cost, with this the case for both genders together (p-value = 0.83) as well as males (p-value = 0.51) and females separately (p-value = 0.19). This reflects the relatively small number of index injuries taking place at a sports setting (n = 76), plus sport related injuries often receiving ongoing treatment within outpatients as opposed to at an ED (Table 6.16). The remaining location of index injury groupings are associated with a statistically significant excess ED cost on average, with index injuries taking place at a 'Home' and 'Other' settings tending to be the most costly to treat within the ED.

7.4.2.2. Inpatient sector

Reflecting the much larger overall excess direct medical costs incurred by the inpatient sector compared to the ED sector the excess inpatient treatment cost per index injury of £492.43 (95% CI: £415.66, £569.21; p-value < 0.05) is considerably larger than the ED equivalent (£12.05).

Table 7.7: Mean excess inpatient direct medical costs per index injury by age group, gender and socioeconomic classification

	Mean excess inpatient direct medical costs per index injury (£)	**95% Confidence Interval**		**p-value**
		Lower limit (£)	**Upper limit (£)**	
Total	492.43	415.66	569.21	0.00
0 – 4	**14.93**	**-46.88**	**76.74**	**0.64**
5 – 9	**-3.59**	**-52.05**	**44.87**	**0.89**
10 – 14	**17.28**	**-70.77**	**105.32**	**0.70**
15 – 19	106.95	28.46	185.44	0.01
20 – 24	149.28	55.86	242.69	0.00
25 – 29	**151.71**	**-3.10**	**306.52**	**0.06**
30 – 34	158.48	16.13	300.83	0.03
35 – 39	317.74	149.37	486.11	0.00

	Mean excess inpatient direct medical costs per index injury (£)	95% Confidence Interval		p-value
		Lower limit (£)	Upper limit (£)	
40 – 44	**169.17**	**-22.49**	**360.84**	**0.08**
45 – 49	213.48	15.40	411.56	0.04
50 – 54	**654.54**	**-30.80**	**1,339.89**	**0.06**
55 – 59	**524.96**	**-68.63**	**1,118.55**	**0.08**
60 – 64	**395.35**	**-280.50**	**1,071.19**	**0.25**
65 – 69	727.32	159.67	1,294.97	0.01
70 – 74	1,661.25	1,081.53	2,240.96	0.00
75 – 79	2,979.44	1,714.04	4,244.83	0.00
80 – 84	4,154.86	2,753.63	5,556.09	0.00
85+	5,400.92	4,042.53	6,759.31	0.00
Least deprived	416.33	248.70	583.95	0.00
Next least deprived	466.68	279.76	653.60	0.00
Middle deprived	493.28	337.64	648.92	0.00
Next most deprived	605.37	391.09	819.65	0.00
Most deprived	496.48	353.75	639.20	0.00
Male	263.35	184.17	342.53	0.00
0 – 4	**8.75**	**-91.99**	**109.49**	**0.87**
5 – 9	**-23.29**	**-109.04**	**62.46**	**0.59**
10 – 14	**12.50**	**-12.85**	**37.85**	**0.33**
15 – 19	**44.32**	**-0.82**	**89.46**	**0.05**
20 – 24	164.76	47.70	281.82	0.01
25 – 29	170.23	3.15	337.30	0.05
30 – 34	**98.97**	**-63.78**	**261.72**	**0.23**
35 – 39	341.15	78.62	603.67	0.01
40 – 44	**112.95**	**-35.02**	**260.92**	**0.13**
45 – 49	**295.47**	**-9.86**	**600.79**	**0.06**
50 – 54	**1,069.93**	**-146.98**	**2,286.84**	**0.08**
55 – 59	1,240.83	94.87	2,386.79	0.03
60 – 64	**-193.95**	**-1,276.90**	**889.01**	**0.73**
65 – 69	**798.72**	**-55.51**	**1,652.92**	**0.07**
70 – 74	2,313.70	1,185.52	3,441.88	0.00
75 – 79	**1,216.43**	**-575.69**	**3,008.54**	**0.18**
80 – 84	2,591.11	370.40	4,811.82	0.02
85+	4,705.39	1,442.25	7,968.54	0.01
Least deprived	182.82	3.02	362.63	0.05
Next least deprived	249.71	126.40	373.03	0.00
Middle deprived	142.56	4.47	280.64	0.04
Next most deprived	358.00	124.34	591.65	0.00
Most deprived	335.98	170.10	501.87	0.00
Female	769.61	629.69	909.54	0.00
0 – 4	**23.16**	**-29.78**	**76.09**	**0.39**
5 – 9	**19.99**	**-8.46**	**48.44**	**0.17**
10 – 14	**24.75**	**-197.71**	**247.21**	**0.83**
15 – 19	212.33	15.90	408.76	0.03
20 – 24	**119.14**	**-35.51**	**273.79**	**0.13**
25 – 29	**119.10**	**-191.52**	**429.72**	**0.45**
30 – 34	**245.17**	**-12.26**	**502.59**	**0.06**
35 – 39	286.29	108.84	463.73	0.00
40 – 44	**237.44**	**-147.43**	**622.32**	**0.23**
45 – 49	**134.06**	**-121.30**	**389.41**	**0.30**
50 – 54	**183.77**	**-327.85**	**695.39**	**0.48**

	Mean excess inpatient direct medical costs per index injury (£)	95% Confidence Interval		p-value
		Lower limit (£)	Upper limit (£)	
55 – 59	**-91.31**	**-587.00**	**404.37**	**0.72**
60 – 64	891.23	42.75	1,739.72	0.04
65 – 69	**680.89**	**-75.52**	**1,437.31**	**0.08**
70 – 74	1,327.75	667.35	1,988.14	0.00
75 – 79	3,645.28	2,039.11	5,251.45	0.00
80 – 84	4,742.41	3,003.18	6,481.64	0.00
85+	5,579.62	4,086.65	7,072.58	0.00
Least deprived	684.74	389.79	979.69	0.00
Next least deprived	720.91	341.65	1100.18	0.00
Middle deprived	925.85	623.69	1228.01	0.00
Next most deprived	912.80	530.05	1295.55	0.00
Most deprived	696.53	451.52	941.53	0.00

Whilst the mean excess inpatient direct medical cost per index injury is statistically different from zero at the 95% confidence level (p-value < 0.05) for both males and females, the figure applicable to the latter gender is very nearly 3 times as large as the equivalent figure for males (£769.61 versus £263.35). This marked difference in terms of the size of the excess direct medical inpatient costs associated with male and female members of the injured cohort suggests that the length of stay as an inpatient represents the major predictor of inpatient treatment costs. In Chapter 6 it was shown that the excess number of inpatient admissions on average was relatively constant between males and females (Table 6.8), whereas a considerably larger number of excess inpatient bed-days were found to follow an index injury sustained by a female member of the injured cohort (Table 6.11). Hence, the direct medical costs of inpatient treatment appear to be more positively related to the length of inpatient admissions as opposed to the frequency of the admissions.

When considering males and females together the age ranges with a statistically significant mean excess inpatient treatment cost include 15 to 24, 30 to 39, 45 to 49 and 65+ year olds. For the younger age ranges in this list, especially the 15 to 24 year olds, the association with an excess inpatient cost on average that is statistically different from zero reflects the tendency for these individuals to be involved with activities, such as dangerous driving, that frequently result in the suffering of serious injuries requiring lengthy inpatient stays (Turner and McClure 2003). Similarly the statistically significant mean excess inpatient treatment cost applicable to those members of the injured cohort aged 65+ is most likely a reflection of the fact that the majority of injuries sustained by this demographic subgroup tend to be serious enough to warrant a lengthy admission to hospital (Shabot and Johnson 1995; Horan and Little 1998).

The excess inpatient costs per index injury are markedly higher among the older ages and sharply increase from one age group to the next, ranging from £727.32 for individuals aged 65 to 69, to £5,400.92 for those aged 85+. This tendency for excess inpatient treatment costs on average to be far greater amongst the more elderly members of the injured cohort is additionally observed when focusing on males and females separately. In the case of the former, the three highest mean excess inpatient direct medical costs per index injury of £4,705.39, £2,591.11 and £2,313.70 each occur at the ages of 85+, 80 to 84 and 70 to 74, respectively. Similarly in the case of females, whereas the highest mean excess inpatient treatment costs up to the age of 69 equates to £891.23, for those aged 70+ the equivalent costs range from £1,327.75 to £5,579.62. The evident positive relationship between the mean excess costs of inpatient treatment and the age of the injured individual reflects both the equally positive relationship observed between age and the number of excess inpatient admissions (Table 6.8) and the length of the excess inpatient admissions (Table 6.11). As discussed in Chapter 6 the older individuals within the population are far more susceptible to injuries that not only warrant admission to hospital but additionally require continued treatment and observation for a prolonged period (Shabot and Johnson 1995; Horan and Little 1998). Inevitably therefore older aged individuals attract a far greater amount of inpatient resources to treat their injuries relative to younger aged individuals, resulting in a higher excess direct medical inpatient treatment cost per index injury.

Across all index injuries by far the highest mean excess inpatient cost arises following index injuries sustained by members of the injured cohort categorised within the 'Next most deprived' socioeconomic grouping (£605.37). This reflects the high number of excess inpatient bed-days also associated with individuals assigned this level of deprivation (Table 6.11). The remaining socioeconomic categories are generally very similar, although it is apparent that excess inpatient costs are lowest amongst individuals within the 'Least deprived' grouping (£416.33).

When focusing on males specifically the 'Next most deprived' socioeconomic grouping is associated with the highest mean excess inpatient costs per index injury (£358.00) but in this instance the 'Most deprived' category follows close behind (£335.98). Index injuries sustained by males classified with this level of deprivation lead to excess costs being incurred by the inpatient sector that are much higher than that observed when index injuries are sustained by males in the 'Next least deprived' (£249.71), 'Least deprived' (£182.82) and 'Middle deprived' (£142.56) socioeconomic groups. With regards to index injuries sustained by females excess inpatient costs per index injury are lowest on average when sustained by females within the 'Least deprived' category (£684.74), although index injuries sustained by females in the 'Most deprived' category also lead to low excess inpatient costs (£696.53). It is apparent from Table 7.7 that highest excess inpatient costs result when index injuries are sustained by females associated with the socioeconomic groupings of 'Middle deprived' (£925.85) and 'Next most deprived' (£912.80).

In general there appears to be a positive relationship between the socioeconomic status of the injured cohort followed up as part of this study and the size of the excess costs incurred within the inpatient sector. This can be accounted for by more deprived individuals possessing more co-morbidities on average than less deprived individuals (Akker et al. 2000; Kosler et al. 2004), meaning the former possess a reduced capacity to respond well to treatment following injury (Koval et al. 1998; Lew et al. 2002), which thereby leads to a higher number of lengthy and costly inpatient stays. Several studies additionally report a positive relationship between the level of deprivation associated with an individual and the severity of the injury they sustain (Hippisley-Cox et al. 2002; Park et al. 2009). More severe injuries tend to be more costly to treat given the need for a more resource intensive form of medical treatment being required. The level of severity associated with the index injuries sustained by the injured cohort followed up as part of this study could not be deduced however, meaning further research is necessary in order to ascertain whether the increased severity of the injury incurred by the most deprived represents a valid explanation for the higher excess inpatient treatment costs observed in this study.

Table 7.8: Mean excess inpatient direct medical costs per index injury by injury type and gender

	Mean excess inpatient direct medical costs per index injury (£)	95% Confidence Interval		p-value
		Lower limit (£)	Upper limit (£)	
Total	492.43	415.66	569.21	0.00
Skull-brain injury	5,985.37	1,043.47	10,927.27	0.02
Facial fracture, eye injury	**120.06**	**-227.65**	**467.76**	**0.50**
Spine, vertebrae	358.69	122.38	595.00	0.00
Internal organ injury	**2,656.88**	**-1,487.81**	**6,801.56**	**0.20**
Upper extremity fracture	522.04	285.12	758.95	0.00
Upper extremity, other injury	**31.10**	**-99.00**	**161.20**	**0.64**
Hip fracture	10,136.77	7,748.23	12,525.30	0.00
Lower extremity, fracture	1,205.56	797.83	1,613.29	0.00
Lower extremity, other injury	282.46	124.58	440.35	0.00
Superficial injury, open wounds	267.54	137.53	397.56	0.00
Burns	**551.49**	**-354.41**	**1,457.40**	**0.23**
Poisonings	1,043.07	427.94	1,658.21	0.00
Other injury	392.76	236.95	548.58	0.00
Male	263.35	184.17	342.53	0.00
Skull-brain injury	6,797.30	840.10	12,754.51	0.03
Facial fracture, eye injury	**-98.39**	**-461.81**	**265.03**	**0.59**
Spine, vertebrae	602.64	157.34	1,047.95	0.01
Internal organ injury	**2,666.14**	**-2,699.80**	**8,032.08**	**0.31**
Upper extremity fracture	**190.86**	**-9.40**	**391.11**	**0.06**
Upper extremity, other injury	**-15.46**	**-86.12**	**55.21**	**0.67**
Hip fracture	6,880.07	3,445.04	10,315.11	0.00
Lower extremity, fracture	340.00	138.62	541.38	0.00
Lower extremity, other injury	208.01	71.55	344.46	0.00
Superficial injury, open wounds	**155.94**	**-1.66**	**313.53**	**0.05**
Burns	**766.27**	**-483.69**	**2,016.23**	**0.22**
Poisonings	914.29	127.18	1,701.40	0.02
Other injury	259.26	87.66	430.86	0.00
Female	769.61	629.69	909.54	0.00
Skull-brain injury	**2,027.20**	**-144.08**	**4,198.48**	**0.06**
Facial fracture, eye injury	**684.37**	**-137.16**	**1,505.90**	**0.10**
Spine, vertebrae	**132.71**	**-59.77**	**325.19**	**0.18**
Internal organ injury	**2,629.08**	**-5,599.16**	**10,857.32**	**0.43**
Upper extremity fracture	908.39	451.70	1,365.07	0.00
Upper extremity, other injury	**80.44**	**-177.01**	**337.88**	**0.54**
Hip fracture	11,368.65	8,345.11	14,392.18	0.00
Lower extremity, fracture	2,067.86	1,281.81	2,853.91	0.00
Lower extremity, other injury	365.56	68.09	663.03	0.02
Superficial injury, open wounds	426.94	205.56	648.31	0.00
Burns	**-2.40**	**-527.81**	**523.00**	**0.99**
Poisonings	1,148.94	230.13	2,067.75	0.01
Other injury	578.81	292.62	865.00	0.00

When considering both genders together most of the index injury groupings listed in Table 7.8 are statistically different from zero at the 95% confidence level, with the exceptions being the categories of 'Facial fracture, eye injury' (p-value = 0.50), 'Internal organ injury' (p-value = 0.20), 'Upper extremity, other injury' (p-value = 0.64) and 'Burns' (p-value = 0.23). These types of injury either tend to be relatively uncommon, such as injuries to the internal organs (Krige et al. 2005; Burkitt et al. 2007; Povýsil et al. 2009), or increasingly dealt with in non-inpatient settings, like certain injuries to the upper extremity (Hensher et al. 1999; Bernstein et al. 2003).

Of the groupings associated with a statistically significant mean excess inpatient treatment cost per index injury the types of index injury most and least costly to treat within the inpatient sector are 'Hip fracture' (£10,136.77) and 'Superficial injury, open wounds' (£267.54), respectively. The dominance of costs by hip fracture related index injuries largely reflects both the high number and long length of inpatient admissions associated with these types of injury, especially amongst older female members of the injured cohort (Table 6.9 and Table 6.12). The opposite is the case for superficial/open wound type injuries.

When focusing on males specifically, along with the injury groupings with no statistically significant excess inpatient cost identified when considering both genders together, the categories of 'Upper extremity fracture' (p-value = 0.06) and 'Superficial injury, open wounds' (p-value = 0.05) are also not statistically different from zero at the 95% confidence level. This reflects the tendency for fractures to the upper extremity to be treated more often in recent years within non-inpatient settings (Hensher et al. 1999; Bernstein et al. 2003), and superficial injuries/open wounds to be dealt with at an ED without the need for subsequent admission to hospital given their usual lack of seriousness. Of the injury groupings for males exhibiting a statistically significant excess inpatient cost on average the most costly type of index injury to treat in the inpatient sector are those classified within the 'Hip fracture' category (£6,880.07) closely followed by those in the 'Skull-brain injury' category (£6,797.30). By contrast, the types of index injury incurred by males that exhibit statistical significance and generate the least excess direct medical costs within the inpatient sector are those classified within the 'Lower extremity, other injury' category (£208.01). In the case of female members of the injured cohort along with the four type of injury categories found not to exhibit a statistically significant mean excess inpatient cost per index injury that were identified when considering both genders together, the categories of 'Skull-brain injury' (p-value = 0.06) and 'Spine, vertebrae' (p-value = 0.18) are also not associated with a per index injury excess inpatient treatment cost on average that is statistically different from zero at the 95% confidence level, reflecting the infrequency of these types of injuries among females. Amongst the other injury groupings the most and least costly type of index injuries to treat within the inpatient sector for females are those within the categories of 'Hip fracture' (£11,368.65) and 'Lower extremity, other injury' (£365.56), respectively.

The high excess inpatient treatment costs associated with hip fractures that are observed amongst female members of the injured cohort is to be expected given the high number of excess inpatient admissions and bed-days resulting from index injuries sustained by females within this particular injury grouping. The finding that hip fractures are the most costly type of index injuries amongst males however is more surprising and signifies that although hip fracture injuries sustained by this gender result in fewer lengthy excess inpatient admissions compared to females they still represent a major source of excess inpatient treatment costs per index injury. Like in the case of females this is a reflection of the fact that older males in particular also possess a reduced capacity to respond to medical care following debilitating injuries such as hip fractures (Shabot and Johnson 1995; Horan and Little 1998). The most likely explanation as to why the injury grouping of 'Lower extremity, other injury' is associated with the lowest statistically significant excess inpatient cost per index injury when focusing on males and females separately concerns these types of injury increasingly being dealt with in non-inpatient settings (Hensher et al. 1999; Bernstein et al. 2003), thereby reducing the need for lengthy, and thus costly, inpatient treatment.

Table 7.9: Mean excess inpatient direct medical costs per index injury by external cause and gender

	Mean excess inpatient direct medical costs per index injury (£)	95% Confidence Interval		p-value
		Lower limit	Upper limit	
Total	492.43	415.66	569.21	0.00
Mechanism of injury				
Motor Vehicle Traffic Crash	5,116.88	22.91	10,210.86	0.05
Fall	3,073.93	1,842.67	4,305.20	0.00
Burns	**137.67**	**-495.88**	**771.21**	**0.66**
Cut/pierce	**192.73**	**-60.90**	**446.37**	**0.13**
Struck by/against	**736.42**	**-253.67**	**1,726.50**	**0.14**
Poisoning	1,542.87	241.42	2,844.32	0.02
Other	**830.80**	**-125.25**	**1,786.85**	**0.09**
Location of injury				
Home	841.23	670.34	1,012.12	0.00
Work	123.50	43.88	203.12	0.00
RTA	222.32	114.73	329.90	0.00
Sport	**199.42**	**-6.09**	**404.93**	**0.06**
Other	213.28	131.05	295.30	0.00
Male	263.35	184.17	342.53	0.00
Mechanism of injury				
Motor Vehicle Traffic Crash	**7,207.72**	**-383.99**	**14,799.44**	**0.06**
Fall	1,770.38	230.20	3,310.56	0.02
Burns	**210.11**	**-704.03**	**1,124.26**	**0.64**
Cut/pierce	**159.71**	**-109.27**	**428.68**	**0.24**
Struck by/against	**654.41**	**-434.38**	**1,743.20**	**0.23**
Poisoning	1,862.03	10.67	3,713.38	0.04
Other	**121.67**	**-358.77**	**602.11**	**0.62**
Location of injury				
Home	391.66	228.05	555.28	0.00
Work	97.47	27.24	167.71	0.01
RTA	213.16	65.80	360.51	0.00
Sport	**233.33**	**-28.19**	**494.86**	**0.08**
Other	149.23	39.38	258.98	0.01
Female	769.61	629.69	909.54	0.00
Mechanism of injury				
Motor Vehicle Traffic Crash	**935.20**	**-1,377.26**	**3,247.66**	**0.41**
Fall	4,578.78	2,619.49	6,538.06	0.00
Burns	**-7.23**	**-691.66**	**677.20**	**0.98**
Cut/pierce	**289.75**	**-385.33**	**964.83**	**0.37**
Struck by/against	**989.58**	**-1,463.23**	**3,442.38**	**0.39**
Poisoning	**1,320.29**	**-486.20**	**3,126.78**	**0.15**
Other	**2,057.41**	**-414.79**	**4,529.62**	**0.11**

	Mean excess inpatient direct medical costs per index injury (£)	95% Confidence Interval		p-value
		Lower limit	Upper limit	
Location of injury				
Home	1,202.11	923.72	1,480.50	0.00
Work	**198.35**	**-35.47**	**432.16**	**0.10**
RTA	231.89	74.47	389.31	0.00
Sport	**121.27**	**-219.33**	**461.87**	**0.47**
Other	309.55	186.77	431.88	0.00

When considering both genders together the mechanism of injury categories of 'Burns' (p-value = 0.66), 'Cut/pierce' (p-value = 0.13), 'Struck by/against' (p-value = 0.14) and 'Other' (p-value = 0.09) each incur a mean excess cost to the inpatient sector that is not statistically different from zero at the 95% confidence level. This is most likely due to the injuries arising from these mechanisms not being serious enough to lead to costly ongoing treatment as an inpatient. Burn injuries, for instance, are often in receipt of subsequent phases of treatment within an outpatient setting (Table 6.16). Amongst the statistically significant mechanism of injury categories the highest mean excess inpatient cost is generated following an index injury sustained in an MVTC incident (£5116.88), with the next highest associated with a fall related incident (£3073.93). These findings reflect the seriousness of any injury sustained in an MVTC incident, at any age and gender, and the seriousness of hip fractures resulting from falls amongst older females, both of which can lead to a long and costly stay in hospital as an inpatient.

In the case of index injuries sustained by males the highest mean excess inpatient cost arises when an index injury results from a MVTC mechanism of injury (£7,207.72), however in this instance this category does not exhibit statistical significance (p-value = 0.06). This is surprising given the tendency for young males to partake in high risk driving that frequently leads to serious trauma being incurred that often require multiple and lengthy periods of inpatient treatment. Potential explanations for this include the relatively small number of index injuries associated with the MVTC cause (n = 36), plus the possibility of inadequate coding of this particular cause of injury within inpatient settings due perhaps to the urgency with which MVTC trauma cases are admitted to hospital, although further research is required to verify this. Amongst the statistically significant mechanism of injury categories for males, index injuries resulting from a poisoning cause result in the highest excess inpatient costs on average (£1,862.03). Males in particular may be more susceptible to serious poisoning type injuries than females due to their increased risk of suicide (Nordström, Samuelsson and Asberg 1995; Hawton, Zahl and Weatherall 2003). The majority of poisoning admissions to hospital will be to manage mental health problems and reduce the risk of further self-harm rather than the treatment of the poisoning related condition. The most costly index injuries treated within the inpatient sector amongst females result from fall incidents (£4,578.78). Older aged females are frequent fallers who often suffer hip fractures which result in long periods of inpatient treatment due to their reduced capacity to respond to treatment (Shabot and Johnson 1995; Horan and Little 1998).

Irrespective of gender index injuries incurred at a sports location are not associated with a mean excess inpatient cost that is statistically different from zero. This reflects the relatively small number of index injuries sustained through sport (n = 76), plus the tendency for sports related injuries to receive treatment post-injury within an outpatient as opposed to an inpatient setting (Table 6.16). Index injuries amongst females occurring at a work location also exhibit statistical insignificant mean excess inpatient costs. This finding can largely be accounted for by the fact that females tend to work in less dangerous occupations that have a relatively low risk of serious injury (U.S. Department of Labor, Bureau of Labor Statistics 1998).

Index injuries sustained in the home account for the largest share of excess inpatient treatment costs, with this the case for males and females. The extent to which the mean excess inpatient cost per index injury incurred at a home location exceeds the other location of injury categories is most marked for females however. The mean excess inpatient cost is £1,202.11 for injuries in the home compared to the next highest of £309.55 associated with the 'Other' location of injury category. This finding reflects the high number of hip fracture falls amongst elderly females that most frequently occur within the home.

7.4.2.3. Outpatient sector

The total figure of £2,227,480 excess direct medical costs incurred by the outpatient sector across the 30,387 index injuries equates to a per index injury excess outpatient expenditure average of £73.30 (95% CI: £68.44, £78.17; p-value < 0.05).

Table 7.10: Mean excess outpatient direct medical costs per index injury by age group, gender and socioeconomic classification

	Mean excess outpatient direct medical costs per index injury (£)	**95% Confidence Interval**		**p-value**
		Lower limit (£)	**Upper limit (£)**	
Total	73.30	68.44	78.17	0.00
0 – 4	49.61	35.14	64.09	0.00
5 – 9	71.67	53.79	89.56	0.00
10 – 14	52.38	32.57	72.19	0.00
15 – 19	51.50	37.99	65.01	0.00
20 – 24	57.62	46.08	69.16	0.00
25 – 29	57.14	41.35	72.93	0.00
30 – 34	61.60	45.11	78.09	0.00
35 – 39	76.87	61.47	92.28	0.00
40 – 44	65.38	51.88	78.88	0.00
45 – 49	78.71	54.12	103.31	0.00
50 – 54	96.16	21.32	171.01	0.01
55 – 59	91.86	61.99	121.73	0.00
60 – 64	112.79	87.64	137.94	0.00
65 – 69	132.28	103.01	161.54	0.00
70 – 74	135.89	105.09	166.70	0.00
75 – 79	136.82	107.72	165.93	0.00
80 – 84	119.04	86.56	151.52	0.00
85+	148.05	118.88	177.22	0.00
Least deprived	85.07	74.83	95.31	0.00
Next least deprived	64.41	51.75	77.07	0.00
Middle deprived	70.00	56.41	83.58	0.00
Next most deprived	73.95	61.96	85.93	0.00
Most deprived	71.75	63.55	79.94	0.00
Male	70.61	64.53	76.70	0.00
0 – 4	53.28	33.42	73.14	0.00
5 – 9	70.97	42.46	99.48	0.00
10 – 14	51.62	28.71	74.52	0.00
15 – 19	51.39	38.21	64.58	0.00
20 – 24	75.26	61.97	88.55	0.00
25 – 29	59.93	45.23	74.63	0.00
30 – 34	66.57	48.45	84.70	0.00
35 – 39	76.33	58.02	94.64	0.00
40 – 44	68.02	51.17	84.86	0.00
45 – 49	88.19	53.80	122.57	0.00

	Mean excess outpatient direct medical costs per index injury (£)	95% Confidence Interval		p-value
		Lower limit (£)	Upper limit (£)	
50 – 54	124.72	26.42	223.02	0.01
55 – 59	85.14	55.43	114.86	0.00
60 – 64	107.57	68.42	146.71	0.00
65 – 69	126.09	82.12	170.07	0.00
70 – 74	99.34	52.11	146.57	0.00
75 – 79	134.58	76.28	192.88	0.00
80 – 84	151.40	88.65	214.15	0.00
85+	184.03	109.55	258.51	0.00
Least deprived	66.93	52.96	80.90	0.00
Next least deprived	74.19	58.45	89.93	0.00
Middle deprived	56.43	40.39	72.47	0.00
Next most deprived	83.17	67.64	98.71	0.00
Most deprived	71.91	62.00	81.82	0.00
Female	76.56	68.74	84.38	0.00
0 – 4	44.72	23.71	65.74	0.00
5 – 9	72.51	52.99	92.03	0.00
10 – 14	53.57	17.52	89.63	0.00
15 – 19	51.68	22.99	80.37	0.00
20 – 24	23.29	1.34	45.24	0.04
25 – 29	52.22	17.08	87.37	0.00
30 – 34	54.35	23.59	85.12	0.00
35 – 39	77.60	51.14	104.07	0.00
40 – 44	62.17	40.34	84.00	0.00
45 – 49	69.54	34.24	104.83	0.00
50 – 54	**63.80**	**-53.13**	**180.73**	**0.28**
55 – 59	97.64	48.21	147.07	0.00
60 – 64	117.19	84.53	149.85	0.00
65 – 69	136.30	97.27	175.32	0.00
70 – 74	154.58	114.76	194.39	0.00
75 – 79	137.67	104.06	171.27	0.00
80 – 84	106.88	68.84	144.92	0.00
85+	138.81	107.44	170.17	0.00
Least deprived	105.92	90.89	120.95	0.00
Next least deprived	52.94	32.54	73.34	0.00
Middle deprived	86.74	63.74	109.73	0.00
Next most deprived	62.49	43.78	81.19	0.00
Most deprived	71.54	57.89	85.19	0.00

Both gender groupings are associated with a mean excess outpatient direct medical cost per index injury that is statistically different from zero at the 95% confidence level (p-value < 0.05). There is not much difference in the excess outpatient costs by gender, with index injuries sustained by females (£76.56) generating slightly higher excess outpatient treatment costs on average compared to those index injuries sustained by males (£70.61). The lack of any major difference in the mean excess outpatient costs per index injury according to the gender of the injured is largely a reflection of the fact that no real difference was observed between males and females when considering the number of excess outpatient visits on average per index injury (Table 6.14). The absence of any noticeable gender impact on excess outpatient costs suggest that the amount of outpatient resources devoted to the treatment of injuries is relatively even between the genders.

For males and females together, all 5 year age groups exhibit a mean excess outpatient treatment cost per index injury that is statistically significant. There is a general positive relationship between the excess outpatient direct medical costs generated and age at index injury, whereby the size of the former tends to increase as the age of the injured cohort increases. This trend is also apparent when stratifying the injured individuals into males and females. In the case of males, for instance, excess outpatient treatment costs range from £51.39 to £88.19 for those aged up to 49, whereas males aged 60+ generate mean excess outpatient treatment costs ranging from £99.34 to £184.03. Similarly, for females the three lowest mean excess outpatient direct medical costs per index injury (£23.29, £44.72, £51.68) each occur amongst females aged between 0 and 24, whilst the three highest excess outpatient treatment costs on average (£154.58, £138.81, £137.67) are associated with females aged 70+. The finding that the size of the excess direct medical costs incurred within the outpatient sector increases along with the age of the injured individual is not only likely to be a by-product of the older subgroup of the population being associated with a higher number of excess outpatient visits on average than younger aged individuals (Table 6.14), but is also likely to be the result of increased outpatient resources being devoted to each index injury sustained by older aged individuals given their reduced ability to recover from injury resulting in increased long-term outpatient treatment needs applicable to this subgroup of the population (Shabot and Johnson 1995; Horan and Little 1998).

Across all index injuries those sustained by individuals categorised within the 'Least deprived' socioeconomic grouping lead to the highest mean excess outpatient costs being generated, with the figure of £85.07 being much higher than the lowest excess outpatient cost average of £64.41, which arises when index injuries are sustained by members of the injury cohort classified within the 'Next least deprived' socioeconomic grouping. This same pattern is observed when solely considering index injuries incurred by females, whereby the highest and lowest mean excess outpatient costs per index injury of £105.92 and £52.94 are associated with the 'Least deprived' and 'Next least deprived' socioeconomic categories, respectively. For males, index injuries amongst the 'Next most deprived' culminate in the highest excess outpatient costs on average (£83.17), with index injuries amongst the 'Middle deprived' leading to the lowest (£56.43).

The finding that higher excess costs are incurred within the outpatient sector following index injuries sustained by females categorised as amongst the least deprived within the injured cohort can potentially be explained by the fact that outpatient treatment tends to deal with less serious injuries, which in turn tend to be more frequently sustained by the more affluent in society (Hippisley-Cox et al. 2002; Park et al. 2009). Furthermore, due to less serious injuries being treated medical attention at outpatients is at times not essential. In these cases more deprived individuals may choose not to attend outpatient treatment (McClure, Newell and Edwards 1996; Hamilton, Round and Sharp 2002) given they can less afford to spare the time and/or the transport costs.

Table 7.11: Mean excess outpatient direct medical costs per index injury by injury type and gender

	Mean excess outpatient direct medical costs per index injury (£)	**95% Confidence Interval**		**p-value**
		Lower limit (£)	**Upper limit (£)**	
Total	73.30	68.44	78.17	0.00
Skull-brain injury	240.65	119.47	361.84	0.00
Facial fracture, eye injury	104.69	58.48	150.90	0.00
Spine, vertebrae	**-1.02**	**-18.60**	**16.55**	**0.91**
Internal organ injury	**55.38**	**-306.61**	**417.37**	**0.75**
Upper extremity fracture	262.84	249.83	275.85	0.00
Upper extremity, other injury	32.88	21.11	44.65	0.00
Hip fracture	139.50	95.39	183.62	0.00
Lower extremity, fracture	257.07	235.45	278.68	0.00
Lower extremity, other injury	16.06	4.45	27.67	0.01
Superficial injury, open wounds	19.85	11.79	27.90	0.00
Burns	548.17	392.58	703.76	0.00
Poisonings	132.75	68.54	196.97	0.00
Other injury	19.34	6.19	32.49	0.00

	Mean excess outpatient direct medical costs per index injury (£)	95% Confidence Interval		p-value
		Lower limit (£)	Upper limit (£)	
Male	70.61	64.53	76.70	0.00
Skull-brain injury	210.42	90.42	330.41	0.00
Facial fracture, eye injury	109.55	54.16	164.95	0.00
Spine, vertebrae	**3.17**	**-14.36**	**20.70**	**0.72**
Internal organ injury	**-105.79**	**-413.34**	**201.75**	**0.47**
Upper extremity fracture	249.61	232.10	267.11	0.00
Upper extremity, other injury	27.53	12.11	42.94	0.00
Hip fracture	252.06	174.93	329.18	0.00
Lower extremity, fracture	280.89	254.70	307.08	0.00
Lower extremity, other injury	23.72	11.36	36.08	0.00
Superficial injury, open wounds	19.64	8.71	30.56	0.00
Burns	561.87	383.08	740.66	0.00
Poisonings	69.46	32.22	106.69	0.00
Other injury	**13.76**	**-3.33**	**30.85**	**0.12**
Female	76.56	68.74	84.38	0.00
Skull-brain injury	**388.07**	**-103.42**	**879.56**	**0.10**
Facial fracture, eye injury	92.11	6.75	177.47	0.04
Spine, vertebrae	**-4.91**	**-34.65**	**24.83**	**0.75**
Internal organ injury	**538.89**	**-915.78**	**1,993.55**	**0.36**
Upper extremity fracture	278.28	258.85	297.72	0.00
Upper extremity, other injury	38.55	20.63	56.47	0.00
Hip fracture	96.93	44.30	149.56	0.00
Lower extremity, fracture	233.33	198.98	267.69	0.00
Lower extremity, other injury	**7.52**	**-12.81**	**27.85**	**0.47**
Superficial injury, open wounds	20.14	8.33	31.96	0.00
Burns	512.85	171.06	854.63	0.01
Poisonings	184.79	71.87	297.70	0.00
Other injury	27.12	6.53	47.70	0.01

When stratifying the entire injured cohort, including both males and females, according to the type of index injury sustained it is apparent from Table 7.11 that all injury groupings generate a mean excess outpatient direct medical cost per index injury that is statistically different from zero at the 95% confidence level apart from the categories of 'Spine, vertebrae' (p-value = 0.91) and 'Internal organ injury' (p-value = 0.75), which both represent groups of injury largely treated within the inpatient sector (Harris et al. 1980; Augenstein et al. 1995; Livingston et al. 1998; Timothy, Towns and Girn 2004). Excluding these two particular injury groupings the types of index injury incurring the highest and lowest excess outpatient treatment costs on average are within the categories of 'Burns' (£548.17) and 'Lower extremity, other injury' (£16.06), respectively.

When focusing specifically on the male members of the injured cohort it is evident that along with the two injury groupings identified as not being associated with a statistically significant mean excess outpatient treatment cost when considering males and females together, this is also the case for the injury grouping of 'Other injury' (p-value = 0.12). For females the four categories of injury associated with an excess outpatient treatment cost on average that is not statistically different from zero include 'Skull-brain injury' (p-value = 0.10), 'Spine, vertebrae' (p-value = 0.75), 'Internal organ injury' (p-value = 0.36) and 'Lower extremity, other injury' (p-value = 0.47), with the first three of these categories including injuries that tend to be relatively infrequent amongst females. For both males and females when considering only the injury groupings exhibiting a statistically significant excess outpatient direct medical cost the index injuries most and least costly to treat within the outpatient sector are those within the 'Burns' (males: £561.87; females £512.85) and 'Superficial injury, open wounds' (males: £19.64; females £20.14) categories, respectively.

To a large extent the pattern observed in terms of the size of the excess direct medical costs incurred within the outpatient sector on average across different types of index injury reflects the equivalent number of excess outpatient visits observed per index injury (Table 6.15). For both males and females burn related index injuries result in by far the highest mean excess number of outpatient contacts and also generate by far the highest mean excess outpatient direct medical costs, with the reverse true for index injuries within the 'Lower extremity, other injury' category, when considering both genders together, and index injuries within the 'Superficial injury, open wounds' grouping, in the case of males and females being considered separately. This latter category is largely associated with a low excess outpatient treatment cost given superficial and open wound injuries can usually be dealt with at an ED and tend not to warrant outpatient treatment. As indicated in section 6.4.2.3 of Chapter 6 when discussing the relatively low count of excess outpatient visits associated with injuries to the lower extremities, the comparatively low excess outpatient costs may also reflect the fact that the outpatient dataset analysed as part of this study may potentially not have included all of the visits to outpatients for the use of rehabilitation services (this is identified as a limitation of the outpatient data source listed in section 10.4 of Chapter 10).

Table 7.12: Mean excess outpatient direct medical costs per index injury by external cause and gender

	Mean excess outpatient direct medical costs per index injury (£)	**95% Confidence Interval**		**p-value**
		Lower limit	**Upper limit**	
Total	73.30	68.44	78.17	0.00
Mechanism of injury				
Motor Vehicle Traffic Crash	277.91	97.25	458.57	0.00
Fall	263.12	194.65	331.58	0.00
Burns	611.47	369.57	853.36	0.00
Cut/pierce	305.70	187.11	424.29	0.00
Struck by/against	164.11	86.03	242.19	0.00
Poisoning	199.98	71.04	328.91	0.00
Other	175.67	130.59	220.75	0.00
Location of injury				
Home	66.36	58.48	74.24	0.00
Work	38.28	26.03	50.53	0.00
RTA	**18.11**	**-4.09**	**40.31**	**0.11**
Sport	129.84	48.70	210.97	0.00
Other	77.69	70.87	84.67	0.00
Male	70.61	64.53	76.70	0.00
Mechanism of injury				
Motor Vehicle Traffic Crash	266.39	15.86	516.92	0.04
Fall	262.71	174.47	350.95	0.00
Burns	609.68	295.81	923.55	0.00
Cut/pierce	352.97	247.84	458.09	0.00
Struck by/against	143.66	58.98	228.34	0.00
Poisoning	119.64	48.28	191.01	0.00
Other	188.74	129.03	248.45	0.00
Location of injury				
Home	59.05	47.29	70.80	0.00
Work	36.33	23.11	49.56	0.00
RTA	**20.89**	**-8.95**	**50.73**	**0.17**
Sport	107.25	10.28	204.21	0.03
Other	76.30	68.19	84.60	0.00
Female	76.56	68.74	84.38	0.00
Mechanism of injury				
Motor Vehicle Traffic Crash	300.94	59.23	542.64	0.02
Fall	263.58	155.68	371.49	0.00
Burns	615.04	195.52	1034.57	0.01
Cut/pierce	**166.86**	**-208.37**	**542.08**	**0.36**
Struck by/against	227.26	30.96	423.56	0.02
Poisoning	256.00	43.22	468.77	0.02
Other	153.07	85.38	220.77	0.00

	Mean excess outpatient direct medical costs per index injury (£)	95% Confidence Interval		p-value
		Lower limit	Upper limit	
Location of injury				
Home	72.23	61.61	82.85	0.00
Work	43.88	15.37	72.39	0.00
RTA	**15.20**	**-17.85**	**48.25**	**0.37**
Sport	181.90	24.09	339.70	0.03
Other	79.78	67.73	91.92	0.00

It is apparent from Table 7.12 that all of the mechanism of injury categories exhibit a statistically significant mean excess outpatient cost per index injury except injuries amongst females caused by cut/pierce incidents (p-value = 0.36). This reflects the statistically insignificant mean excess count of outpatient attendances associated with this mechanism of injury category and demographic group. Irrespective of gender index injuries resulting from a burn related mechanism of injury result in the highest mean excess outpatient cost. Again this follows the pattern observed in relation to the mean excess count of outpatient contacts, whereby burn injuries often require subsequent phases of outpatient treatment but are not serious enough to warrant subsequent ED attendances or inpatient admissions.

With regards to the location of injury the category of 'RTA' is associated with a statistically insignificant mean excess outpatient cost per index injury for both males (p-value = 0.17) and females (p-value = 0.37). This finding most likely reflects the seriousness of injuries arising from an RTA related incident which mean ongoing inpatient treatment is often more appropriate than ongoing outpatient treatment. In keeping with the number of outpatient contacts observed on average, index injuries sustained at a 'Sport' location lead to the highest mean excess outpatient cost (Total = £129.84; Male = £107.25; Female = £181.90). In contrast to the case of RTA injuries described above, sport related injuries tend not to be serious enough to warrant ongoing inpatient treatment meaning outpatient treatment is often sufficient.

7.4.2.4. ED, inpatient and outpatient sectors combined

Thus far in this chapter the excess direct medical costs generated following the occurrence of index injuries sustained by the injured cohort under investigation have been presented for the ED, inpatient and outpatient sectors individually. However, the excess direct medical cost model devised as part of this study was developed in such a way to allow the aggregated impact of a given injury on the resources of multiple healthcare sectors to be reported. This is due to the presence of anonymous patient identifiers making it possible to ascertain whether, for instance, inpatient treatment had been preceded by medical attention in an ED or succeeded by care in an outpatient setting over the course of the post-index injury period. Hence, in this section the combined excess direct medical costs, encompassing ED, inpatient and outpatient treatment expenditures, following the occurrence of index injuries sustained by the injured cohort will be presented.

The combined excess direct medical costs incurred across the ED, inpatient and outpatient sectors equates to £17,557,200, with treatment expenditures incurred by the inpatient sector making up most of this figure, comprising 85.2% of the total. This aggregated excess healthcare expenditure total of £17.6 million was generated following the occurrence of 30,387 index injuries. Hence, on average each index injury surveyed as part of this investigation ultimately culminates in combined excess treatment costs amounting to £577.79 (95% CI: £500.32, £655.26; p-value < 0.05).

Table 7.13: Mean excess combined direct medical costs per index injury by age group, gender and socioeconomic classification

	Mean excess combined direct medical costs per index injury (£)	**95% Confidence Interval**		**p-value**
		Lower limit (£)	**Upper limit (£)**	
Total	577.79	500.32	655.26	0.00
0 – 4	74.51	8.59	140.43	0.03
5 – 9	82.05	29.72	134.37	0.00
10 – 14	**81.05**	**-13.12**	**175.23**	**0.09**
15 – 19	174.46	93.16	255.75	0.00
20 – 24	216.81	119.53	314.10	0.00
25 – 29	221.32	62.03	380.61	0.01
30 – 34	229.72	85.76	373.68	0.00
35 – 39	405.26	232.97	577.56	0.00

	Mean excess combined direct medical costs per index injury (£)	95% Confidence Interval		p-value
		Lower limit (£)	Upper limit (£)	
40 – 44	245.68	51.49	439.87	0.01
45 – 49	300.64	89.65	511.63	0.01
50 – 54	768.45	27.20	1,509.71	0.04
55 – 59	626.56	32.55	1,220.57	0.04
60 – 64	**516.42**	**-165.08**	**1,197.91**	**0.14**
65 – 69	872.79	299.70	1,445.89	0.00
70 – 74	1,807.41	1,223.33	2,391.50	0.00
75 – 79	3,129.55	1,859.77	4,399.33	0.00
80 – 84	4,291.17	2,887.65	5,694.69	0.00
85+	5,570.91	4,207.82	6,934.00	0.00
Least deprived	511.13	342.11	680.16	0.00
Next least deprived	544.30	355.51	733.09	0.00
Middle deprived	575.34	417.40	733.28	0.00
Next most deprived	691.31	475.39	907.24	0.00
Most deprived	581.18	437.36	725.00	0.00
Male	346.04	266.02	426.06	0.00
0 – 4	**73.91**	**-31.80**	**179.62**	**0.17**
5 – 9	**59.88**	**-31.11**	**150.86**	**0.20**
10 – 14	77.12	38.62	115.62	0.00
15 – 19	112.34	60.78	163.89	0.00
20 – 24	249.89	129.61	370.18	0.00
25 – 29	241.04	69.48	412.60	0.01
30 – 34	175.17	12.67	337.67	0.04
35 – 39	429.41	163.39	695.43	0.00
40 – 44	192.71	40.00	345.42	0.01
45 – 49	386.27	64.61	707.92	0.02
50 – 54	**1,224.38**	**-77.70**	**2,526.46**	**0.07**
55 – 59	1,335.87	194.66	2,477.09	0.02
60 – 64	**-82.72**	**-1,174.66**	**1,009.21**	**0.88**
65 – 69	934.80	73.00	1,796.59	0.03
70 – 74	2,430.34	1,295.63	3,565.05	0.00
75 – 79	**1,367.86**	**-447.20**	**3,182.92**	**0.14**
80 – 84	2,758.49	536.70	4,980.28	0.02
85+	4,915.95	1,638.07	8,193.83	0.00
Least deprived	259.15	77.10	441.19	0.01
Next least deprived	335.66	208.61	462.70	0.00
Middle deprived	212.45	72.16	352.74	0.00
Next most deprived	452.68	217.23	688.14	0.00
Most deprived	421.44	254.42	588.46	0.00
Female	858.19	717.12	999.26	0.00
0 – 4	75.31	13.28	137.33	0.02
5 – 9	108.58	71.65	145.50	0.00
10 – 14	**87.21**	**-146.85**	**321.28**	**0.47**
15 – 19	278.99	78.85	479.12	0.01
20 – 24	**152.44**	**-13.16**	**318.03**	**0.07**
25 – 29	**186.59**	**-133.60**	**506.78**	**0.25**
30 – 34	309.18	46.05	572.31	0.02
35 – 39	372.82	184.41	561.22	0.00
40 – 44	**310.01**	**-78.34**	**698.35**	**0.12**
45 – 49	**217.69**	**-58.27**	**493.65**	**0.12**
50 – 54	**251.74**	**-342.43**	**845.90**	**0.40**

	Mean excess combined direct medical costs per index injury (£)	95% Confidence Interval		p-value
		Lower limit (£)	Upper limit (£)	
55 – 59	**15.93**	**-489.60**	**521.46**	**0.95**
60 – 64	1,020.60	164.99	1,876.20	0.02
65 – 69	832.48	68.50	1,596.46	0.03
70 – 74	1,489.00	822.59	2,155.42	0.00
75 – 79	3,794.90	2,185.79	5,404.01	0.00
80 – 84	4,867.05	3,124.40	6,609.70	0.00
85+	5,739.18	4,241.49	7,236.87	0.00
Least deprived	800.79	504.01	1097.58	0.00
Next least deprived	788.79	406.83	1170.75	0.00
Middle deprived	1,022.91	716.43	1329.39	0.00
Next most deprived	987.88	602.14	1373.61	0.00
Most deprived	780.28	533.26	1027.31	0.00

The mean excess combined direct medical cost per index injury is statistically different from zero for both males and females at the 95% confidence level (p-value < 0.05). The total excess treatment costs incurred across the ED, inpatient and outpatient sectors associated with females however are considerably larger than the equivalent male figure (£858.19 versus £346.04). This difference between genders reflects the fact that the majority of the combined excess direct medical cost total is comprised expenditures generated within the inpatient sector (85.2%), which, as indicated in Table 7.7, is dominated by excess treatment costs attributable to injuries sustained by females.

When considering both genders together most age groups are associated with a statistically significant excess combined direct medical cost per index injury on average, with the exceptions being members of the injured cohort aged 10 to 14 (p-value = 0.09) and 60 to 64 (p-value = 0.14). The lowest mean combined excess treatment costs are applicable to index injuries sustained by individuals aged 0 to 4 (£74.51), whilst the combined excess expenditures on average are highest following index injuries suffered by those aged 85+ (£5,570.91). Indeed, Table 7.13 signifies that there is a positive relationship between age and the size of the excess combined direct medical costs generated when focusing on the whole of the injured cohort, and males and females separately. This finding can be explained by the fact that such a trend was additionally present when considering excess treatment costs incurred within both the inpatient (Table 7.7) and outpatient sectors (Table 7.10), reflecting the reduced capacity of older aged individuals to recover from injury (Shabot and

Johnson 1995; Horan and Little 1998), resulting in an increased number and length of inpatient admissions, and a greater need for ongoing treatment within outpatient settings.

When considering the whole of the injured cohort followed up as part of this study mean excess combined costs per index injury are relatively similar amongst individuals categorised in the 'Least deprived' (£511.13), 'Next least deprived' (£544.30), 'Middle deprived' (£575.34) and 'Most deprived' (£581.18) socioeconomic groupings. By contrast, index injuries sustained by individuals within the 'Next most deprived' category lead to a much higher excess combined cost on average (£691.31), reflecting the dominance of this category in terms of excess inpatient costs across all index injuries (Table 7.7).

When focusing specifically on index injuries sustained by males it is apparent from Table 7.13 that the 'Next most deprived' (£452.68) and 'Most deprived' (£421.44) socioeconomic groupings are associated with the highest mean excess combined costs, whereas the 'Middle deprived' and 'Least deprived' categories are associated with the lowest excess combined costs per index injury on average (£212.45 and £259.15, respectively).

With regards to female members of the injured cohort highest combined excess costs on average result when index injuries are sustained by females categorised within the 'Middle deprived' (£1,022.91) group closely followed by index injuries sustained by females within the 'Next most deprived' group (£987.88). The categories of 'Most deprived', 'Next least deprived' and 'Least deprived' each have comparatively low mean excess combined costs (£780.28, £788.79 and £800.79, respectively).

Table 7.14: Mean excess combined direct medical costs per index injury by injury type and gender

	Mean excess combined direct medical costs per index injury (£)	95% Confidence Interval		p-value
		Lower limit (£)	Upper limit (£)	
Total	577.79	500.32	655.26	0.00
Skull-brain injury	6,254.46	1,347.46	11,161.46	0.01
Facial fracture, eye injury	**234.84**	**-125.75**	**595.43**	**0.20**
Spine, vertebrae	366.79	127.52	606.07	0.00
Internal organ injury	**2,731.63**	**-1,330.87**	**6,794.13**	**0.18**
Upper extremity fracture	797.25	558.88	1,035.62	0.00
Upper extremity, other injury	**75.16**	**-58.92**	**209.24**	**0.27**
Hip fracture	10,281.91	7,896.78	12,667.05	0.00
Lower extremity, fracture	1,474.70	1,063.85	1,885.56	0.00
Lower extremity, other injury	309.33	149.71	468.95	0.00
Superficial injury, open wounds	301.10	169.94	432.26	0.00
Burns	1,102.71	168.05	2,037.38	0.02
Poisonings	1,188.78	566.61	1,810.95	0.00
Other injury	423.41	264.86	581.97	0.00
Male	346.04	266.02	426.06	0.00
Skull-brain injury	7,038.27	1,124.68	12,951.85	0.02
Facial fracture, eye injury	**21.90**	**-372.20**	**415.99**	**0.91**
Spine, vertebrae	612.57	164.52	1,060.63	0.01
Internal organ injury	**2,595.96**	**-2,514.16**	**7,706.08**	**0.29**
Upper extremity fracture	453.64	250.53	656.75	0.00
Upper extremity, other injury	**23.13**	**-51.59**	**97.85**	**0.54**
Hip fracture	7,140.93	3,694.34	10,587.53	0.00
Lower extremity, fracture	633.47	426.36	840.58	0.00
Lower extremity, other injury	242.11	103.27	380.96	0.00
Superficial injury, open wounds	189.06	30.16	347.96	0.02
Burns	1,335.43	56.30	2,614.57	0.04
Poisonings	997.30	207.20	1,787.39	0.01
Other injury	284.45	109.67	459.23	0.00
Female	858.19	717.12	999.26	0.00
Skull-brain injury	**2,433.41**	**-41.48**	**4,908.30**	**0.05**
Facial fracture, eye injury	**784.95**	**-13.62**	**1,583.51**	**0.05**
Spine, vertebrae	**139.12**	**-61.31**	**339.55**	**0.17**
Internal organ injury	**3,138.65**	**-6,447.05**	**12,724.35**	**0.42**
Upper extremity fracture	1,198.10	739.62	1,656.58	0.00
Upper extremity, other injury	**130.30**	**-134.44**	**395.04**	**0.33**
Hip fracture	11,470.02	8,452.37	14,487.68	0.00
Lower extremity, fracture	2,312.76	1,521.52	3,104.00	0.00
Lower extremity, other injury	384.36	84.12	684.59	0.01
Superficial injury, open wounds	461.11	237.67	684.55	0.00
Burns	**502.55**	**-194.00**	**1,199.09**	**0.15**
Poisonings	1,346.20	413.61	2,278.78	0.01
Other injury	617.06	326.04	908.08	0.00

When stratifying the whole of the injured cohort by the type of index injury sustained three groupings of injury are not associated with a combined excess direct medical costs per index injury that is statistically different from zero at the 95% confidence level, including 'Facial fracture, eye injury' (p-value = 0.20), 'Internal organ injury' (p-value = 0.18) and 'Upper extremity, other injury' (p-value = 0.27). This finding is to be expected given these particular types of index injury did also not generate a statistically significant mean excess inpatient cost (Table 7.8), whilst the mean excess ED costs were not statistically different from zero for the categories of 'Internal organ injury' and 'Upper extremity, other injury' (Table 7.5). Of the injury groupings that are associated with a statistically significant combined excess treatment cost on average per index injury the most and least costly categories to treat are 'Hip fracture' (£10,281.91) and 'Superficial injury, open wounds' (£301.10), respectively. This is largely reflective of the fact that excess inpatient expenditures, which dominate the overall combined total, are also highest and lowest following the occurrence of these particular types of index injuries (Table 7.8).

When focusing specifically on index injuries sustained by male members of the injured cohort it is apparent from Table 7.14 that amongst the injury groupings associated with a mean excess combined direct medical cost per index injury that is statistically different from zero at the 95% confidence level, it is most costly to treat index injuries within the 'Hip fracture' category (£7,140.93) closely followed by those in the 'Skull-brain injury' category (£7,038.27). Lowest statistically significant excess costs amongst males are applicable to index injuries categorised within the 'Superficial injury, open wounds' grouping (£189.06). In terms of index injuries sustained by female members of the injured cohort the statistically significant mean excess combined cost is by far the highest within the 'Hip fracture' grouping (£11,470.02), with this figure lowest on average following the occurrence of index injuries within the 'Lower extremity, other injury' category (£384.36).

Table 7.15: Mean excess combined direct medical costs per index injury by external cause and gender

	Mean excess combined direct medical costs per index injury (£)	**95% Confidence Interval**		**p-value**
		Lower limit	**Upper limit**	
Total	577.79	500.32	655.26	0.00
Mechanism of injury				
Motor Vehicle Traffic Crash	5,384.40	285.76	10,483.05	0.04
Fall	3,343.93	2,115.10	4,572.75	0.00
Burns	**741.75**	**-16.72**	**1,500.22**	**0.06**
Cut/pierce	501.85	193.29	810.41	0.00
Struck by/against	**893.95**	**-117.19**	**1,924.32**	**0.08**
Poisoning	1,750.29	461.44	3,080.31	0.01
Other	999.10	27.17	1,951.44	0.04
Location of injury				
Home	920.81	748.70	1,092.91	0.00
Work	173.12	89.02	257.22	0.00
RTA	251.99	136.42	367.57	0.00
Sport	330.75	78.96	582.55	0.01
Other	303.41	220.25	386.42	0.00
Male	346.04	266.02	426.06	0.00
Mechanism of injury				
Motor Vehicle Traffic Crash	**7,467.83**	**-119.32**	**15,054.98**	**0.05**
Fall	2,044.51	526.67	3,562.33	0.01
Burns	**817.77**	**-263.30**	**1,898.83**	**0.13**
Cut/pierce	509.11	187.60	830.63	0.00
Struck by/against	**787.45**	**-342.95**	**1,917.84**	**0.17**
Poisoning	1,989.68	180.17	3,875.71	0.03
Other	**303.64**	**-192.86**	**795.43**	**0.23**
Location of injury				
Home	462.80	296.94	628.65	0.00
Work	144.86	68.92	220.80	0.00
RTA	243.09	85.58	400.61	0.00
Sport	347.06	18.73	675.39	0.04
Other	239.21	128.60	349.92	0.00
Female	858.19	717.12	999.26	0.00
Mechanism of injury				
Motor Vehicle Traffic Crash	**1,217.55**	**-1,271.72**	**3,706.81**	**0.32**
Fall	4,843.99	2,868.46	6,819.52	0.00
Burns	**589.73**	**-308.63**	**1,488.08**	**0.18**
Cut/pierce	**480.51**	**-366.48**	**1,327.50**	**0.25**
Struck by/against	**1,222.73**	**-1,206.30**	**3,762.91**	**0.30**
Poisoning	**1,583.34**	**-231.30**	**3,418.96**	**0.09**
Other	**2,202.05**	**-309.64**	**4,655.02**	**0.09**

	Mean excess combined direct medical costs per index injury (£)	95% Confidence Interval		p-value
		Lower limit	Upper limit	
Location of injury				
Home	1,288.46	1,008.50	1,568.41	0.00
Work	254.39	11.89	496.90	0.04
RTA	261.29	91.38	431.20	0.00
Sport	**293.18**	**-89.57**	**675.93**	**0.13**
Other	399.87	274.78	524.43	0.00

Given 85.2% of the combined excess cost total is comprised excess inpatient costs the pattern of the former in terms of the most/least costly mechanisms and locations of injury mirror what was observed for these categories when considering excess inpatient costs specifically. When considering both genders together the MVTC mechanism is associated with the highest statistically significant mean excess combined cost (£5,384.40) followed by the category of 'Fall' (£3,343.93). The mechanism groups of 'Burns' and 'Struck by/against' exhibit mean excess combined costs that are not statistically different from zero at the 95% confidence level (p-value = 0.06 and p-value = 0.08, respectively).

For males, index injuries sustained by an MVTC mechanism of injury lead to by far the highest mean excess combined cost, although this figure is associated with a p-value that is very slightly statistically insignificant. Similarly, the categories of 'Burns' and 'Struck by/against' continue to not be statistically different from zero at the 95% confidence level. This is also the case for these two mechanisms when focusing on index injuries incurred by females, along with the categories of 'Cut/pierce' and 'Poisoning'. Index injuries amongst females resulting from falls are associated with by far the highest statistically significant mean excess combined cost (£4,843.99), reflecting the dominance of this category observed when considering mean excess inpatient costs per index injury (Table 7.9).

With regards to the location at which the index injury was sustained it is apparent from Table 7.15 that only the category of 'Sport' amongst females is associated with a mean excess combined cost per index injury that is statistically insignificant (p-value = 0.13). This is most likely explained by females not participating so frequently in dangerous sports which have a high risk of serious injury requiring long-term treatment and care. Irrespective of gender the location grouping with the highest mean excess combined costs per index injury is 'Home', reflecting the frequency and seriousness of DIY, falls and other accidents that occur in the home. This is especially the case for females, where a given index injury sustained in the home culminates in excess combined costs of £1,288.46 on average, which is much greater than the mean excess combined cost applicable to the next highest location of injury category of 'Other' (£399.87).

7.5. Chapter summary

This chapter has reported on the extent of the excess direct medical costs incurred by the healthcare sector during the post-index injury period. These excess treatment expenditures were inferred by subtracting the direct medical costs expected to have arisen over the follow-up period, in the absence of any index injuries being suffered by the injured cohort, from the direct medical costs observed and calculated in the presence of such index injuries.

Based on the 30,387 index injuries, excess direct medical costs in the region of £0.4 million, £15.0 million and £2.2 million are incurred by the ED, inpatient and outpatient sectors respectively, amounting to an overall total of around £17.6 million across all three healthcare providers combined. For every index injury sustained by a member of the injured cohort therefore the excess direct medical cost faced by the ED, inpatient and outpatient sectors on average are £12.05, £492.43 and £73.30, respectively, equating to an overall, combined, average of £577.79.

Chapter 8 – Results IV – Miscellaneous

8.1. Introduction

Together with estimating the excess HSU and direct medical costs following the occurrence of an index injury, as reported in Chapters 6 and 7 respectively, additional analysis was undertaken to determine the extent to which these results changed when including the healthcare event associated with the initial treatment of the index injury, when excluding individuals from the injured cohort if associated with an injury related healthcare event during the pre-index injury period, and when extrapolating to an all Wales level. The results of this miscellaneous analysis are presented within this chapter.

8.2. Inclusion of index injury healthcare event

The excess HSU and direct medical cost results presented in Chapters 6 and 7 did not include the ED attendance or inpatient admission associated with the initial treatment of the index injury. It was assumed that counting this healthcare contact may potentially over-inflate the extent of HSU and direct medical costs observed during the post-index injury period given every individual within the injured cohort must have attended an ED or been admitted to hospital due to injury at least once in order to be included within the study. Had this index injury healthcare event been included as part of the observed HSU and direct medical cost calculations however the size of the excess HSU and direct medical cost results reported earlier in this thesis could be even greater.

To determine whether this was indeed the case the analysis described as part of the methodology in Chapter 4 and undertaken to produce the excess HSU and direct medical cost results in Chapters 6 and 7 respectively, was repeated so that the follow-up period applicable to each individual within the injured cohort began from the start date of their first injury related ED attendance or inpatient admission on or after 01/04/2005. This differs from the previous analysis during which the follow-up period began from the end date of this particular healthcare event. In Table 8.1 below the excess number of ED attendances, inpatient admissions, inpatient bed-days and outpatient visits per index injury are presented for follow-up periods including and excluding the index injury healthcare event. Similarly, Table 8.2 indicates the extent to which the excess direct medical costs incurred on average per index injury by the ED, inpatient and outpatient sectors, plus all three sectors combined, vary depending on whether the index injury healthcare event was included as part of the calculations or not.

Table 8.1: Mean excess HSU per index injury during follow-up periods including and excluding the index injury healthcare event

	Excluding index injury healthcare event	Including index injury healthcare event
Excess ED attendances	0.12	1.09
Excess inpatient admissions	0.07	0.16
Excess inpatient bed-days	1.00	1.90
Excess outpatient visits	0.55	0.55

Table 8.2: Mean excess direct medical costs generated per index injury during follow-up periods including and excluding the index injury healthcare event

	Excluding index injury healthcare event (£)	Including index injury healthcare event (£)
Excess ED direct medical costs	12.05	110.41
Excess inpatient direct medical costs	492.43	751.05
Excess outpatient direct medical costs	73.30	86.99
Excess combined direct medical costs	577.79	948.44

It is evident from Tables 8.1 and 8.2 above that inclusion of the healthcare event associated with the initial treatment of the index injury for the most part leads to a far greater mean excess HSU and direct medical cost figure per index injury. For instance, when the index injury healthcare event is not included as part of the analysis every index injury on average results in 0.12 excess ED attendances, generating excess treatment costs incurred within the ED sector of £12.05 per index injury. By contrast the equivalent figures observed when the index injury healthcare event is incorporated into the analysis are 1.09 excess ED attendances, resulting in an excess cost to the ED sector of £110.41 per index injury. Similar findings are apparent when comparing the impact on the number of excess inpatient admissions and inpatient bed-days (Table 8.1), and the excess direct medical costs incurred within the inpatient sector, plus the ED, inpatient and outpatient sectors combined (Table 8.2), following the inclusion/exclusion of the index injury healthcare event. Much less of a difference is evident in terms of excess outpatient visits and direct medical costs, which is reflective of the fact that the index healthcare event took the form of either an ED attendance or an inpatient admission and not an outpatient appointment.

This analysis therefore reveals the considerable extent of HSU and direct medical costs resulting solely from the index injury healthcare event. In not incorporating this particular healthcare event into the final excess HSU and direct medical cost calculations the results presented in Chapters 6 and 7 more accurately reflect the true long-term repercussions on the healthcare sector, in terms of both utilisation and direct medical costs, over and above the initial treatment phase. However, by excluding the index injury healthcare event the excess HSU and direct medical costs reported as part of this study is likely to underestimate the true HSU and direct medical cost burden of injury on the healthcare sector.

8.3. Exclusion of individuals associated with a prior injury related healthcare event

When determining the extent of excess HSU and direct medical costs for each member of the injured cohort, the pre-index injury period spanned from 01/04/2004 up to but not including the date of the first ED attendance or inpatient admission associated with the treatment of the index injury, as indicated by point D in Figure 4.2 of Chapter 4. During this timeframe it is possible some of these individuals will have been in receipt of ED and/or inpatient treatment for an injury. Despite this, the entire injured cohort formed part of the excess HSU and direct medical cost calculations. To determine the impact on the size of the excess direct medical costs specifically following the exclusion of individuals associated with a prior injury related ED or inpatient healthcare event, the analysis undertaken to determine the cost results presented in Chapter 7 was repeated so that members of the injured cohort associated with ED or inpatient treatment for an injury during the pre-index injury period were identified and not incorporated into the excess direct medical cost calculations. The presence of such a prior injury was identified in two ways:

- Identification method 1

Individuals within the injured cohort were flagged and subsequently excluded from the final calculations if they were associated with an injury event requiring ED or inpatient treatment/care that occurred during the pre-index injury period and was considered to be related to the original index injury event. To determine the relationship between the index injury event and any prior ED/inpatient injury event the reverse of the process described in section 4.5.1.1 of Chapter 4, used to identify whether a new injury had been sustained during the follow-up period, was undertaken.

Firstly, all the ED/inpatient injury related events taking place during the pre-index injury period, plus the index injury itself, were assigned to a type of injury grouping based on their primary injury diagnosis, according to the classifications outlined in the study by Meerding et al. (2004). Next, depending on the type of index injury sustained, a pre-specified number of days* was subtracted from the start date of the index injury event. If a prior ED/inpatient injury event was then identified with a start date within this interval, whilst being assigned the same type of injury grouping relative to the index injury, it was considered to be the same injury. All individuals within the injured cohort to which this situation applied were then excluded from the subsequent direct medical cost calculations (n = 385).

(* Research question 1 answered as part of section 9.1 of Chapter 9 lists the specific number of days allowed between the injury related healthcare events and explains how these were determined).

- Identification method 2

Individuals within the injured cohort were flagged if they were in receipt of any injury related ED attendance or inpatient admission taking place during the pre-index injury period. Unlike in 'Identification method 1' described above, the prior ED/inpatient healthcare event did not have to be associated with the same injury as the index injury but just had to be injury related and have taken place during the pre-index injury period. All individuals within the injured cohort to which this situation applied were then excluded from the subsequent direct medical cost calculations (n = 6,064).

The alternative overall excess direct medical cost results including and excluding individuals with a prior injury can be viewed in Table 8.3

Table 8.3: Excess direct medical costs incurred within the ED, inpatient and outpatient sectors following the inclusion and exclusion of individuals with a prior injury

	Including individuals with prior injury	Excluding individuals with prior injury	
		Identification method 1 (n = 385)	Identification method 2 (n = 6,064)
Excess ED direct medical costs	£366,162	£398,647	£614,236
Excess inpatient direct medical costs	£14,963,558	£14,768,546	£13,690,738
Excess outpatient direct medical costs	£2,227,480	£2,211,702	£2,170,423

It is apparent from Table 8.3 that in excluding individuals with a prior injury related ED or inpatient healthcare event the overall excess direct medical costs incurred within the inpatient and outpatient sectors decrease. When individuals are removed from the cost calculations if they are found to have attended an ED or been admitted to hospital due to an injury that is considered related to the index injury (identification method 1) the total excess inpatient treatment costs fall by £195,012 (1.3%), whilst the total excess outpatient direct medical costs fall by £15,778 (0.7%). A greater reduction in the size of the excess direct medical costs incurred by the inpatient and outpatient sectors is evident when members of the injured cohort are removed from the study if associated with any injury related ED attendance or inpatient admission taking place during the pre-index injury period (identification method 2). In this case, inpatient and outpatient treatment costs fall by £1,272,820 (8.5%) and £57,057 (2.6%), respectively. For the overall expenditures generated within the inpatient sector in particular therefore, excluding individuals from the injured cohort with a prior injury detected through the use of identification method 2 results in a considerable reduction in the size of the excess inpatient direct medical costs reported.

Interestingly the impact of only calculating excess direct medical costs among individuals found not to have sustained a prior injury in receipt of ED or inpatient treatment during the pre-index injury period is reversed when focusing specifically on expenditures generated within the ED sector. As opposed to resulting in reduced ED treatment costs when excluding individuals from the study known to have sustained a prior injury, the size of the overall excess ED direct medical costs incurred increase. Determining the presence of a prior injury via identification method 1, for instance, serves to increase ED treatment costs by £32,485 (8.9%), whilst utilising identification method 2 leads to expenditures generated within the ED sector rising by £248,074 (67.7%). The finding that excluding individuals with a prior injury results in higher excess ED direct medical costs indicates that these particular individuals are largely expected to be associated with a greater ED treatment bill than is actually the case. That is, overall, members of the injured cohort flagged through identification method 1 were expected to generate costs within the ED sector to the value of £32,485 more than that which was observed, leading to a net loss in the corresponding excess figure (observed costs – expected costs) of £32,485. Hence, by not including these individuals within the direct medical cost calculations the resulting overall excess direct medical costs incurred by the ED sector increases by £32,485, given the net loss of this amount is no longer generated.

The most likely reason why excess ED direct medical costs increase when individuals identified as having a prior injury are excluded from the study, whereas the equivalent excess totals applicable to the inpatient and outpatient sectors decrease, concerns the fact that the majority of the prior injuries detected were in receipt of ED treatment.

For instance, of the 385 prior injuries flagged via identification method 1 a total of 268 (69.6%) were treated within the ED sector. Similarly, of the 5,535 prior injuries flagged via identification method 2 in receipt of either ED or inpatient treatment (529 prior injuries flagged via identification method 2 were treated at both an ED and within hospital as an inpatient), 5,385 (97.3%) received ED treatment. Hence, on average the individuals within the injured cohort identified as having a prior injury are more likely to be associated with higher ED expenditures during the pre-index injury period than they would be associated with inpatient or outpatient expenditures, given they are known to have at least one injury related ED attendance. Since these individuals have relatively high observed pre-index injury ED treatment costs then they would also have high expected post-index injury ED treatment costs, meaning they are more likely to be associated with a net loss in terms of excess ED expenditures than other members of the injured cohort.

8.4. Extrapolation to an all Wales level

The excess HSU and direct medical cost results presented in this study are applicable to an injured cohort drawn from a study population comprising individuals resident in Swansea throughout the investigative period (01/04/2004 to 31/03/2007). Hence, the excess HSU totals of 3,647 ED attendances, 2,119 inpatient admissions, 30,492 inpatient bed-days and 16,715 outpatient visits, plus the excess direct medical costs of £366,162, £14,963,558 and £2,227,480 incurred by the ED, inpatient and outpatient sectors, would be far greater if the injured cohort was instead drawn from an all Wales study population. To estimate the excess HSU and direct medical costs applicable to an injured cohort drawn from a study population comprising individuals resident in Wales throughout the investigative period two different extrapolation methods were employed.

- Extrapolation method 1

One means to determine the number of index injuries associated with an all Wales study population is to multiply the number of index injuries applicable to a Swansea study population by a figure that represents the extent to which the Wales study population is larger than the Swansea study population.

The study population used as part of this investigation, comprising individuals resident in Swansea throughout the investigative period, totalled 196,129 individuals. Based on the same selection process the equivalent study population comprising individuals resident in Wales throughout the investigative period would equate to 2,879,261 individuals. Hence, the all Wales study population is 14.7 times larger than the Swansea study population (2,879,261 / 196,129 = 14.7). Using the figure of 14.7 as an extrapolation factor the 30,387 index injuries applicable to a Swansea setting would be translated into 446,689 index injuries (30,387 x 14.7 = 446,689) associated with all of Wales.

Therefore, based on 446,689 index injuries and per index injury excess HSU figures of 0.12 (95% CI: 0.11, 0.13) ED attendances, 0.07 (95% CI: 0.06, 0.08) inpatient admissions, 1.00 (95% CI: 0.78, 1.23) inpatient bed-days and 0.55 (95% CI: 0.52, 0.58) outpatient visits, the overall excess HSU totals would rise to 53,603 (95% CI: 49,136; 58,070) ED attendances, 31,268 (95% CI: 26,801; 35,735) inpatient admissions, 446,689 (95% CI: 348,417; 549,427) inpatient bed-days and 245,679 (95% CI: 232,278; 259,080) outpatient visits.

Similarly, based on 446,689 index injuries and an excess direct medical ED cost of £12.05 (95% CI: £11.05, £13.05), inpatient cost of £492.43 (95% CI: £415.66, £569.21), outpatient cost of £73.30 (95% CI: £68.44, £78.17) and combined cost of £577.79 (95% CI: £500.32, £655.26) per index injury, the overall excess direct medical costs incurred by the ED, inpatient and outpatient sectors would increase to £5,382,602 (95% CI: £4,935,913; £5,829,291), £219,963,064 (95% CI: £185,670,750; £254,259,846) and £32,742,304 (95% CI: £30,571,395; £34,917,679), thereby equating to a combined excess direct medical cost of £258,092,437 (95% CI: £223,487,440; £292,697,434).

- <u>Extrapolation method 2</u>

Another extrapolation method that could be used to determine the number of index injuries applicable to Wales as a whole is to calculate the proportion of the total injury related ED and inpatient healthcare events applicable to the Swansea study population that is made up of index injuries. The same proportion of the total injury related ED and inpatient healthcare events applicable to an all Wales study population could then be used to estimate the number of Welsh index injuries.

Based on the 196,129 individuals resident in Swansea throughout the investigative period, the total number of injury related ED attendances taking place between 01/04/2005 and 31/03/2007 equates to 40,051, with the equivalent number of inpatient admissions totalling 4,717. Hence, for individuals within the Swansea study population the 30,387 index injuries came from a total of 44,768 ED/inpatient healthcare events, resulting in a ratio of 0.7 (30,387 / 44,768 = 0.7). Based on an all Wales study population of 2,879,261 the total number of injury related inpatient admissions taking place between 01/04/2005 and 31/03/2007 equates to 79,749. The equivalent number of ED attendances could not be inferred from the data sources available since ED data could only be accessed for Morriston hospital and not the whole of Wales at the time of analysis. However, given there are 8.5 injury related ED attendances for every inpatient admission amongst the Swansea study population (40,051 / 4,717 = 8.5) the number of injury related ED attendances amongst an all Wales study population can be estimated as 677,867 (8.5 x 79,749 = 677,867). Therefore, for individuals within an all Wales study population there are a total of 757,616 ED/inpatient healthcare events (677,867 + 79,749 = 757,616). Consequently given a ratio of index injury to ED/inpatient healthcare event of 0.7 applicable to the Swansea study population, the number of index injuries applicable to an all Wales study population can be estimated as 530,331 (0.7 x 757,616 = 530,331).

Thus, based on 530,331 index injuries and per index injury excess HSU figures of 0.12 (95% CI: 0.11, 0.13) ED attendances, 0.07 (95% CI: 0.06, 0.08) inpatient admissions, 1.00 (95% CI: 0.78, 1.23) inpatient bed-days and 0.55 (95% CI: 0.52, 0.58) outpatient visits, the overall excess HSU totals would rise to 63,640 (95% CI: 58,336; 68,943) ED attendances, 37,123 (95% CI: 31,820; 42,426) inpatient admissions, 530,331 (95% CI: 413,658; 652,307) inpatient bed-days and 291,682 (95% CI: 275,772; 307,592) outpatient visits.

Similarly, based on 530,331 index injuries and an excess direct medical ED cost of £12.05 (95% CI: £11.05, £13.05), inpatient cost of £492.43 (95% CI: £415.66, £569.21), outpatient cost of £73.30 (95% CI: £68.44, £78.17) and combined cost of £577.79 (95% CI: £500.32, £655.26) per index injury, the overall excess direct medical costs incurred by the ED, inpatient and outpatient sectors would increase to £6,390,489 (95% CI: £5,860,158; £6,920,820), £261,150,894 (95% CI: £220,437,383; £301,869,709) and £38,873,262 (95% CI: £36,295,854; £41,455,974), thereby equating to a combined excess direct medical cost of £306,419,948 (95% CI: £265,335,206; £347,504,691).

Consequently, irrespective of the extrapolation method adopted, factoring up the number of index injuries applicable to a study population based in Swansea to an equivalent number of index injuries applicable to a study population encompassing all of Wales serves to markedly increase the size of the overall excess HSU and direct medical cost results reported. Indeed, in terms of the combined excess direct medical cost total, the already considerable figure of £17.6 million resulting from index injuries sustained by Swansea residents rises to £258.1 million/£306.4 million (depending on the extrapolation method used) when the number of index injuries estimated amongst all Welsh residents are considered.

8.5. Chapter summary

This chapter has shown the extent to which the excess HSU and direct medical cost figures reported in earlier chapters of this study can change following the inclusion of the index injury healthcare event, the exclusion of members of the injured cohort with a prior injury and the extrapolation to an all Wales level.

Inclusion of the healthcare event associated with the index injury serves to considerably increase the mean excess HSU and direct medical costs observed per index injury, with this finding most applicable to the ED and inpatient sectors.

By excluding individuals within the injured cohort who have previously been in receipt of ED or inpatient treatment for an injury the overall excess direct medical costs observed within the inpatient and outpatient sectors decrease, whereas the equivalent treatment costs generated within the ED sector increase.

Extrapolation of the excess HSU and direct medical costs applicable to a study population resident in Swansea to the equivalent figures applicable to a study population encompassing all residents of Wales serves to considerably increase the overall extent of excess HSU and direct medical costs reported, thereby further signifying the substantial burden on the healthcare sector associated with the occurrence of injuries.

Chapter 9 – Research questions

In light of the limitations identified amongst the current literature and hence the associated gaps in assumed knowledge, discussed as part of Chapter 2, the following two methodological questions were posed and answered as part of this study.

9.1. Research question 1

Research question 1 – *Is it possible to develop a methodology which determines a pre-defined number of days that should be allowed between two ED/inpatient treated injury events before it is reasonable to classify the second case as an entirely new injury event as opposed to being related to a previous injury event?*

9.1.1. Research question 1: Brief review of the problem

During the course of the investigative period of this study it is likely that certain members of the injured cohort will receive treatment/care within the health service sector for an injury related condition on more than one occasion. This may be due to the need for ongoing follow-up procedures, or the occurrence of complications, with both of these types of cases related to a previous injury healthcare event. Such repeat injury events in receipt of healthcare can include re-attendances, re-admissions and revisits to the same or a different ED, inpatient or outpatients department respectively, or may involve transfers between certain health service providers. Alternatively, additional visits to the ED, inpatient or outpatient sectors may be necessary to treat, care for and rehabilitate an entirely new injury.

Effectively distinguishing between new and repeat injury events in receipt of medical attention has long presented a problem within injury research. Whilst determining the relationship between current and past injury events is relatively straight forward in smaller scale investigations that allow study participants to be interviewed and thus queried as to the origin of their injury, such personal questioning is not feasible in quantitative studies which involve the analysis of large scale population based healthcare datasets. Consequently, in these latter type investigations it can be extremely difficult to deduce with any great certainty whether a given injury event in receipt of healthcare is in any way connected to a previous injury induced healthcare event.

Inferring whether subsequent healthcare contacts due to injury are connected to a previous injury related medical event is vitally important in an investigation seeking to report on the burden associated with new injury cases. Assuming every subsequent injury event in receipt of healthcare is ultimately connected with a previous injury related healthcare event may result in a significant underestimation of the number of new cases of injury taking place in a given year. It would be equally misleading however to assume that all subsequent injury involved healthcare events have each been caused by the occurrence of separate, unconnected, injuries, with this belief potentially culminating in an overestimation of the number of new injuries in receipt of medical attention.

9.1.2. Research question 1: Review of existing literature

The potential for under-/over-counting the number of injuries in receipt of medical attention has long been recognised within the field of injury based research. Much of the existing literature, such as studies by Smith, Langlois and Buechner (1991), Langley et al. (2002), Boufous and Williamson (2003) and Boufous and Finch (2005), has tended to focus on how best to determine the incidence of inpatient injury cases specifically.

Smith, Langlois and Buechner (1991) outline several different hypotheses that have been advanced in an attempt to best define a ‘new’ injury in receipt of inpatient care/treatment, such as the exclusion of certain types of admission, including transfers in from another hospital, elective admissions or admissions that do not originate in the ED. However, the adoption of these approaches was found to potentially lead to an actual underestimation of injuries given the high number of new injury events that may be excluded. Based on their study population, for instance, Smith, Langlois and Buechner (1991) found that by omitting elective admissions the overall incidence rate for 'true' injuries was lowered from 10.03 per 1,000 population to 7.23 per 1,000 population, a fall of 28%. A similar reduction of 26% ensued following the exclusion of admissions not through the emergency room. Moreover, the authors identified an apparent lack of consistency between variables associated with multiple admissions.

> ...of all elective admissions, only 19 percent were also identified as readmissions, and only 52 percent were also identified as admissions not through the emergency room. Similarly, only 28 percent of all readmissions were also identified as elective admissions, and only 39 percent were listed as admissions not through the emergency room (Smith, Langlois and Buechner 1991, p.1151).

Many of the studies undertaken with the aim to effectively identify incident inpatient injury cases have focused on the importance of how an injury is operationally defined. Much debate has centred on whether injury cases should be selected based on their principal diagnosis (Langley et al. 2002; Boufous and Williamson 2003), or whether case selection should be based solely on the external cause assigned to a given healthcare event (Langley et al. 2002). Discussion has also focused on whether medical injuries resulting from complications of medical and surgical care, and misadventures, should be excluded (Smith, Langlois and Buechner 1991; Langley at al. 2002; Boufous and Williamson 2003). Opinion is mixed, however, with there again seemingly being a trade-off between under-/overestimating the number of incident injuries. For example, with regards to a case selection based on external cause rather than diagnosis, Langley et al. (2002) found the incidence of injury requiring inpatient treatment in New Zealand to be substantially inflated.

A common suggestion amongst the studies listed above, which has been proposed as a means to effectively distinguish between first time injury cases and subsequent repeat injury events, involves the incorporation of a specific readmission variable which can be used to indicate a readmission for the same problem/condition. The inclusion of such a field within healthcare datasets will most certainly make the task of determining whether multiple injury cases are related in any way much easier. However, this field is not widely available in many healthcare registries and its inclusion does not guarantee the correct identification of a readmission for the same injury. Indeed in their publication Boufous and Finch (2005, p.335) state "it is possible that some hospitals/coders may be using this even when a previous admission is related to other injuries or health conditions".

An alternative method of identifying healthcare events related to the same injury involves the linkage of these events using variables such as a unique identification number. Essentially, the ability to ascertain whether a given injury event is associated with the same individual as the previous event(s) makes it easier to determine if the healthcare events in question are in any way connected. Boufous and Finch (2005), for instance, adopted an internal probabilistic data linkage method to identify multiple separations for injurious falls for each patient in their study, finding 93.9% of inpatient separations scrutinized to correspond to first admissions/incident cases. However, knowledge that multiple injury cases are associated with the same individual is not evidence in itself that these cases are necessarily related in any way. The date a given injury has occurred additionally represents an important component in this decision making process.

> Routine recording of the 'date of injury' would further simplify the process of determining whether these readmissions are for the same injury or for a new injury that might have occurred at a later date (Boufous and Finch 2005, p.335).

However, whilst determining the date an injury has actually occurred is straightforward in those cases when treatment is immediately sought after the injury related incident has taken place, this process is much more difficult when there is a delay in healthcare treatment being sought after an injury incident, or when no new injury incident has taken place meaning it is not obvious as to whether the treatment sought is connected to an earlier injury or not. In these instances it may not be clear whether the healthcare event in question should be assigned a previously recorded date of injury or a new date of injury. Moreover, the actual date an injury has taken place is not a readily available variable within most healthcare datasets, and even when it is the potential exists that it will be incorrectly recorded or missing.

Given the above difficulties associated with the use of a date of injury field as a means to determine the relationship between healthcare events known to be associated with the same patient, several investigations have attempted to identify repeat injury cases in receipt of medical attention by focusing on healthcare events recorded as taking place within a pre-specified interval after the end of an initial index healthcare event. Essentially, all subsequent healthcare events with a start date within this period are considered to be related to the original index stay. Although several studies have been undertaken in this way from a review of the existing literature it seems the length of the periods over which subsequent occurring healthcare events are considered repeat cases as opposed to new ones varies considerably between studies (Table 9.1).

Table 9.1: List of studies considering repeat events over a specified period, together with the type of injury and healthcare sector featured, the % of the study population with a re-event and the period over which re-events are considered

Study	Injury type	Healthcare sector	% of study population with re-event	Period over which re-events considered
Jaglal et al. 2009	Spinal cord injury	Inpatient	27.5%	1 year
Pagliacci et al. 2008	Spinal cord lesion	Inpatient	51.0%	2 years
Paker et al. 2006	Spinal cord injury	Inpatient	7.6%	5 years
Cardenas et al. 2004	Spinal cord injury	Inpatient	-	1, 5, 10, 15 and 20 years
Cifu et al. 1999	Traumatic brain injury	Inpatient	20 – 22.5%	1, 2 and 3 years
Giusti et al. 2008	Hip fracture	Inpatient	30.1%	3 months and 3 – 12 months
Greenberg et al. 2000	Minor trauma from motor vehicle accidents	Emergency room of trauma centre	1.8%	1 year
Hahnel, Burdekin and Anand 2009	Hip fracture	Inpatient	19%	3 months
Boockvar et al. 2003	Hip fracture	Inpatient	32%	6 months
Cullen, Johnson and Cook 2006	Total hip replacement	Inpatient	8.5%	28 days
Dowd et al. 1996	Assaultive injury	Inpatient	6.4%	1 year
French et al. 2008	Hip fracture	Inpatient	18.3%	30 days
Howson, Yates and Hatcher 2008	Deliberate self-harm	ED	18%	1 year

Study	Injury type	Healthcare sector	% of study population with re-event	Period over which re-events considered
Marwitz et al. 2001	Traumatic Brain injury	Inpatient	22.9% (1 year post-injury); 17.0% (5 years post-injury)	1 and 5 years
Middleton et al. 2004	Spinal cord injury	Inpatient	58.6%	10 years
Ottenbacher et al. 2003	Hip fracture	Inpatient	16.7%	180 days
Savic et al. 2000	Chronic spinal cord injury	Inpatient	64%	6 years
Teixeira et al. 2009	Hip fracture	Inpatient	32%	1 year
Voss, Knottenbelt and Peden 1995	Minor head injury	Trauma unit	2.1%	5 years
Wilson and Stott 2007	Femoral fractures	Inpatient	23%	30 days

It is clear from Table 9.1 above that the length of the period over which potential repeat healthcare events are considered is not consistent across the 20 studies appraised, ranging from between 28 days (Cullen, Johnson and Cook 2006) and 20 years (Cardenas et al. 2004). Furthermore, there additionally seems to be marked variation amongst those investigations focusing on re-events applicable to the same type of injury. Studies by Boockvar et al. (2003), French et al. (2008), Hahnel, Burdekin and Anand (2009) and Teixeira et al. (2009) each report on the extent of inpatient readmissions associated with patients initially in receipt of inpatient treatment for a hip fracture. However, despite the apparent similarity in the aim of these investigations the length of the periods over which subsequent inpatient admissions are considered readmissions as opposed to new inpatient cases differ considerably. French et al. (2008) allow for a 30 day interval from the end of the index inpatient admission to the start of any subsequent inpatient event, Hahnel, Burdekin and Anand (2009) and Boockvar et al. (2003) adopt a 3 months and 6 months interval respectively, whilst Teixeira et al. (2009) categorises all subsequent inpatient admissions taking place within 1 year of the initial index hip fracture hospitalisation as repeat admissions.

One major reason for this apparent discrepancy concerns the lack of a consensus in any method used to determine the interval between healthcare events over which readmissions are identified. Indeed, in the case of the investigation undertaken by

Wilson and Stott (2007) only readmissions within the first 30 days were considered given this is the period of time commonly used in New Zealand (the setting for the study) as a performance indicator for District Health Boards. Similarly, the 28 day period adopted by Cullen, Johnson and Cook (2006) was based on a specific clinical indicator set by the UK Department of Health for comparing surgical outcomes between trusts. Other studies appear to have no justification for the repeat healthcare event interval adhered to, with perhaps the length of the follow-up period adopted influenced by the particular dataset analysed or the resource restrictions associated with the investigation.

Table 9.1 signifies that 12 of the 20 studies appraised have confined their search for repeat healthcare events to 1 year or less after the initial index event. This raises the question of why only injury cases in receipt of treatment within a single year should be classed as readmissions for the same injury. Additional healthcare events taking place beyond this 1 year period may too be related to the original index event given there is no pre-defined time limit for additional treatment to be required.

Moreover, whilst each of the 20 studies specified the interval over which repeat injury events were considered, together with reporting on the percentage of their study cohort associated with a repeat healthcare event, in only three of the articles is a specific mention made of the average time between the initial index healthcare event taking place and the subsequent occurrence of repeat events. Pagliacci et al. (2008) report a median period between the onset of spinal cord lesion treatment and readmission to hospital of 3.4 years. Focusing on inpatient readmissions after inpatient discharge for hip fracture, Boockvar et al. (2003) found the median time to first readmission was 41 days, whilst in terms of re-presentation to the ED following deliberate self-harm, Howson, Yates and Hatcher (2008) found the mean and median time to re-presentation to be 85 and 32 days respectively. In a further three studies the number of days during which most of the study cohort are associated with a repeat injury event is reported. For example, despite having a follow-up length of 1 year Dowd et al. (1996) report that the majority (70%) of patients with a previous hospitalisation for assault were subsequently hospitalised within 30 days of the initial injury. French et al. (2008) found most (60.1%) of their hip fracture cohort identified as being associated with a 30 day readmission returned to hospital within 2 weeks, whilst focusing on re-attendances to a trauma unit after head injury Voss, Knottenbelt and Peden (1995) report that nearly half of all patients came back four or more days after the injury.

The delay between the end of the initial index injury event and the first subsequent repeat event is additionally reported on in the study by Teixeira et al. (2009). However, the findings presented in this particular article differ slightly from those reported by the investigations discussed previously in that varying time intervals over which subsequent admissions are considered related to the index admission are stated, with such intervals dependent on the type of complication leading to readmission. For instance, a subsequent admission to hospital due to 'Bronchitis' must have taken place within 1 month in order to be classed as related to the initial index stay, whereas any subsequent admission assigned a diagnosis of 'Pain' need only to have occurred within 1 year of the index hospitalisation for it to be classed as a repeat event. In varying the intervals over which readmissions can potentially take place based on the specific diagnosis associated with the health events in question Teixeira et al. (2009) allow for greater flexibility and accuracy in the decision making process. Instead of just grouping all subsequent admissions following the initial index stay together and assuming that they are all equivalent and should be treated the same, the study accounts for potential differences in the causes of the later admissions which will undoubtedly influence the relationship between the initial and subsequent healthcare events. One drawback of the study by Teixeira et al. (2009) however, concerns the fact that it focuses solely on readmissions following surgical treatment for hip fracture. Hence, the readmission delays from the index stay apply only to complications arising after hip fracture surgery and thus cannot be generalised to infer whether subsequent healthcare events following the treatment/care of other types of injury taking place within the periods specified are related or unrelated to the initial index stay. Indeed, this limitation represents a feature of each of the 20 studies appraised given they all focus on identifying repeat healthcare events following an initial index event associated with a single type of injury only, thereby failing to encompass all injury types within their investigations. Six of the articles base their findings on repeat cases taking place after an initial index stay related to spinal cord injuries (Savic et al. 2000; Middleton et al. 2004; Cardenas et al. 2004; Paker et al. 2006; Pagliacci et al. 2008; Jaglal et al. 2009), another six confine their investigations to look only at hip fracture injuries (Boockvar et al. 2003; Ottenbacher et al. 2003; Giusti et al. 2008; French et al. 2008; Teixeira et al. 2009; Hahnel, Burdekin and Anand 2009), whilst two focus on traumatic brain injuries (Cifu et al. 1999; Marwitz et al. 2001). The remaining studies attempt to identify repeat injury events following initial index events associated with minor head injuries (Voss, Knottenbelt and Peden 1995), hip replacements (Cullen, Johnson and Cook 2006), femoral fractures (Wilson and Stott 2007), motor vehicle crashes (Greenberg et al. 2000), assault (Dowd et al. 1996) and deliberate self-harm (Howson, Yates and Hatcher 2009).

To conclude, a review of the existing literature dealing with the issues on which this research question is based reveal that several proposals have been suggested to best determine whether a given injury event is a new or a repeat case. Past literature has shown that the imposition of certain inclusion and exclusion criteria, such as focusing only on certain types of admission or restricting the types of injury considered, may represent a means to distinguish between new and repeat injury cases, but their adoption runs the risk of under-/overestimating the true number of new injuries reported. The introduction of a readmission variable indicating whether a given healthcare event is a first time admission or not has been widely recommended but the presence of such a variable within healthcare datasets is currently not widely available plus there exists some debate as to whether it is being used accurately. Several studies have advocated the use of unique individual identifiers that make it possible to determine whether multiple injury cases are associated with the same patient, but this knowledge must be supplemented with information concerning the date of injury or start/end of treatment dates in order to better infer whether two or more injury related healthcare events are associated with each other. The date of injury is not a commonly collected variable within many healthcare datasets, and even when it is available its effective use is dependent on a given healthcare event accurately being assigned to the correct date of injury. This is far from certain and is made more difficult by the fact that the main priority for medical staff is to treat/care for their patients and not play detective, which at times may be necessary to accurately ascertain the initial injury from which a given healthcare event has resulted. In contrast, the start and end dates of treatment represent routinely collected variables within all healthcare datasets, required for administrative purposes as well as research ones, and such dates have been used by past studies to group related healthcare events together. That is, multiple injury cases are often considered related and of a repeat nature if they are found to be associated with the same individual and have taken place within a pre-defined number of days of each other. Significantly, however, it appears from the review of existing literature undertaken as part of answering this research question that an empirically established methodology for determining the length of this pre-defined interval over which readmissions for the same injury are considered has yet to be advanced.

9.1.3. Research question 1: Aim

To develop a methodology which determines a pre-defined number of days that should be allowed between two ED/inpatient treated injury events before it is reasonable to classify the second case as an entirely new injury event as opposed to being related to a previous injury event.

9.1.4. Research question 1: Methodology

- Injury event subset – inclusion/exclusion criteria

For the purposes of answering this research question injury related ED attendances and inpatient admissions taking place between 01/04/2001 and 31/03/2007 formed the injury event subset under investigation. ED attendances of interest were identified from the AWISS dataset encompassing attendances to Morriston ED, whilst inpatient admissions were searched for within the PEDW records.

All ED attendances/inpatient admissions with a start date during the period 01/04/2001 and 31/03/2007 were included within the injury event subset provided they were recorded with a primary diagnosis of injury. For inpatient admissions the following ICD-10-CM diagnoses were classed as injuries: S00 – T73, T75, T78, excluding "*Maltreatment syndromes*" (T74), "*Certain early complications of trauma, not elsewhere classified*" (T79), "*Complications of surgical and medical care, not elsewhere classified*" (T80-T88), "*Sequelae of injuries, of poisoning and of other* *consequences of external causes*" (T90-98). With regards to the ED attendances under investigation, injury related events were identified by searching for the presence of injury diagnoses within the ED diagnosis codes specific to Morriston ED.

(A full list of the Morriston ED diagnoses codes used to determine an injury event within the ED sector can be found in Table A1 in Appendix 1, whilst the implications associated with confining analysis to injuries recorded in the primary position only, together with excluding certain diagnosis and external cause codes, are discussed in detail in section 10.4 of Chapter 10).

The presence of a unique identification number within the ED and inpatient records made it possible to identify the individual to which the injury events were associated. Individuals were excluded from the injury event subset if they were found to have attended ED or been admitted as an inpatient during the year prior to their first ED/inpatient contact identified between 01/04/2001 and 31/03/2007. Furthermore, given the aim of this research question was to determine whether a subsequent injury event was related to a previous one it followed that individuals were removed from the final injury event subset if they were only associated with a single injury event during the period 01/04/2001 and 31/03/2007.

- Determining the relationship between injury events

No re-attendance/re-admission variables indicating repeat attendances/admissions were available within either the ED or inpatient datasets under scrutiny. Hence, for the purposes of answering this research question, related healthcare events were assumed to have taken place whenever the initial and subsequent healthcare events associated with a given individual took place within a pre-defined interval and were found to be the result of an injury that was part of the same type of injury category. The type of injury categories used were based on the 13 injury groupings created as part of the study by Meerding et al (2004), including 'Skull-brain injury', 'Facial fracture, eye injury', 'Spine, vertebrae', 'Internal organ injury', 'Upper extremity fracture', 'Upper extremity, other injury', 'Hip fracture', 'Lower extremity fracture', 'Lower extremity, other injury', 'Superficial injury, open wounds', 'Burns', ‘Poisoning’, ‘Other injury’. The relationship between injury events was determined separately for ED attendances, inpatient admissions and combinations of the two.

(The ICD-10-CM codes and Morriston ED diagnosis/anatomical area codes used to classify each inpatient admission/ED attendance into a Meerding group are listed in Tables A5.1 and A5.2, respectively, in Appendix 5).

To determine the relationship between injury healthcare events the following steps were undertaken. Firstly, individuals identified as having multiple ED attendances were extracted from the final injury event subset along with the dates of their first and second occurring ED attendances and the primary diagnosis of these attendances. Each ED attendance was then categorised into a Meerding type of injury grouping based on its primary injury diagnosis. Next the number of individuals who had their second ED attendance taking place within 1 day of their first ED attendance were counted, and then the number of these particular individuals who’s second ED attendance was of the same Meerding category as the first was determined. This made it possible to infer the percentage of second occurring ED attendances that started within 1 day of the first ED attendance and which were also associated with an injury that was categorised within the same Meerding group. This process was repeated, incrementing the number of days between the first and second ED attendances by 1 day at a time, allowing the cumulative percentage of ED attendances matched on Meerding group to be deduced.

Once all individuals with multiple ED attendances were accounted for the above process was replicated for individuals associated with multiple inpatient admissions, for individuals with an ED attendance followed by an inpatient admission and for individuals with an inpatient admission followed by an ED attendance.

9.1.5. Research question 1: Results

Tables A6.1 – A6.4 displayed in Appendix 6 show the cumulative percentage of ED attendances, inpatient admissions, ‘ED attendance to inpatient admission’ cases and ‘inpatient admission to ED attendance’ cases, respectively, matched on Meerding injury group as the number of days between the occurrence of the first and second of these healthcare events was incrementally increased from 1 day to 90 days.

For instance, from Table A6.1 it is evident that when the first ED attendance is associated with an injury within the ‘Facial fracture, eye injury’ Meerding category 91.7% of the subsequent ED attendances starting within 1 day are in receipt of treatment for an injury also within the same ‘Facial fracture, eye injury’ Meerding category. As the number of days between the first and second ED attendances is then increased the cumulative percentage of these attendances continuing to be associated with an injury within the same Meerding grouping (in this case the Meerding category ‘Facial fracture, eye injury’) steadily falls to the point that when there is a 65 day gap between the initial and subsequent ED events less than half of the subsequent ED events are in receipt of treatment for an injury within the same Meerding grouping as the initial ED event. That is, for injuries categorised within the ‘Facial fracture, eye injury’ Meerding category once the number of days between the first and second ED attendances associated with the same individual exceed 65 days the latter occurring ED attendance is more likely than not to have been the result of an injury that is part of an alternative Meerding nature of injury group.

A cumulative percentage of healthcare events matched on Meerding category of below 50% indicates that more often than not the second occurring healthcare event is associated with an injury that is part of a different Meerding injury grouping compared to that associated with the first healthcare event. As a consequence the number of days between the initial and subsequent cases for which this situation applies was considered to indicate the point at which the healthcare events of interest were no longer related to each other. In cases where the cumulative percentage of matches tended to fluctuate around the 50% threshold level the number of days after which the cumulative percentage of matches remained below 50% and did not rise above this level thereafter was chosen as the point at which the healthcare events were no longer related. For example, in the case of the ‘Hip fracture’ Meerding grouping, when 18 days have passed between the first and second ED attendances less than half (48%) are associated with injuries that are part of the same Meerding category. However, after a gap between events of 32 days the cumulative percentage of cases which match on Meerding grouping actually rises to 50% before again falling to below this level when 34 days have passed between healthcare events, after which the cumulative percentage of matched cases remains below the 50% level (Table A6.1). In this situation the number of days used to signify the point at which the healthcare events are no longer related to each other is 34 and not 18.

Tables 9.2 – 9.5 below list the number of days to have passed between the initial and subsequent ED attendances (Table 9.2), inpatient admissions (Table 9.3), 'ED attendance to inpatient admission' cases (Table 9.4) and 'inpatient admission to ED attendance' cases (Table 9.5) for less than 50% to match on Meerding injury grouping, and hence for the healthcare events of interest to be considered unrelated to each other.

Table 9.2: Number of days to have passed between first and second ED attendances for less than 50% of individuals to be associated with cases that match on Meerding injury grouping.

Meerding injury grouping	**Number of days**	**Number of individuals**	**Number of individuals matched on Meerding group**
Skull-brain injury	97	5	2
Facial fracture, eye injury	65	81	40
Spine, vertebrae	97	560	279
Internal organ injury	-	-	-
Upper extremity fracture	142	1,608	803
Upper extremity, other injury	107	967	483
Hip fracture	34	39	19
Lower extremity, fracture	165	825	411
Lower extremity, other injury	145	1,735	866
Superficial injury, open wounds	299	6,537	3,266
Burns	-	-	-
Poisonings	32	104	50
Other injury	103	1,287	642

Table 9.3: Number of days to have passed between first and second inpatient admissions for less than 50% of individuals to be associated with cases that match on Meerding injury grouping.

Meerding injury grouping	Number of days	Number of individuals	Number of individuals matched on Meerding group
Skull-brain injury	NA*	1,073	639
Facial fracture, eye injury	865	1,138	568
Spine, vertebrae	NA*	801	479
Internal organ injury	248	267	133
Upper extremity fracture	NA*	5,657	3,560
Upper extremity, other injury	525	1,101	550
Hip fracture	NA*	5,072	3,866
Lower extremity, fracture	NA*	3,690	2,265
Lower extremity, other injury	1,241	919	459
Superficial injury, open wounds	332	3,117	1,557
Burns	NA*	741	479
Poisonings	NA*	7,428	5,355
Other injury	463	3,043	1,521

* NA indicates cases where the cumulative percentage of healthcare events matched on Meerding injury group does not fall below the 50% threshold.

Table 9.4: Number of days to have passed between 'ED to inpatient' cases for less than 50% of individuals to be associated with cases that match on Meerding injury grouping.

Meerding injury grouping	Number of days	Number of individuals	Number of individuals matched on Meerding group
Skull-brain injury	NA*	107	82
Facial fracture, eye injury	NA*	518	427
Spine, vertebrae	118	299	149
Internal organ injury	-	-	-
Upper extremity fracture	NA*	3,565	2,419
Upper extremity, other injury	77	354	176
Hip fracture	NA*	2,068	1,832
Lower extremity, fracture	NA*	2,342	1,712
Lower extremity, other injury	1	210	91
Superficial injury, open wounds	105	3,789	1,893
Burns	-	-	-
Poisonings	NA*	1,069	992
Other injury	1	1,492	503

* NA indicates cases where the cumulative percentage of healthcare events matched on Meerding injury group does not fall below the 50% threshold.

Table 9.5: Number of days to have passed between 'inpatient to ED' cases for less than 50% of individuals to be associated with cases that match on Meerding injury grouping.

Meerding injury grouping	Number of days	Number of individuals	Number of individuals matched on Meerding group
Skull-brain injury	3	4	1
Facial fracture, eye injury	30	11	5
Spine, vertebrae	1	1	0
Internal organ injury	-	-	-
Upper extremity fracture	402	141	70
Upper extremity, other injury	1	2	0
Hip fracture	122	33	16
Lower extremity, fracture	346	75	37
Lower extremity, other injury	1	4	1
Superficial injury, open wounds	75	71	35
Burns	-	-	-
Poisonings	29	41	20
Other injury	1	12	5

It is apparent from Tables 9.2 – 9.5 that for some Meerding groups not very many days need to pass between the first and second events before less than 50% of the second healthcare events are associated with an injury which is part of the same Meerding group as the first healthcare event. It only takes 32 and 34 days between ED attendances, for instance, in order for the Meerding groupings of 'Poisoning' and 'Hip fracture' respectively to fall below this 50% threshold (Table 9.2). That is, on average, in the case of 'Poisoning' and 'Hip fracture' related injuries just 32 and 34 days respectively need to have passed for the second occurring ED attendance to more likely than not be associated with an injury that is part of a different Meerding grouping compared to the initial ED attendance. Similarly, when focusing on the percentage of successful matches on Meerding grouping as the number of days between the first and second inpatient admissions are incrementally increased, 'internal organ injuries' require the least number of days to have passed (248) before more of the second round of inpatient admissions are associated with an injury forming part of an alternative Meerding group to the one the injury associated with the initial inpatient admission is in (Table 9.3). In the case of 'ED attendance to inpatient admission' cases this same finding applies to the 'Lower extremity, other' and 'Other' Meerding group of injuries (Table 9.4), which only require a single day to have passed before the majority of the injuries attributed to the second occurring inpatient event are part of a different Meerding group compared to the injury found to have induced the initial ED event. Similarly, a single day is all that is required for this situation to apply for the 'Spine, vertebrae', 'Upper extremity, other', 'Lower extremity, other' and 'Other' Meerding group of injuries, with regards to 'inpatient admission to ED attendance' cases (Table 9.5).

In contrast, it is apparent from Tables 9.2 – 9.5 that certain Meerding groups require a much longer period between the first and second occurring events before less than 50% of the latter are found to be associated with an injury that is part of the same Meerding group as the first healthcare event. Indeed, it is evident from Tables A6.1 – A6.4 in Appendix 6 that some of the Meerding groupings continue to remain above the 50% threshold level after 90 days have passed between the first and second healthcare events. This is the case for the 'Superficial injury, open wounds' Meerding group of injuries in the context of the relationship between the first and second ED attendances, for example, whereby as many as 299 days need to have passed for the second occurring event to more likely than not be associated with an injury that is part of a different Meerding grouping compared to the initial ED attendance (Table A6.1).

Furthermore, on occasions there are instances where the cumulative percentage of healthcare events matched on Meerding injury group does not fall below the 50% threshold no matter how many days pass between the occurrence of the first and second contacts. That is, regardless of the specified period that is allowed between their occurrences some initial and subsequent healthcare events are always more likely than not to be associated with an injury that forms part of the same Meerding injury grouping. For ED attendances and 'inpatient admission to ED attendance' cases this scenario does not apply to any of the Meerding groupings (Tables 9.2 and 9.5), however, for inpatient admissions this is the case for the 'Skull-brain injury', 'Spine, vertebrae', 'Upper extremity fracture', 'Hip fracture', 'Lower extremity fracture', 'Burns' and 'Poisoning' Meerding groups of injuries (Table 9.3), whilst in the context of ED followed by inpatient injury contacts this finding holds for the 'Skull-brain injury', 'Facial fracture, eye injury', 'Upper extremity fracture', 'Hip fracture', 'Lower extremity fracture' and 'Poisoning' Meerding groups of injuries (Table 9.4). In these particular instances it follows that any subsequent healthcare event taking place which has been caused by an injury that is part of the same Meerding grouping as the injury associated with the initial healthcare event can be assumed to be related to that healthcare event regardless of the number of days which have passed between the start and end of the healthcare events in question.

9.1.6. Research question 1: Discussion

9.1.6.1. Limitations

Determining whether a given injury related healthcare event is in some way associated with a prior occurring injury related healthcare event is not straightforward. When answering this research question several assumptions were made in an attempt to simplify this process. Failure of these assumptions to hold true may influence the accuracy of the findings reported.

- Firstly, whilst it was possible for individuals to be associated with more than two injury events during the investigative period 01/04/2001 and 31/03/2007, for this research question the relationship between injury events (i.e. are they associated with the same injury or not) was determined only for the first two injury events which took place (i.e. an individual's first two ED attendances, or first two inpatient admissions, or first ED attendance followed by first inpatient admission, or vice versa). Hence, it is assumed that any common pattern in the relationship between the first two injury events continues to apply with regards to the relationship between the second and third, third and fourth, fourth and fifth injury events and so on.

- A second assumption was based on the premise that all injuries categorised within a given Meerding nature of injury grouping were effectively the same type of injury. However, the Meerding groupings utilised tend to be based on the area of the body injured and can be rather broad, thus allowing the potential for several unrelated injuries to categorised within the same Meerding grouping. For instance, the Meerding group of 'Lower extremity, other' can include injuries such as a wound to the leg and a trapped nerve in the foot which may not actually be connected in any way. Similarly, the potential exists for injuries within different Meerding groupings to actually be related to the same injury event. An injury to the skull/brain may cause a fall which results in a fractured hip, for example. Whilst it could be argued that these injuries are connected the fact they are part of alternative Meerding categories ('Skull-brain injury' and 'Hip fracture' respectively) means for this research question they would be regarded as not being the same injury. Smith et al identified this potential inadequacy of identifying repeat injury events based on the use of a unique person identifier to link data on multiple healthcare events for the same patient:

> Such linkage also fails to enable researchers to determine whether or not the admission was for the same injury or for a completely new injury with the same nature and/or cause of injury, for example, a fracture of the hip on the opposite side from a new fall. In addition, the principal diagnosis may change with repeat admissions for multiple trauma, further complicating data linkage (Smith, Langlois and Buechner 1991, p.1156)

- Another limitation concerns the inability to account for the nature of intent associated with each of the injury events under consideration when determining the presence of a relationship. Owing to small numbers it did not prove possible to stratify the injury events into whether they were self-inflicted or not. However, it could be argued that self-inflicted injuries lead to a greater frequency of ED attendances/inpatient admissions than unintentional injuries due to the fact they are more likely to be repeated by the injured party. For instance, Conner et al. (2003) identified very high relative risks for suicidal behaviour associated with self-inflicted injuries. In a separate study, Colman et al (2004) found individuals who self-harmed themselves to be chronic users of the ED, with their rates of return visits approximately 20 times greater than a random sample of 'other' ED users. Similarly, focusing on the incidence of hospitalisation due to intoxication amongst children in Washington State, Gauvin, Bailey and Bratton (2001) found multiple admissions to be significantly more common amongst self-inflicted intoxication patients (66%) compared with unintentional poisoning ones (11%).

- Finally, despite the fact that the investigative period over which this research question was answered covered a total of six years (01/04/2001 – 31/03/2007) for certain nature of injury groupings only a small number of individuals were available on which to base the relationship between the first and second healthcare events. This was especially the case for initial inpatient admissions followed by ED attendances, whereby for the Meerding groupings of 'Skull-brain injury', 'Spine, vertebrae', 'Upper extremity, other' and 'Lower extremity, other' fewer than five patients were available to be analysed. The reliability and robustness of the findings reported would be improved if based on a larger subset of patients. The primary reason for only a small number of cases being present for certain types of injury grouping concerned the fact that only attendances from Morriston ED, and not the whole of Wales, were available to be analysed as part of this study. This in itself represents a further drawback of the analysis undertaken as part of this research question which should be accounted for when interpreting the results. ED records drawn from across Wales would further increase the number and variability of the data analysed thereby improving the reliability of the findings.

9.1.6.2. Implications

As a consequence of answering this research question it has been possible to develop a methodology which determines a pre-specified number of days that can be allowed between two injury related healthcare events before more often than not the subsequent occurring healthcare event can be regarded as being associated with a new, different, injury compared to the one which caused the initial healthcare event.

- These findings may potentially have a significant impact on the process of determining whether injury induced healthcare events are connected in any way. As indicated earlier in this chapter it has long been recognised that identifying the presence of repeat/new injuries is vital when attempting to calculate the incidence of injuries. Failure to do this successfully may result in an under-/overestimation of the number of new injury related healthcare events reported. Whilst past studies have recognised the importance of distinguishing between new and repeat injury healthcare events in receipt of medical attention none have yet provided an empirically substantiated methodology for determining the number of days that should be allowed to pass between events before any subsequent healthcare event is considered related to the previous healthcare event. The answering of this research question has attempted to fill this void through the provision of such a methodology which can potentially be adopted by other investigations seeking to distinguish between new and repeat injury events within administrative healthcare datasets.

- The methodology and results presented during the answering of this research question adds to the methods and findings proposed by existing studies which have been initiated with the aim to identify the presence of repeat healthcare events. A major feature of the methodology and results presented here concern the incorporation of different types of injury into the investigation. As indicated earlier in this chapter, whilst several pre-existing studies have distinguished between new and repeat healthcare events the analysis undertaken has been confined to a single injury type, meaning the results cannot be generalised to other injuries. In addition, much of the existing literature is limited in the sense that repeat injury induced healthcare events are only searched for within a restricted time period. Indeed, 12 of the 20 studies appraised in section 9.1.2 of this chapter have only considered subsequent healthcare events to be related to a previous index healthcare event if they start within one year of the end of the index event. However, there is no reason why additional treatment for a previous injury may not be necessary beyond this annual interval. For the analysis undertaken as part of this research question it is possible for repeat events to take place up to 6 years after the end of the initial index injury event.

- Furthermore, whilst the methodology for determining the relationship between initial and subsequent injury healthcare events has been applied specifically in the answering of this research question to those taking place within the ED and inpatient healthcare sectors, this methodology is equally applicable to deducing the relationship pattern between the healthcare events associated with alternative health service providers, such as outpatient and GP cases.

9.1.7. Research question 1: Summary

The answering of this research question provides for the first time an empirically tested methodology for determining the number of days that should be allowed between healthcare events associated with different types of injury before any subsequent case can be considered to be unrelated to the previous case.

Further analysis of this research question is necessary to consider the impact of intent on the relationship between initial and subsequent healthcare events given the apparent difference in the aetiology of self-inflicted and unintentional injuries. Moreover, given the analysis undertaken within this chapter has been confined to Morriston ED attendances it would be interesting, and arguably necessary, to extend this analysis to incorporate all ED attendances across Wales in order to ascertain whether the findings presented in section 9.1.5 continue to hold true. In addition, development of the methodology outlined in this chapter to include healthcare events from alternative health service providers, such as outpatient appointments and GP visits, is required so that the relationship specific to these particular healthcare events can be deduced.

Whilst the answering of this research question has shown that the use of unique individual identifiers, in combination with the start/end of healthcare treatment dates, represent a useful and effective means of inferring the relationship between multiple healthcare events, it is important to recognise that this is not the only solution. Indeed, as advocated by Smith, Langlois and Buechner (1991) and Boufous and Williamson (2003), the robustness and reliability of any method to distinguish between new and repeat healthcare events will undoubtedly be improved following the widespread adoption and accurate completion of a first admission variable within healthcare datasets that poses the question 'is this the first medically treated event for this condition?'.

9.2. Research question 2

Research question 2: Do the direct medical costs of injury reported as part of an investigation involving the analysis of multiple healthcare datasets linked via anonymous patient identifiers differ from the findings based on the separate parallel analysis of unlinked healthcare datasets?

9.2.1. Research question 2: Brief review of the problem

The 'joined up' approach adopted as part of this study, involving the simultaneous analysis of multiple datasets via the anonymous linkage of patient identifiers, differs from the methodology adhered to prior to the recent developments in record linkage techniques. In the past administrative healthcare datasets have been analysed separately, with the incidence and direct medical cost of injury findings applicable to each health service provider either reported on individually or summed together in an attempt to arrive at a total incidence/direct medical cost figure associated with the entire healthcare sector. One major drawback of this past approach, however, concerns the inability to fully acquire the complete picture of the healthcare journey at an individual patient level. That is, by analysing administrative healthcare datasets separately, with there being no way of knowing whether a given healthcare event occurring within one healthcare sector is related to another healthcare event taking place within a different healthcare sector, it is not possible to infer the overall impact of a given injury on the demand for the services of several different health service providers.

For example, an individual hospitalised following an injury to his/her back in a fall would be identified as part of an inpatient dataset, contributing to the cost injury imposes on the operating expenses of one or more hospitals who provide the immediate treatment of the injury. If this injury patient is subsequently in need of further treatment at an outpatient clinic in order to improve mobility then they would also be recorded in an outpatients register. Consequently, the expenditures associated with such an individual would additionally be incorporated in the calculation of costs attributable to this other health service provider. However, without the ability to accurately determine whether this particular injury patient is the same individual receiving injury related treatment and rehabilitation in each of these separate datasets that record the use/demand for these services, it is not possible to accurately infer the total direct medical cost of injury imposed across multiple healthcare sectors relating to this specific patient.

9.2.2. Research question 2: Review of existing literature

As has been indicated in Chapter 2, several past research studies have been undertaken with the aim to report on the direct medical costs associated with the occurrence of injuries. In some of these investigations such expenditures have been determined following the linking together of healthcare datasets through the use of unique individual identifiers (Samsa, Landsman and Hamilton 1996; Rask et al. 1998; Unwin and Codde 1998; Hansagi et al. 2001; Chandler and Berger 2002; Dryden et al. 2004; Brown et al. 2006; Cameron et al. 2006; Davis et al. 2007; Curtis et al. 2009). In the other investigations this 'joined up' approach has not been possible meaning the direct medical costs incurred by health service providers following the treatment/care/rehabilitation of injuries have had to be reported separately for each healthcare sector.

Whilst differences in the approaches to estimating the direct medical costs of injury is apparent across research studies, what is less clear is whether the ability to link together administrative healthcare datasets at an individual patient level produces different estimates of resource utilisation and resulting direct medical costs associated with the occurrence of injury compared to studies reporting results based on no record linkage.

9.2.3. Research question 2: Aim

To ascertain whether there is a major difference between direct medical cost of injury estimates using linked patient records and the equivalent estimates acquired from a parallel use of separate unlinked datasets, following the occurrence of an index injury.

9.2.4. Research question 2: Methodology

Two alternative analysis methods were adopted, reflecting the ability and inability to link together the healthcare datasets of interest.

- Analysis Method 1

Analysis Method 1 involved the ED, inpatient and outpatient datasets, from which the direct medical costs of injury were to be estimated, being joined together through utilising data linkage techniques made possible by the presence of an anonymised linking field within each dataset. Essentially, therefore, the ability to link the healthcare datasets of interest in this way meant that Analysis Method 1 could conform to the methodology implemented to determine the extent of excess HSU and direct medical costs outlined in Chapter 4.

To recap, in order to determine the initial study population the first step involved identifying residents of Swansea known to be living in the area throughout the investigative period spanning from 01/04/2004 to 31/03/2007. Members of this study population found to have sustained an injury in receipt of treatment within the ED and/or inpatient sector during the period 01/04/2005 to 31/03/2007 were then extracted in order to form the injured cohort, with each individual's first occurring injury healthcare event within the primary diagnosis position being classed as the index injury healthcare event. Next all subsequent ED, inpatient and outpatient healthcare events (for all conditions) associated with each member of the injured cohort were identified during the follow-up period, spanning from the end of the index injury event up to either 31/03/2007 (i.e. the end of the investigative period), the date of death (in the case of individuals dying prior to the study end) or the start date of a new, unrelated, ED/inpatient injury event. The number and length of these healthcare events (excluding the healthcare event associated with the treatment of the index injury) were then determined to infer the extent of HSU observed throughout the post-index injury period, with the extent of observed direct medical costs incurred over this interval deduced by applying unit costs acquired from the TFR2 accounts (Financial Information Strategy Programme 2007) to each unit of healthcare activity. The direct medical cost figures expected during this timeframe were then determined based on the cost of healthcare contacts known to have taken place in the period prior to the occurrence of the index injury, whilst also taking into account the age of the injured patient, any dataset trends and the length of the follow-up period. Finally, the extent of excess direct medical costs associated with each index injury was estimated by finding the difference between the observed and expected direct medical cost figures.

- Analysis Method 2

In Analysis Method 2 the same ED, inpatient and outpatient healthcare datasets were analysed as in Analysis Method 1, but in this instance they were appraised separately as if data linkage was not possible. To achieve this, and thus replicate the process of events that would have ensued had a common patient identifier not been present, the anonymous record linking field was masked in each of the healthcare datasets, thereby eliminating the ability to link together two or more different, but potentially associated, records.

First, the number of injury ED attendances and inpatient admissions taking place during the period 01/04/2005 to 31/03/2007 were identified using the same injury related Morriston ED and ICD-10-CM primary diagnosis codes as in Analysis Method 1. The number of injury related outpatient contacts were determined by extracting all outpatient appointments taking place between 01/04/2005 and 31/03/2007 associated with a specialty code of treatment of either 'Trauma and orthopaedics', 'Neurosurgery' or 'Burns/plastic surgery' (injuries in receipt of outpatient care had to be identified through the presence of injury related specialty codes as opposed to diagnosis codes given incomplete coverage of the latter within the outpatient dataset scrutinized as part of this study). Next, all the injury healthcare events within the ED, inpatient and outpatient datasets sustained by someone not from Swansea were excluded, as determined by the presence of a non-Swansea LSOA of residence associated with the injury event recorded within the ED, inpatient and outpatient datasets. The direct medical costs of each healthcare event was then estimated by applying unit costs acquired from the TFR2 accounts (Financial Information Strategy Programme 2007) to each component of health service activity, in the same way as in Analysis Method 1.

9.2.5. Research question 2: Results

- Analysis Method 1

Given Analysis Method 1 involved estimating the extent of excess HSU and resulting excess direct medical costs of injury through the implementation of the methodology devised and discussed in Chapter 4 of this thesis, the results of Analysis Method 1 are necessarily the same as those reported in Chapters 6 and 7 of this thesis.

In summary, based on the 30,387 index injuries identified amongst the injured cohort a total of 3,647 excess ED attendances, 2,119 excess inpatient admissions, 30,492 excess inpatient bed days and 16,715 excess outpatient contacts were recorded over the course of the investigative period. For every index injury these figures equate to an extra 0.12 ED attendances, 0.07 inpatient admissions, 1.00 inpatient bed days and 0.55 outpatient contacts taking place during the post-index injury period relative to the number expected to have occurred over the same timeframe in the absence of an injury.

In terms of the resulting excess direct medical costs incurred by the ED, inpatient and outpatient healthcare sectors amounts of £366,162, £14,963,558 and £2,227,480 were generated, respectively, equating to an overall direct medical cost incurred by all three healthcare sectors combined of £17,557,200. Thus, given the 30,387 index injuries identified, for every index injury sustained by a member of the injured cohort the excess direct medical cost faced by the ED, inpatient and outpatient sectors on average equated to £12.05, £492.43 and £73.30, respectively, equating to an overall combined average of £577.79.

- Analysis Method 2

During the follow-up period applicable to Analysis Method 2, spanning from 01/04/2005 to 31/03/2007, a total of 57,853 ED attendances, 7,522 inpatient admissions, culminating in 62,959 inpatient bed days, and 82,333 outpatient contacts were found to be associated with the injured cohort under scrutiny. Based on the TFR2 accounts from which the unit costs of each medically treated healthcare event has been derived as part of this study, these figures amount to a direct medical cost of £5,809,020, £28,063,018 and £10,490,564 being incurred by the ED, inpatient and outpatient sectors respectively, resulting in a combined aggregated direct medical cost of £44,362,602.

In contrast to Analysis Method 1 the number of actual index injuries sustained throughout the course of the follow-up period could not be identified as part of Analysis Method 2, given the inability to link healthcare records together. Furthermore, no repeat event indicator was present within the healthcare datasets analysed. Instead, therefore, each injury related ED attendance, inpatient admission and outpatient contact identified when performing Analysis Method 2 had to be assumed to be associated with a new injury. Consequently, based on 57,853 ED attendances, 7,522 inpatient admissions and 82,333 outpatient contacts, the average direct medical cost per ED attendance, inpatient admission and outpatient contact equated to £100.41 (£5,809,020 / 57,853), £3,730.79 (£28,063,018 / 7,522) and £127.42 (£10,490,564 / 82,333), respectively. In addition by summing the ED, inpatient and outpatient injury events together the direct medical cost per injury event across all three sectors was equal to £300.34 (£44,362,602 / [57,853 + 7,522 + 82,333]).

9.2.6. Research question 2: Discussion

9.2.6.1. Summary of main findings

It is apparent from section 9.2.5 that the calculation of treatment expenditures specific to the ED, inpatient and outpatient sectors individually are considerably larger when performed following implementation of Analysis Method 2 compared to Analysis Method 1. This suggests that the inability to link healthcare datasets together through the use of patient identifiers in such a way to allow a new, unrelated, injury healthcare event to be clearly distinguished from a recurring, related, injury healthcare event has a marked impact on the extent of the overall direct medical costs reported to have been incurred by each healthcare sector following the occurrence of an index injury.

Furthermore, section 9.2.5 additionally signifies that there is a difference observed between the analysis methods when considering the direct medical costs associated with a given injury event on average (i.e. an index injury in Analysis Method 1; an index ED attendance, inpatient admission or outpatient contact in Analysis Method 2). For instance, an index injury identified as part of Analysis Method 1 is found to incur ED treatment costs of around £12, which is much less than the £100 average direct medical cost applicable to an index ED attendance when Analysis Method 2 is undertaken. A similarly marked difference is apparent when comparing inpatient treatment costs, whereby every index injury that is identified as part of Analysis Method 1 serves to culminate in excess inpatient direct medical costs of £492, whilst when implementing Analysis Method 2 every inpatient admission assigned an injury diagnosis costs on average £3,731, over £3,000 more.

9.2.6.2. Reasons for alternative reporting of direct medical costs

Several reasons exist for the apparent variations in the extent of the direct medical costs reported following the implementation of these two different analysis methodologies.

- Given the aim of this research question was to estimate the extent of direct medical costs associated with the occurrence of an index injury, as part of Analysis Method 1 only injury related ED attendances, inpatient admissions and outpatient contacts were counted during the follow-up period if they were considered to be related to the initial index injury sustained by that particular individual, based on the findings presented in research question 1 in section 9.1 of this chapter. Consequently, adherence to Analysis Method 1 meant that any healthcare events involving the treatment/care of an injury that were not deemed to be connected to the initial index injury served to signal the end of the follow-up period and were excluded from the excess direct medical cost calculations. In contrast, the inability to link healthcare records together as part of Analysis Method 2 meant that ascertaining whether multiple injury related healthcare events within the same healthcare sector were related in any way was not possible. This was due to the fact that in the absence of any readmission variable, together with no unique patient identifier being available, no means existed to ascertain whether two or more injury related healthcare events were associated with the same person or not. Thus, each new injury related healthcare event recorded within the ED, inpatient and outpatient sectors had to be assumed to be unrelated to any previous healthcare events, which meant that all injury related ED attendances, inpatient admissions and outpatient contacts taking place between 01/04/2005 and 31/03/2007 had to be counted as part of Analysis Method 2.

  An example of the difference between the two analysis methods in this particular respect is presented below:

Consider the case of individual A who is admitted as an inpatient for 2 days to receive treatment for a wound type injury on 20/06/2005 and is then identified as being readmitted as an inpatient on 10/01/2007 for additional wound related treatment. Based on the methodology and findings presented as part of research question 1 (section 9.1 Chapter 9), given the first healthcare event is due to an injury that forms part of the 'Superficial injury, open wounds' Meerding nature of injury grouping it follows that any subsequent admission as an inpatient for an injury categorised within this same Meerding grouping that occurs within 332 days of discharge should be regarded as a repeat injury event. In the case of individual A the succeeding admission as an inpatient has taken place in excess of 332 days after the end of the initial inpatient admission (10/01/2007 – 22/06/2005 = 568 days). Consequently, this additional inpatient admission should be regarded as being the result of a new injury. The ability to link healthcare events to individuals as part of Analysis Method 1 means this exact scenario can be identified and accounted for; meaning the inpatient admission taking place in 2007 would not be counted as it is considered a new, unconnected, injury healthcare event. However, the inability to link healthcare events to individuals as part of Analysis Method 2 means such detailed scrutiny of the relationship between the inpatient admissions is not possible. Hence, this subsequent healthcare event would have been counted according to this particular methodology even though it is most likely not related to the index inpatient admission (based on the findings of research question 1, section 9.1 Chapter 9).

Related to the point above, the fact that in Analysis Method 1 all healthcare events observed during the follow-up period could be assigned to a given individual and attributed to the initial index injury meant that both injury and non-injury ED attendances, inpatient admissions and outpatient contacts could be counted and costed. That is, as part of Analysis Method 1 it was possible to include in the direct medical cost calculations the healthcare resources consumed during the treatment/care of non-injury related conditions given the presence of a unique patient identifier meant these healthcare events could also be traced back to an individual who is known to have been in receipt of earlier ED/inpatient treatment for an injury. Alternatively, the lack of a unique patient identifier within the healthcare datasets appraised within Analysis Method 2 meant that only injury related healthcare events could be counted and costed given there was no way of knowing whether a particular non-injury ED attendance, inpatient admission or outpatient contact was associated with the same individual who had earlier sustained an injury that was in receipt of healthcare treatment.

- Another major difference between Analysis Methods 1 and 2 concerns the fact that in the case of the former the final direct medical costs reported relate only to the excess healthcare expenditures associated with the occurrence of injuries. That is, for Analysis Method 1 the direct medical costs are essentially those healthcare expenditures remaining after subtracting from the direct medical costs observed during the follow-up period the value of the direct medical costs expected over this timeframe in the absence of any injury, based on the extent of healthcare expenditures observed during the pre-follow-up period. In the case of Analysis Method 2, however, the final direct medical costs reported relate to the actual healthcare expenditures observed during the follow-up period and not the excess equivalent, acquired after deducting the healthcare expenditures expected during the follow-up period. It was not possible to infer excess direct medical costs as part of Analysis Method 2 since there was no way of knowing whether any of the injury related healthcare events observed during the follow-up period were associated with the same individual in receipt of treatment/care for an injury during the pre-follow-up period.

- The way in which outpatient contacts were counted and costed also varied depending on the analysis methodology adopted. For Analysis Method 1 both injury and non-injury outpatient contacts were accounted for but only if they were considered related to an earlier index injury. That is, only if they took place during the follow-up period applicable to an individual known to have been in receipt of ED/inpatient treatment for an injury. Hence, as part of

Analysis Method 1 there was no need to distinguish between injury and non-injury related outpatient contacts. In contrast, in the case of Analysis Method 2 it was necessary to separate apart injury and non-injury outpatient contacts due to the fact only the former were to comprise part of the direct medical cost calculations, given the absence of a unique patient identifier meant there was no way of connecting non-injury outpatient contacts to an individual known to have been in receipt of earlier healthcare treatment for an injury. However, this need to distinguish between the outpatient contacts in terms of the type of condition treated/cared for presented the problem of finding out whether a given outpatient event was actually associated with an injury or not, due to the lack of diagnosis codes available within the outpatient dataset scrutinized as part of this study. In an attempt to confine the outpatient contacts to those related to an injury, only contacts assigned an injury related specialty of 'Trauma and orthopaedics', 'Neurosurgery' or 'Burns/plastic surgery' were considered. Identifying injury related outpatient contacts in this way is not ideal however given the possibility that certain injury induced outpatient contacts will be assigned a different specialty code, or alternatively given the potential for non-injury related outpatient contacts being categorised within the specialties of 'Trauma and orthopaedics', 'Neurosurgery' or 'Burns/plastic surgery'.

Hence, as a result of it not being possible to overcome the diagnosis deficiencies inherent within the outpatient dataset by connecting a particular outpatient contact to an individual known to have been in receipt of earlier ED/inpatient treatment for an injury, as in the case of Analysis Method 1, there existed a possibility that the number of injury related outpatient contacts counted and costed as part of Analysis Method 2 may have been under- or overestimated depending on the way in which specialty codes had been assigned to each outpatient contact.

9.2.6.3. Limitations

- To a certain degree the answering of this research question represents a crude comparison of two alternative analysis methodologies and has been undertaken with the aim to infer whether the ability or otherwise to link healthcare datasets together has any influence on the scale of the direct medical costs reported following an index injury. Whilst this has been shown to be the case in relation to the specific study populations and healthcare datasets under scrutiny within this investigation there is no guarantee that the scale of the difference reported here, or indeed any difference at all, will persist in other investigations involving alternative study populations and healthcare datasets. However, the marked difference in the size of the direct medical costs resulting from each analysis method suggests that continued divergence may very well be apparent in additional studies that are undertaken in this area. Further research is required to confirm this.

- The findings presented as part of answering this research question can only be used to show that there is a difference when the aim is to infer the size of the direct medical costs following the occurrence of the first index injury per injured individual. If, for instance, Analysis Method 1 had been undertaken in such a way so as to allow multiple subsequent index injuries to have been incurred by a particular individual, as opposed to the follow-up period being curtailed after the first index injury, then it is likely that the overall direct medical cost results reported across all injuries following implementation of Analysis Method 1 in this research question will have been greater and thus closer to the healthcare expenditures reported following implementation of Analysis Method 2. It must be noted, however, that it was not possible to account for the HSU and direct medical costs associated with subsequent index injuries as part of this study for the reasons outlined in section 10.4 of Chapter 10.

- Together with there being a possibility of the differences observed between the analysis methodologies reported as part of this research question being less marked due to Analysis Method 1 being undertaken slightly differently, this situation may also arise following adjustments to the way in which Analysis Method 2 was performed. For instance, if a readmission variable had been present within the ED, inpatient and outpatient datasets appraised during this study then the ability to distinguish between new and repeat injury induced healthcare events would have been possible even in the absence of any unique patient identifiers. If this had been the case then there would only have been a need to count and infer the direct medical cost of injury healthcare events taking place during 01/04/2005 and 31/03/2007 that were identified as new events or events related to a new event treated/cared for within the interval 01/04/2005 and 31/03/2007. In this way injury healthcare events taking place during 01/04/2005 and 31/03/2007 that were identified as related to a new injury event with a start date prior to 01/04/2005 could be excluded from the direct medical cost calculations. Hence, the presence of a readmission variable within the healthcare datasets scrutinized as part of Analysis Method 2 may have served to reduce the number of injury related healthcare events identified. Furthermore, if the readmission variable was sufficiently detailed so that it was possible to connect non-injury healthcare events to earlier injury ones then it may even have been viable during implementation of Analysis Method 2 to count and cost those non-injury healthcare events taking place between 01/04/2005 and 31/03/2007 that were identified as being related to a prior injury healthcare event occurring within this interval.

9.2.6.4. Implications

Despite the limitations acknowledged in section 9.2.6.3 above the answering of this research question can potentially have several implications for future research aimed at assessing the direct medical costs associated with the occurrence of an index injury amongst a given study population.

- The fact that for the first time the ability or otherwise to link healthcare datasets together via the presence of unique patient identifiers has been shown to influence the scale of the direct medical costs reported represents a major finding which arguably has a bearing on the design of all future cost of injury studies. Now the decision as to whether to incorporate data linkage techniques has been shown to be an important one that can potentially have a marked impact on the final cost results reported.

- Specifically in the case of cost of injury studies seeking to estimate the healthcare treatment expenditures associated with an index injury it has been shown that the ability to link healthcare records together in such a way that it is possible to infer to which individual a given injury is associated represents a vital feature of this type of cost of injury study. As shown when adhering to Analysis Method 2 the inability to do this, due to the absence of unique patient identifiers, means that all injury related healthcare events must be counted and costed, whilst no non-injury healthcare events can be counted and costed at all. As recognised in the limitations listed in section 9.2.6.3 of this chapter this situation may change slightly in the presence of a readmission variable within the healthcare datasets appraised, however, this field is not widely available in many health administrative registers and even when it is the accuracy with which it is filled in is questionable (Boufous and Finch 2005). This latter point is particularly true in the case of any readmission variable present within a dataset which has no unique patient identifiers available to link healthcare events to the same patient. In such instances it is necessary for the readmission variable to be sufficiently detailed and accurate to make it possible to link injury and non-injury healthcare events together without knowing to whom each is associated, which may prove very difficult in practice.

- In answering this research question it has been shown that the excess direct medical cost model devised and developed as part of this study, that allows the cost of excess healthcare events to be determined by finding the difference between the treatment expenditures associated with healthcare events observed and expected during the follow-up period, can only be implemented when data linkage is possible. Without the ability to connect given healthcare events to the same patient due to the absence of unique patient identifiers, there is no way of determining whether healthcare events known to have taken place prior to the start of the follow-up period are associated with the same individual in receipt of healthcare treatment during the actual follow-up period. Without knowing the pre-follow-up healthcare history of a given patient it is not possible to predict the extent of direct medical costs expected during follow-up, thereby eliminating the prospect of calculating excess figures which rely on subtracting expected treatment costs from their observed equivalent.

9.2.7. Research question 2: Summary

The answering of this research question suggests the ability or otherwise to link healthcare events together, in such a way that it is possible to determine their relationship both between and within healthcare datasets, can potentially have a major impact on the scale of the direct medical costs reported following the occurrence of an index injury. Implementation of the 'joined-up' approach adopted as part of Analysis Method 1, whereby multiple healthcare events could be attributed to a given patient making it feasible to distinguish between new and repeat healthcare events, resulted in a much lower overall direct medical cost estimate incurred by the ED, inpatient and outpatient sectors compared to the equivalent estimate reported following adoption of Analysis Method 2, in which no linkage of healthcare records could be performed due to the absence of unique patient identifiers.

Reasons for the apparent difference in the results according to the analysis methodology adopted include: (i) the ability to employ data linkage making it possible for only injury related ED attendances, inpatient admissions and outpatient contacts to be counted and costed if they are considered related to the initial injury sustained by a given individual; (ii) the ability to employ data linkage making it possible for non-injury related ED attendances, inpatient admissions and outpatient contacts to be counted and costed due to it being possible to connect these healthcare events to an individual who has already sustained an initial injury; (iii) the ability to employ data linkage making it possible to find the excess direct medical costs following an index injury by calculating the difference between the treatment expenditures associated with healthcare events observed and expected during the follow-up period; (iv) the ability to employ data linkage making it possible to identify outpatient contacts assumed to be related to an injury event, all of which can be counted and costed, as opposed to attempting to distinguish between injury and non-injury outpatient contacts through the use of specialty codes that may serve to under-/overestimate the true number of injury related outpatient contacts.

The findings presented as part of answering this research question must be put into context, however. They relate only to direct medical cost of injury studies seeking to report on the treatment expenditures associated with an index injury and apply only to the study population and healthcare datasets analysed as part of this investigation. Hence, the differences observed between the alternative analysis methodologies based on the presence/absence of unique patient identifiers may potentially be reduced or eliminated altogether if multiple index injuries were accounted for as part of Analysis Method 1, or if a readmission variable had been available within the healthcare datasets appraised as part of Analysis Method 2, or if both analysis methods had been performed on alternative study populations using different healthcare datasets.

Despite such potential shortcomings, in answering this research question a clear difference has for the first time been shown to exist depending on the ability/inability to link healthcare records together. It has been possible to clearly signify the virtues of data linkage as a component of any study aiming to report on the direct medical costs of an index injury. Without the ability to link healthcare events together it has been shown that several integral features of any study seeking to report on the wide-ranging, longitudinal, impact of an index injury are no longer possible. These include the counting and costing of injury and non-injury induced healthcare events considered related to an earlier injury, and the opportunity to report on excess HSU and direct medical costs by finding the difference between the observed and expected estimates of these outcome measures.

Chapter 10 – Discussion

10.1. Introduction

In satisfying the main aims and objectives set out in Chapter 3 this study has developed a model that has successfully utilised large scale, linkable and fully anonymised healthcare datasets as a means to estimate the extent of excess HSU and direct medical costs arising following the occurrence of an index injury. The main findings resulting from this analysis are presented within this discussion chapter, and then compared, along with the associated methodology, with the findings/methodology of the studies appraised during the literature review conducted in Chapter 2. Finally the limitations, strengths and implications of this study are described in detail.

10.2. Summary of main findings

10.2.1. Excess HSU

Every index injury on average culminated in an extra 0.12 (95% CI 0.11, 0.13) ED attendances (or equivalently 12% of a single ED attendance), 0.07 (95% CI 0.06, 0.08) inpatient admissions, 1.00 (95% CI 0.78, 1.23) inpatient bed days and 0.55 (95% CI 0.52, 0.58) outpatient contacts taking place during the post-index injury period relative to the number expected to have occurred over the same timeframe in the absence of any injury. That is, for every 10,000 index injuries between 1,100 and 1,300 excess ED attendances, between 600 and 800 excess inpatient admissions, between 7,800 and 12,300 excess inpatient bed days, and between 5,200 and 5,800 excess outpatient contacts are estimated to take place over the course of the follow-up period.

Below, the mean excess HSU findings per index injury are summarised in terms of the gender and age of the injured cohort, and the type of index injury sustained.

- Gender

Whereas the mean excess count of ED attendances, inpatient admissions and outpatient visits per index injury are not greatly influenced by the gender of the injured individual this is not the case in relation to the mean excess count of inpatient bed-days per index injury. Indeed, when focusing specifically on the length of inpatient stay it is apparent that the observed count of bed-days relative to the number expected is considerably larger for females than males, with the former requiring 3 times as many excess days as an inpatient post-index injury compared to the equivalent figure for males.

- Age

Age is not a major predictor of the likelihood of ED treatment being sought after the occurrence of injury with high and low excess ED attendance counts on average per index injury evident amongst the young, middle aged and older subgroups of the injured cohort. However, there is a clear positive relationship between age and excess counts of inpatient admissions, inpatient bed-days and outpatient visits, with these particular units of healthcare activity far greater following index injuries sustained by older aged individuals within the injured cohort.

- Socioeconomic classification

A general pattern is evident when considering the socioeconomic status of the injured cohort and the excess levels of HSU observed during the post-index injury period. Excess counts of ED attendances, inpatient admissions and inpatient bed-days each tend to be lower following index injuries sustained by individuals within the least deprived socioeconomic grouping. By contrast, index injuries amongst individuals associated with this level of deprivation tend to lead to higher excess counts of outpatient attendances on average.

- <u>Type of index injury</u>

Certain groupings of index injury, such as the categories of 'Internal organ injury' and 'Facial fracture, eye injury', are associated with either a statistically insignificant or a very low statistically significant count of excess units of activity across the ED, inpatient and outpatient healthcare sectors, reflecting the fact that they are relatively uncommon types of injury. Other index injury groupings only display these characteristics within particular healthcare sectors. Hip fractures and injuries to the spine/vertebrae, for instance, tend to exhibit low and statistically insignificant counts within the ED sector given they often bypass ED treatment and are admitted straight to hospital. Upper and lower extremity injuries tend to be associated with low and statistically insignificant counts within the inpatient sector since these types of injury are increasingly being treated in non-inpatient settings.

The types of index injuries leading to the highest statistically significant counts of healthcare activity are also not consistent across the ED, inpatient and outpatient sectors, whilst they additionally vary by gender. The categories of 'Skull-brain injury' and 'Superficial injury, open wounds' are associated with a large mean excess number of ED attendances for males and females, respectively. Injuries to the skull and brain also lead to a high number of inpatient admissions and bed-days amongst male members of the injured cohort, whereas the number and length of inpatient admissions for females are by far the highest following the occurrence of hip fractures. Irrespective of gender, the highest mean excess count of outpatient visits is associated with a burn index injury.

- <u>Mechanism of injury</u>

When considering excess counts of ED attendances each of the mechanism of injury categories are statistically insignificant at the 95% confidence level. Index injuries categorised within the 'MVTC' and 'Fall' mechanism of injury groups lead to by far the highest mean counts of excess inpatient admissions amongst males and females, respectively. This pattern is also evident with regards to excess counts of inpatient bed-days on average. In terms of the mean excess counts of outpatient contacts per index injury, highest counts are observed following index injuries caused by a 'Burns' mechanism.

- Location of injury

Irrespective of gender index injuries sustained at a sports setting lead to a statistically insignificant count of excess ED attendances, inpatient admissions and inpatient bed-days at the 95% confidence level. By contrast index injuries at this particular location of injury culminate in by far the highest excess count of outpatient contacts on average. Index injuries sustained within the home lead to the highest excess counts of inpatient admissions amongst females, with this the case for RTA type incidents when considering counts of excess inpatient admissions amongst males. The location category of 'Home' dominates excess counts of inpatient bed-days for both males and females.

10.2.2. Excess direct medical costs

Following an index injury the excess direct medical costs incurred by the ED, inpatient and outpatient healthcare sectors are estimated to be around £12.05 (95% CI £11.05, £13.05), £492.43 (95% CI £415.66, £569.21) and £73.30 (95% CI £68.44, £78.17), respectively, equating to a combined figure of £577.79 (95% CI £500.32, £655.26). Across the entire injured cohort this amounts to an overall excess direct medical cost total of £17.6 million, with the vast majority of this figure (85.2%) comprising the cost of inpatient treatment.

Below, the mean excess direct medical cost findings per index injury are summarised in terms of the gender and age of the injured cohort, and the type of index injury sustained.

- Gender

There is no apparent variation in terms of gender when considering the mean excess direct medical cost per index injury generated within the ED and outpatient sectors. By contrast the size of the excess inpatient treatment costs associated with a given index injury on average is far greater amongst females than males. This finding suggests that the direct medical costs of inpatient treatment is more positively related to the length of inpatient admissions as opposed to the frequency of the admissions, given variation by gender was only observed in the case of the former.

- Age

The age at which the index injury is sustained is only related to the size of the direct medical costs generated within the inpatient and outpatient sectors. That is, as the age of the injured cohort increases so too does the mean excess inpatient and outpatient treatment costs observed per index injury. This pattern is not evident when considering excess direct medical costs incurred by the ED sector specifically, with high and low ED treatment costs a feature of index injuries sustained by the young, middle aged and older members of the injured cohort.

- Socioeconomic classification

There is an apparent inverse relationship between the socioeconomic status of the injured cohort and the mean excess costs generated within the outpatient sector on average following an index injury, whereby higher costs ensue when index injuries amongst the least deprived are sustained. The opposite of this pattern is more evident when considering the impact of socioeconomic status on excess cost levels observed within the ED and inpatient sectors however.

- Type of index injury

Within the ED sector the highest treatment costs on average arise following skull/brain injuries when considering both genders together as well as males specifically, whilst ED attendances treating superficial/open wound injuries are the most costly amongst females. In terms of the size of the direct medical costs incurred by the inpatient sector these are largest following the occurrence of hip fracture index injuries, with this finding applicable to both males and females. Similarly, irrespective of gender, outpatient treatment costs per index injury are highest on average when a burn injury has been sustained by a member of the injured cohort.

Particular types of index injury, such as injuries to the internal organs and face/eye, are associated with either a low or statistically insignificant excess treatment cost on average within the ED, inpatient and outpatient sectors, due to the relative infrequency with which they occur. Other groupings of index injury are associated with a mean excess direct medical cost that is low or not statistically different from zero at the 95% confidence level only within particular healthcare sectors, which is a reflection of the characteristics of those specific types of injury. For instance, this is the case for hip fractures in terms of ED treatment costs given they are almost always admitted straight to hospital, whilst low/statistically insignificant inpatient treatment costs tend to apply to upper/lower extremity injuries since they are increasingly being dealt with in non-inpatient settings.

- Mechanism of injury

Index injuries sustained via a 'Burns' mechanism culminate in by far the highest costs incurred within the outpatient sector on average, with this the case for both males and females. When considering the whole of the injured cohort index injuries caused by an MVTC related mechanism lead to the highest excess level of inpatient costs, followed by index injuries caused by a 'Fall' mechanism. This latter mechanism is most prominent amongst females, with male index injuries sustained within MVTC and poisoning related incidents leading to the highest excess inpatient costs on average. Irrespective of gender each of the mechanism of injury groupings exhibit statistical insignificance in terms of excess costs generated within the ED sector.

- Location of injury

Whereas index injuries sustained at a sports setting lead to the highest excess cost levels observed within the outpatient sector, this location category is not associated with a statistically significant mean excess ED or inpatient cost per index injury. Highest direct medical costs are generated within the inpatient sector following index injuries sustained within the home.

10.2.3. The size of the excess HSU, direct medical cost and overall economic burden of injury

This study signifies the marked scale of the excess HSU and direct medical costs that arise following the occurrence of an index injury, with the size of the latter when extrapolated to the whole of Wales being as high as £306.4 million. Moreover, since the focus of this investigation is only on the direct medical costs associated with the occurrence of an index injury it follows that the actual total economic costs incurred, incorporating also the indirect costs of injury, will be much higher than the direct medical cost figures reported in this study. The magnitude of the excess HSU, direct medical cost and overall economic burden resulting from injury highlight the importance of deciding on the correct allocation of resources and the appropriate setting of policy priorities when attempting to tackle the injury problem.

10.3. Comparison with current literature

As indicated in Chapter 2, a variety of past studies have been initiated with the aim of reporting on the scale of the HSU and direct medical costs associated with the occurrence of injuries. In this section, the methodology and findings applicable to this study will be discussed in terms of the pre-existing literature as a means to determine the extent of any similarities and differences observed.

10.3.1. HSU

In terms of study design, like in this investigation, just under half of the studies appraised during Stage 2 of the literature review followed up their cohort of individuals solely through the use of computerised searches of healthcare and population databases (Holmberg and Thorngren 1988; Blose and Holder 1991; Bergman, Brismar and Nordin 1992; Samsa, Landsman and Hamilton 1996; Hansagi et al. 2001; Dryden et al. 2004; Brown et al. 2006; Cameron et al. 2006; Locker et al. 2007; Guilcher et al. 2010). The remaining 11 studies collected some information through the use of questionnaires/surveys (Safran, Graham and Osberg 1994; Levi 1997; Rask et al. 1998; Hodgkinson et al. 2000; Bishai and Gielen 2001; Wiktorowicz et al. 2001; Maraste, Persson and Berntman 2003; Miettinen et al. 2004; Seematter-Bagnoud et al. 2006; Slomine et al. 2006; Gabbe et al 2007), however, such direct questioning of the study population could not be conducted as part of this investigation due to the large size of the injured cohort (n = 30,387) followed-up.

Whilst the utilisation of data linkage as a means to join together records from multiple different but related datasets comprised a major component of this study only a third of the pre-existing studies made use of data linkage techniques in this way (Samsa, Landsman and Hamilton 1996; Rask et al. 1998; Hansagi et al. 2001; Dryden et al. 2004; Brown et al. 2006; Cameron et al. 2006). Five of the research articles surveyed in Chapter 2 incorporated a control cohort against which to compare the HSU findings applicable to their injured cohort of individuals (Blose and Holder 1991; Bergman, Brismar and Nordin 1992; Dryden et al. 2004; Brown et al. 2006; Cameron et al. 2006). Instead of adopting such a method as part of this study, the level of HSU identified during the post-index injury follow-up period was compared with the levels observed amongst the same individuals prior to the start of the follow-up period. In this way the injured cohort incorporated into this study could act as their own controls. Only two of the pre-existing studies appraised performed any sort of comparison in HSU between the pre-and post-index injury periods (Wiktorowicz et al. 2001; Brown et al. 2006).

In keeping with the findings reported in Chapter 6 all of the studies reviewed during Stage 2 of the literature review reported an increase in HSU levels during the follow-up period. The results of this study signify that on average a given index injury leads to a greater number of outpatient visits (0.55) compared to the number of ED attendances (0.12) and inpatient admissions (0.07). Similarly, when comparing directly the number of ED, inpatient and outpatient contacts resulting from a given injury episode, Bishai and Gielen (2001) found that for every 100 injury conditions there were a total of 254 outpatient visits, compared to just 23 ED attendances and only four hospitalisations. Furthermore, in the study by Blose and Holder (1991) the number of outpatient events exceeded the number of emergency room contacts and inpatient admissions.

Another similarity between the HSU results of this study and those presented within pre-existing studies concerns the higher level of care applicable to females and older aged individuals. Blose and Holder (1991), for instance, identify the relative risk of receiving care following an injury to be higher for both female members of their sample cohort plus those aged above 51. Similarly, the mean excess count of inpatient bed-days was found to be far higher following an index injury sustained by a female individual followed-up as part of this study, whilst the excess number/length of inpatient admissions and the number of outpatient visits per index injury were also identified as being greater amongst the elderly members of this injured cohort. In contrast to the findings of this study, however, whereby the age of the injured individual is not found to be a major predictor of ED attendance, Locker et al. (2007) identify frequent users of the ED as being older aged individuals. One reason for this difference concerns the latter study considering all presentations to the ED and not just those specific to an injury related index ED event. Moreover, Locker et al. (2007) were only reporting on the number of ED attendances observed during the follow-up period and not the excess number calculated when considering the number of ED attendances expected during the follow-up period, as was the case in this study.

Variations in the HSU observed according to the type of index injury sustained that are reported as part of this study are difficult to compare with equivalent findings presented by the pre-existing studies appraised during the literature review undertaken in Chapter 2, given only four of the 21 articles reviewed stratified their HSU results by injury type (Bishai and Gielen 2001; Cameron et al. 2006, Brown et al. 2006, Guilcher et al. 2010). One notable difference in terms of the impact of different injuries on HSU concerns the levels associated with poisoning. Bishai and Gielen (2001), for instance, identify poisoning as the injury type most likely to result in ED attendances, whereas this particular grouping of index injuries is found to lead to a statistically insignificant count of excess ED attendances when the whole of the injured cohort followed up as part of this study is considered. Similarly, Bishai and Gielen (2001), and also Cameron et al. (2006), find the number of hospitalisations highest among their poisoning group of patients, whilst within this study index injuries due to poisoning are again associated with a statistically insignificant excess inpatient admission count on average. Potential reasons for these contrasting results include Bishai and Gielen (2001) basing their findings solely on self-reported medical utilisation reported by their sample cohort, which may be influenced by recall bias, and the fact the investigations by Bishai and Gielen (2001) and Cameron et al. (2006) were undertaken in the US and Canada respectively, which may have alternative hospital admission thresholds for poisoning compared to Wales, the setting for this investigation. Furthermore, another possible reason for the difference in HSU associated with poisoning concerns the studies by Bishai and Gielen (2001) and Cameron et al. (2006) reporting on the number of poisoning related healthcare events that were observed post-injury as opposed to the excess number involving a comparison with the number of poisoning related healthcare events expected post-injury, as was the case in this study.

Another major difference between this investigation and existing studies reporting on HSU levels by injury type concerns the number and length of healthcare events associated with spinal cord injuries. Cameron et al. (2006), for instance, find these types of injury account for the highest length of hospital stays, whereas, somewhat surprisingly it could be argued, the mean excess number of bed-days per spinal cord index injury estimated within this study is relatively low. Additional research is required to determine whether this difference can be explained by the fact that only excess HSU related to spinal cord injuries are reported as part of this study.

10.3.2. Direct medical costs

In keeping with this study most of the current literature reviewed during Chapter 2 based their direct medical cost findings solely on an electronic search of computerised healthcare related datasets (Unwin and Codde 1998; Dueck, Poenaru, D. and Pichora 2001; Lindqvist 2002; Chandler and Berger 2002; Polinder et al. 2005; Lutge and Muirhead 2005; Sikand et al. 2005; Davis et âl, 2007). Each of the other studies used, at least partly, some form of survey as a means to obtain information about their study population. This method could not be adopted as part of this investigation, however, due to the large size of the injured cohort followed-up.

Only four of the pre-existing studies appraised during the literature review made use of data linkage (Unwin and Codde 1998; Chandler and Berger 2002; Davis et al. 2007; Curtis et al. 2009), whereas this method of linking together healthcare events comprised a major component of this study. The investigations by Unwin and Codde (1998), Dueck, Poenaru and Pichora (2001), Polinder et al. (2005), and Lutge and Muirhead (2005) were each confined to the inpatient sector, in contrast to this study which incorporated healthcare activity within the ED, inpatient and outpatient sectors. The majority of the research studies appraised during the literature review adopted a bottom-up, incidence based, approach to calculating direct medical costs, which represents the approach implemented as part of this investigation. In order to determine the size of the excess direct medical costs incurred within the healthcare sectors of interest within this study the treatment expenditures applicable to the pre-index injury and post-index injury periods were compared. Amongst the pre-existing studies reviewed only Davis et al. (2007) considered the direct medical costs associated with the pre-index injury period, whilst accounting for the long-term follow-up treatment expenditures applicable to their injured cohort represented a feature of just four studies (Miller and Lestina 1996; Meerding, Mulder and van Beeck 2006; Haeusler et al. 2006; Davis et al. 2007).

A number of similarities are apparent when comparing the direct medical cost results presented as part of this study with the results reported in some of the pre-existing studies. For instance, Unwin and Codde (1998), Mathers and Penm (1999), Dueck, Poenaru and Pichora (2001), Polinder et al. (2005) and Curtis et al. (2009) each found the overall direct medical cost of treating injuries increased with age, which is consistent with the findings of this study. Harlan, Harlan and Parsons (1990) report health expenditures relating to injuries to be higher amongst those with low incomes, whilst as part of this study mean excess ED and inpatient costs per index injury are found to be greater amongst the more deprived members of the injured cohort. Both the studies by van Beeck, van Roijen and Mackenbach (1997) and Meerding, Mulder and van Beeck (2006) identify females as accounting for the highest share of direct medical costs, which corresponds with the dominance of females in terms of the excess treatment expenditures per index injury reported in this study. Further similarity between the results presented as part of this investigation and those reported elsewhere involve the extent to which overall direct medical costs are dominated by inpatient treatment costs. Within this study 85.2% of the mean excess combined direct medical costs per index injury are made up of inpatient related expenditures, whilst Schuster et al. (1995), Miller and Lestina (1996) and Meerding, Mulder and van Beeck (2006) each report hospitalised cases as accounting for the largest share of the direct medical costs of injury within their particular investigations (49.1%, 48.7% and 66%, respectively).

In this investigation excess combined direct medical costs are highest following index injuries amongst males and females that are caused by MVTC and fall mechanisms of injury, respectively. Likewise these two mechanism of injuries are associated with the highest direct medical costs reported by the majority of the pre-existing literature. Schuster et al. (1995), Mathers and Penm (1999) and Corso et al. (2006) each find health care expenditures to be highest amongst older females, whilst Corso et al. (2006) observe higher costs attributed to males injured via a MVTC related incident. In the studies by van Beeck, van Roijen and Mackenbach (1997), Lindqvist (2002), Polinder et al. (2005) and Meerding, Mulder and van Beeck (2006) injuries incurred within the home represent the largest sub-category in terms of the accumulation of overall healthcare expenditures. Similarly, index injuries sustained by the injured cohort followed up as part of this investigation accumulated the highest direct medical costs on average when incurred at a home location.

In terms of the type of injury resulting in the greatest direct medical costs, fractures account for the largest share according to most of the current literature, with hip fractures specifically costing the most to treat within the studies undertaken by Lutge and Muirhead (2005), Polinder et al. (2005) and Meerding, Mulder and van Beeck (2006). Similarly, the combined excess direct medical costs incurred across the ED, inpatient and outpatient sectors is highest in this study on average following a hip fracture related index injury. Another consistent result evident in both this investigation and those reviewed in Stage 1 of the literature review concerns lower extremity injuries costing more to treat than upper extremity ones. Meerding, Mulder and van Beeck (2006) find that of the seven injury groups with the highest healthcare costs four involved injuries to the lower extremities, whilst Lindqvist (2002) found that among home, traffic and sport injuries damage to the lower extremities accounted for the largest proportion of costs. In this study an index injury within the 'Lower extremity fracture' group costs on average £1,474 across the ED, inpatient and outpatient sectors combined, whereas an upper extremity fracture costs just £797.

Moreover, there additionally seems to be consistency when considering direct medical costs stratified by both injury type and gender. As part of the study by Harlan, Harlan and Parsons (1990), for instance, the vast majority of poisoning costs were associated with females, who also reported higher costs associated with fractures compared to males but were associated with lower burn related expenditures than their male counterparts. In turn, index injuries due to poisoning sustained by female individuals within this study's injured cohort cost more to treat on average across the ED, inpatient and outpatient sectors combined compared to poisoning index injuries sustained by males (£1,346 versus £997), the combined treatment costs associated with females were greater than males for all the fracture categories represented ('Facial fracture, eye injury', 'Upper extremity fracture', 'Lower extremity fracture' and 'Hip fracture'), whilst also in keeping with the findings reported by Harlan, Harlan and Parsons (1990) burn related index injuries sustained by males within the injured cohort followed-up as part of this study cost more to treat on average than burn related index injuries sustained by females (£1,335 versus £503).

Together with the above noted similarities there are additionally some differences when comparing the results of this study with the findings reported amongst the current literature reviewed during Chapter 2. An example of this concerns the impact of gender on healthcare treatment expenditures. Although, in keeping with the direct medical cost findings presented in this investigation, the studies by van Beeck, van Roijen and Mackenbach (1997) and Meerding, Mulder and van Beeck (2006) report females as accounting for the largest share of treatment costs, as identified above, certain studies find this is not the case. In their study, for instance, Unwin and Codde (1998) find the cost per hospital episode is higher for males than it is for females, whilst Corso et al. (2006) find males account for 55% of the total injury attributed medical spending. This difference may reflect the alternative settings in which these studies have been conducted. Whereas this study encompassed Welsh residents, with the investigations by van Beeck, van Roijen and Mackenbach (1997) and Meerding, Mulder and van Beeck (2006) based in the Netherlands, both European study populations, Unwin and Codde (1998) and Corso et al (2006) undertook their studies in Australia and the US, respectively. Different study settings can lead to the alternative reporting of results due to different hospital admission thresholds, and varying study population characteristics and types of injury sustained.

A further difference in terms of the direct medical cost findings reported as part of this study compared to those presented amongst a pre-existing investigation is evident when considering the type of injury sustained. Miller and Lestina (1996), for instance, find emergency room spending to be greatest for open wounds (27.2%) and superficial injuries/contusions (23.2%), whereas, although this type of index injury leads to an excess ED treatment cost that is statistically different from zero within this study, it is most costly to treat a skull-brain related injury within the ED sector when sustained by a member of the injured cohort followed-up as part of this investigation. This difference may reflect varying hospital admission thresholds applicable to the healthcare systems in operation within each study, whereby a greater number of individuals with a head injury are admitted straight to hospital without receiving any ED treatment within the healthcare system in operation in the study by Miller and

Lestina (1996) than is the case relative to the Welsh healthcare system that is in operation within this investigation, although further research would be necessary to substantiate this hypothesis fully. What is clear however is given this is an ethnocentric study based on a study population drawn exclusively from individuals resident in Swansea caution must be exercised when generalising the results of this investigation to others undertaken in different areas of Wales and different countries worldwide. It is possible that differences in hospital admission policy across different areas/countries will have an impact on the size of the direct medical costs reported in a given investigation. It is important to note however that in the case of this particular study no significant changes in healthcare policy were observed before, during or after the investigative period.

10.4. Limitations of study

Several limitations of this study have been identified and these are discussed in detail below:

- Only HSU and direct medical costs associated with the ED, inpatient and outpatient sectors following the occurrence of an index injury have been accounted for as part of this study. Due to the unavailability of the necessary datasets it was not possible to determine the extent of treatment/care, in terms of the number of contacts, regularly provided to injured individuals within primary care, through their GP or by social services for example. Also the outpatient data source used as part of this study largely only included treatment services and may not have captured all the forms of rehabilitation often provided within outpatient settings. In order to capture the full scale of the HSU and direct medical cost burden associated with an index injury any future investigation should be extended to encompass these additional forms of healthcare.

  Furthermore, the amount of unpaid assistance provided by the family and friends of injured individuals was not included in the HSU and direct medical cost calculations. The extent of this contribution, however, may potentially be vast. According to Arno et al (1999) the mid-range estimate for the national economic value of informal care giving in 1997 in the US was $196 billion, exceeding the national spending on formal home healthcare ($32 billion) and nursing home care ($83 billion). Consequently, if this type of assistance had not been forthcoming the extent of excess HSU and direct medical costs associated with injury reported as part of this study may have been a lot higher, as patients are instead compelled to seek professional help instead of relying on informal care.

- The possibility exists that the extent of excess HSU and direct medical costs reported as part of this study will be slightly overestimated in cases where individuals who are initially in receipt of healthcare services following an injury suffer unrelated complications during treatment that serve to artificially increase their particular HSU and direct medical costs. Hospital acquired infections, like MRSA for example, have become increasingly prevalent over recent years and can potentially be very serious, increasing the afflicted victims length of inpatient stay considerably, leading to approximately 5,000 deaths and costing the NHS around £1 billion every year (National Audit Office 2000). The contraction of such an infection is very often entirely unrelated to the original condition incurred prior to admittance as an inpatient but in practice it can prove very difficult to separate out the alternative cycles of care. Hence, it would appear that the repercussions of the initial injury, in terms of the treatment and rehabilitation period and the associated cost of care, were far more excessive than is actually the case, potentially culminating in misleading results. This situation, however, is only likely to arise when considering the extent of HSU and direct medical costs associated with inpatient treatment, and is unlikely to represent a widespread issue given the relative infrequency with which these infections occur.

In a similar way the injury related excess HSU and direct medical costs reported in this study may include additional stages of treatment because of pre-existing chronic conditions (Meerding et al. 2006). This is particularly likely to be true in the case of older aged individuals. However, it could be argued that separating costs relating to injury treatment and care from the expenditures associated with any ongoing co-morbidity is impossible and unnecessary in any case. According to Meerding et al (2006, p.275) the inclusion of both types of spending in the cost calculations "is justifiable because the injury was the cause for admission and the additional costs would not have occurred without the injury".

Furthermore, the likelihood of pre-existing chronic conditions increasing the scale of the HSU and direct medical costs reported in this study is significantly reduced given only excess levels of HSU and direct medical costs are presented. Each excess figure accounts for the level of healthcare spending prior to the occurrence of the index injury as part of the expected HSU and direct medical cost totals. Hence, the number, length and cost of healthcare events specifically associated with co-morbidities during the follow-up period will form part of the expected HSU and direct medical cost calculations, and so will not impose an impact on the final excess totals.

- In focusing only on the direct medical costs of injury this study serves to deal with just one component of the total economic costs that may potentially arise following the occurrence of injuries. As indicated in previous chapters the size of the personal and societal losses which tend to be indirectly attributable to the injury incurred, reflected in terms of lost earnings or falls in productivity rates for example, can be considerable. Hence, it is important to note that the cost based results presented in this study refer only to the direct medical costs associated with the occurrence of injuries and therefore cannot be generalised to be indicative of the overall economic costs of injury. Certain types of injury that are not associated with a high level of health expenditure may still generate considerable costs that are borne by the injured individual and the wider economy due to productivity losses, for example.

Moreover, only injuries in receipt of medical care have been accounted for as part of this investigation, however, many injuries may potentially be sustained each year which do not involve treatment/care within the healthcare sector. It is estimated, for example, that approximately 2 million violence-related injuries alone go medically unevaluated each year in the US, with a significant number of these cases being severe (Gallagher 2005). Any study seeking to report on the true burden of injury would need to encompass these additional injuries also.

- This is an ethnocentric study based on a study population drawn exclusively from Swansea. Hence, the direct medical cost results presented must be treated with a degree of discretion due to the fact that, although validated and considered robust, the unit costs drawn from the TFR2 accounts that have been utilised within this study represent a summary measure of all the cases of injury incorporated within this investigation alone. Consequently caution must be exercised when attempting to generalise the results of this study to the different healthcare systems operating in other areas of Wales and other countries worldwide. Given the potential for an alternative intensity of treatment/care provided at certain stages post-injury, together with a contrasting set of resource prices, there exists the possibility that the average costs in these other areas/countries, and hence the unit costs which form part of the cost calculations, will not be the same as the TFR2 specific unit costs used in this study. Also differences in hospital admission policy across different areas/countries will have an impact on the size of the HSU and direct medical costs reported in a given investigation. It is important to note however that in the case of this particular study no significant changes in healthcare policy were observed before, during or after the investigative period.

- An additional, potential, shortcoming associated with the analysis undertaken in this study concerns the method of identifying injury patients within the ED and inpatient datasets through the use of the primary diagnosis field. As a consequence of specifically focusing on the primary diagnosis to identify the occurrence of injury the HSU and direct medical cost results presented rely on a given patient's condition being coded correctly at the time of the ED attendance or inpatient admission. Hence, an erroneous classification or a genuine code being recorded in the wrong diagnosis field may slightly skew the final figures reported. For example, if an older aged individual is admitted as an inpatient suffering from a broken hip following a fall but also exhibits symptoms of pneumonia, with only this latter condition coded in the primary diagnosis position, due to the broken hip being recorded as a secondary diagnosis, then this patient would not have been incorporated into the injury subset that was analysed as part of this investigation. Consequently, confining the search criteria to include only injuries recorded in the primary diagnosis position may lead to an underestimation of the actual number of injuries incurred over the period of interest. Indeed, Boufous and Williamson (2003) identified a reduction in the overall number of injury cases in their study of approximately a quarter when selection was limited to the primary diagnosis field only.

However, in focusing specifically on the primary diagnosis when identifying injury cases in receipt of ED/inpatient treatment the likelihood that a given patient has attended an ED or been admitted to hospital primarily as a result of incurring that particular injury is increased. Extending this criteria to also allow the appearance of an injury diagnosis in a secondary position to signify an injury case may run the risk of individuals being included in the injury subset to be analysed when the injury recorded in the ED and inpatient registers is not the main reason for that healthcare event or merely reflects an old condition that is not in any way related to the ED/inpatient event of interest. According to Boufous and Williamson (2003, p.371) "Taking into account secondary diagnosis fields would consequently include injuries which may not have been serious enough to be admitted to hospital".

Several studies have provided empirical evidence supporting the exclusion of the secondary diagnosis fields during injury related analysis. Boufous and Williamson (2003) found the majority of cases in their investigation, over 80% of non-medical injuries and 73% of all injury separations, were coded in the primary diagnosis field, whilst according to Smith, Langlois and Buechner (1991, p.1149) "Injury discharges selected from principal diagnosis codes represent approximately 80 percent of any true injury-associated discharges in Rhode Island".

- Patients incurring medical injuries, as indicated by an ICD-10-CM diagnosis in the range T80-T88 (Complications of surgical and medical care, not elsewhere classified) have been excluded from the analysis on the grounds that they are not true injuries.

> Medical injuries should be excluded from the definition of injury for most studies because they have a very different aetiology and means of prevention. (Smith, Langlois and Buechner 1991, p.1154).

However, this decision may impact upon the number of injury cases identified as part of this study. For instance, of the 67, 428 public hospital discharges recorded as an injury (in the primary position) in 1998 in New Zealand 17% were in the range of codes not incorporated within this study (Langley and Brenner 2004). Similar findings were presented in the papers by Smith, Langlois and Buechner (1991) and Boufous and Williamson (2003). In addition, the analysis undertaken in this thesis excluded the ICD-10-CM codes T74 (Maltreatment syndromes), T79 (Certain early complications of trauma, not elsewhere classified) and T90-T98 (Sequelae of injuries, of poisoning and of other consequences of external causes). Hence, had the above ICD-10-CM range of codes been included in the definition of injury the extent of the excess HSU and direct medical costs reported as part of this investigation may have been larger.

- Another potential shortcoming of this study concerns the way in which healthcare events considered related to the initial index injury have been counted. For instance, the excess HSU and direct medical cost model developed as part of this study encompasses all ED attendances, inpatient admissions and outpatient contacts (not just injury related ones) that are identified as taking place during the follow-up period. Whilst this feature of the model represents a major strength of this study since it ensures the full impact of a given injury on the subsequent health of an individual is accounted for, it may additionally serve to over-inflate the scale of the excess HSU and direct medical costs reported. This is due to the possibility that some of the non-injury healthcare events taking place during the follow-up period, and thus assumed to be related to the initial index injury, may in fact be completely separate events that would have occurred regardless of the original index injury incident.

The impact of this scenario on the results of this investigation is significantly lessened, however, given only the excess HSU and direct medical costs are reported, which have been inferred by finding the difference between the observed and expected number, length and treatment costs of the healthcare events taking place during the follow-up period. Since, the expected figures are based on the HSU and direct medical cost levels observed prior to the index injury being sustained it is likely some of the non-injury healthcare events observed during the follow-up period that are actually unrelated to the index injury will also have occurred during the pre-follow-up period, especially if related to co-morbidities, meaning they would be accounted for in the expected healthcare figure and would thus not form part of the final excess HSU and direct medical cost findings.

It is important to note however that the pre-index injury period will only be an accurate predictor of HSU and direct medical costs during the post-index injury period provided the co-morbidities and lifestyle choices of the injured cohort continue to have the same impact over both the pre- and post-index injury periods. If this is not the case the estimated excess levels of HSU and direct medical costs applicable to these injured individuals may be reduced, which may give the unwanted impression that preventing injuries in this group is likely to be more challenging and unproductive than is actually the case. Past research has shown however that both past patterns of HSU and costs are strong predictors of future levels of these outcome measures (Bertsimas et al. 2008; Tripp et al. 2008).

- Due to incomplete coding of the diagnoses recorded within the outpatient dataset, leading to the inability to identify incident injury cases within this particular healthcare sector, outpatient contacts were only counted and costed if they were found to be associated with members of the injured cohort in receipt of treatment for an index injury previously identified within the ED or inpatient datasets. Consequently, the excess HSU and direct medical cost findings reported as part of this investigation exclude potential index injuries that are only treated/cared for within the outpatient sector.

Furthermore, the routinely collected outpatient data analysed as part of this study was not sufficiently detailed to allow the type of outpatient service used to be identified. Given the high number of outpatient contacts associated with the injured cohort it would have been very useful to have known what type of service had been visited, such as physiotherapy, fracture clinic, etc.

- As part of this study only the first index injury sustained by a member of the injured cohort has been counted and costed, with the follow-up period being curtailed at the start of any ED or inpatient healthcare event taking place outside the interval of this first index injury. However, in practice this later occurring ED/inpatient healthcare event represents a new index injury for that individual, serving to initiate the start of a new follow-up period, with all ED, inpatient and outpatient treatment taking place during this interval contributing to the HSU and direct medical costs associated with this subsequent index injury event. Hence, in curtailing follow-up at the end of the first index injury event and not including any subsequent index injury events the possibility exists that the overall excess HSU and direct medical cost results reported in this study underestimates the true excess HSU and direct medical cost totals applicable to the injured cohort.

  It should be noted, however, that extending the analysis undertaken in this investigation to incorporate subsequent occurring index injury events was not possible given the finite length of the investigative period. HSU and direct medical costs could only be calculated up to 31/03/2007, given this represented the maximum coverage of the datasets used at the time of the analysis. Hence, since index injuries were only searched for from 01/04/2005 and the fact that the average length of the post-index injury follow-up for the first occurring index injury was 343 days (Table 6.3 Chapter 6), it would not have been possible in some cases to cover the whole of the follow-up period related to any subsequent index injury. If only a half or a quarter of the true follow-up period was accounted for then the excess HSU and direct medical costs associated with the subsequent index injury event would be artificially low, thereby serving to incorrectly lower the average excess HSU and direct medical costs per index injury.

- Finally, in order to present the excess HSU and direct medical costs reported within this study at a per index injury level it has been necessary to identify the relationship between healthcare events caused by injury and in particular to distinguish between new and repeat injury cases in receipt of medical attention. A methodology for achieving this has been developed and implemented as part of this investigation, and is discussed in detail during the answering of research question 1 (section 9.1 of Chapter 9). Whilst the methodology devised has been tested and is considered sufficiently robust to be adopted in full within this study it is based on several assumptions, the failure of which to hold true may impact upon the accuracy of the relationships identified amongst the injury related healthcare events on which the results of this investigation have been based. (A list of the assumptions underlying this methodology is provided in section 9.1.6.1 of Chapter 9).

10.4.1. Overall impact of limitations

Several of the limitations identified above may potentially culminate in the size of the excess HSU and direct medical costs being underestimated or overestimated. On balance, however, it is most likely that the excess levels of HSU and direct medical costs reported in this study are underestimated. This is due to the fact that the impact on these outcome measures of omitting GP treatment, social care and unpaid assistance from family/friends, together with the failure to include index injuries treated only in outpatient settings and any subsequent occurring index injuries, are likely to be far greater than the impact on HSU and direct medical costs arising due to hospital acquired infections, such as MRSA, and the inclusion of healthcare associated with co-morbidities and non-injuries unrelated to the index injury.

10.5. Strengths of study

Whilst the limitations identified above need to be recognised they do not diminish the fact that this study has a number of strengths and consequently adds value to the field of injury based research in a number of ways.

- In reporting on the long-term pattern of excess HSU and direct medical costs associated with the occurrence of an index injury, this study has shown the extent to which injuries can serve to impose a considerable burden on the healthcare sector beyond the acute treatment phase provided within an ED or as an inpatient. As section 1.5.1 of Chapter 1 indicates recent developments within healthcare, involving the increased survival rates from major trauma and the subsequent rise in the number of debilitating injuries inflicting the population, has meant the care and rehabilitation provided to injury survivors following their initial discharge from the ED/inpatient sectors has become more important over the past decade. Despite such developments, the literature review undertaken in Chapter 2 revealed the number of pre-existing studies that have focused purely on the direct medical costs applicable only to the initial ED/inpatient treatment of injuries. In conducting a longitudinal follow-up of the study population, potentially spanning two years post-injury, this study has successfully dealt with this identified knowledge gap by encompassing, and revealing the significance of, the additional treatment and rehabilitation stages of healthcare which are now so very important following the occurrence of injury. Excess outpatient treatment costs alone, for instance, have been estimated at £2.2 million, equating to as much as 12.7% of the total excess healthcare costs reported across the ED, inpatient and outpatient sectors combined.

- A major strength of this study concerns its wide ranging coverage in terms of reporting on the excess HSU and direct medical costs of injury associated with numerous types and external causes of injuries, several demographic subsets of the population and multiple healthcare sectors. This is in contrast to many other previous cost of injury investigations which, as indicated in Chapter 2 when discussing the limitations inherent within the current literature, tend to confine the scope of their studies to a single injury type, external cause, demographic group or health sector. By incorporating a wide range of different types and causes of injury that may potentially be sustained by all individuals within a given population, together with allowing treatment/care to be sought at multiple healthcare providers, this investigation has been able to identify both marked and subtle differences in the scale of HSU and direct medical costs which would have been missed by those investigations focusing on just one type/cause of injury, a particular demographic subset of the population or a single healthcare sector.

- The reliability of the results presented as part of this study is enhanced by the size of the injured cohort upon which the estimated extent of excess HSU and direct medical costs of injury are based. Again, unlike a number of other past studies whose results are often applicable to a relatively small sample size (n < 1,000), the injury cohort followed up in this investigation comprised 30,387 individuals in total. The large scale nature of this study serves to increase the power and accuracy of the findings reported (Bower et al. 2003), serving to reduce the potential for unusual anomalies to skew the final results.

- A particularly unique aspect applicable to this study concerns the reporting of the excess HSU and direct medical cost findings specifically following the occurrence of an index injury. The ability to link the healthcare datasets together and distinguish between new and related injury cases meant that for each individual within the injured cohort the extent of excess HSU and direct medical costs reported could be attributed only to those healthcare events assumed to be directly linked to, and thus a consequence of, the index injury. Hence, any injury related ED attendances, inpatient admissions and outpatient contacts taking place during the post-index injury period that were not considered connected in any way to the initial index injury, based on the findings of research question 1 (section 9.1 Chapter 9), were not counted. Furthermore, the ability to link non-injury healthcare events to patients known to have sustained an earlier index injury in receipt of ED or inpatient treatment, based on the presence of unique patient identifiers, meant that it was additionally possible to include non-injury healthcare events in the excess HSU and direct medical cost calculations. In this way the full impact of the index injury on the overall health of the injured individual could be accounted for, allowing healthcare events related to the index injury but not assigned an injury specific diagnosis code to be accounted for. This aspect of the study is particularly useful in capturing the treatment of psychological sequelae resulting from injury, which are frequently not attributed an injury diagnosis code. Indeed, the ability to capture the impact of injury on the overall health of the individual by determining the excess HSU and direct medical costs associated with non-injury healthcare events taking place during the follow-up period, and considered to be relevant to the index injury, is unique to this study given none of the studies appraised during Stages 1 and 2 of the literature review undertaken in Chapter 2 calculated the HSU and direct medical costs associated with injury in this way.

- This study has signified the benefits of utilising data linkage as a means of estimating the extent of excess HSU and direct medical costs across multiple healthcare sectors over a lengthy pre-injury and post-injury study period. In answering research question 2 (section 9.2.1. Chapter 9) it has been shown that without the ability to link healthcare events together several integral features of any study seeking to report on the wide-ranging, longitudinal, impact of an index injury are no longer possible, such as the counting and costing of injury and non-injury induced healthcare events considered related to an earlier injury, and the opportunity to report on excess HSU and direct medical costs by finding the difference between the observed and expected estimates of these outcome measures. Moreover, in using anonymous patient level identifiers to link the datasets together it has been possible to remotely track individuals in a very detailed way, allowing their presence in multiple datasets several years apart to be identified, with the ability for the specific number, length and direct medical cost of healthcare events to be assigned to each individual.

- A major strength of this study that sets it apart from many other studies concerns the opportunity to utilise a well established data linkage system. In being able to access the SAIL databank set up by HIRU based at Swansea University it proved possible to search millions of health records spanning multiple years and a variety of healthcare sectors, with each record linked via a unique, anonymous, patient level identifier. Such a wealth of data is very rarely available to be analysed in this way due to the lack of the necessary IT infrastructure and the inability to gain the required ethical approval.

- Following the undertaking of the literature review presented in Chapter 2 it is apparent that a number of studies have already reported on the HSU and direct medical costs associated with the occurrence of injuries. However, very few of these investigations have reported on the relative impact of injury on these outcome measures by taking into account the levels of HSU and healthcare expenditures likely to have occurred during the follow-up period in the absence of an injury. Moreover, when the relative impact of injury is considered comparisons with the status quo (i.e. the situation had an injury not been sustained) more often than not tend to be based on the levels of HSU and costs applicable to a non-injured comparison group as opposed to the levels observed during the pre-injury period. In addition, in the rare cases when the situation pre-follow-up is taken into account, with this being the case for only 3 out of the 38 studies appraised during the literature review conducted as part of Chapter 2, no consideration is given to the other demographic and clinical factors that will change over the course of the pre- and post-injury periods, and thus will have a bearing on the levels of HSU and direct medical costs observed during follow-up. Such factors include the older age of the injured individuals, a rising trend in the number and/or costs of healthcare activity inherent within the healthcare registries scrutinized (due to changing insurance status or higher unit costs, for example), or a longer length of follow-up period.

Given the above features of past studies, the model developed as part of the methodology of this investigation is unique in that it identifies the scale of excess

HSU and direct medical costs by finding the difference between the number, length and cost of healthcare events observed during the follow-up period and the number, length and cost of healthcare events expected over this same interval, based on pre-follow-up HSU and costs, age, dataset trends and length of follow-up. In this way the final HSU and direct medical cost results only comprise those ED attendances, inpatient admissions and outpatient contacts taking place following the index injury over and above the healthcare events assumed to have occurred regardless in the absence of any injury.

The potential difference in the scale of the HSU and direct medical costs reported depending on whether they are based solely on the number, length and cost of healthcare events observed post-injury (as is the case in many pre-existing studies) or are based on deducing the excess number, length and cost of healthcare events by finding the difference between the observed and expected totals post-injury (as is the case in this study), can be illustrated using the findings presented in Chapters 6 and 7. It is apparent from Table 6.4 of Chapter 6, for instance, that 12,026 ED attendances, 9,010 inpatient admissions, 62,632 inpatient bed days and 50,214 outpatient contacts are observed during the follow-up period. However, when accounting for the HSU expected over this timeframe in the absence of an injury the equivalent excess number of ED attendances, inpatient admissions, inpatient bed days and outpatient contacts amount to just 3,647; 2,119; 30,492 and 16,715, respectively. Similarly, Table 7.3 of Chapter 7 signifies that the total direct medical costs observed during the follow-up period in the ED, inpatient and outpatient sectors of £1,207,531; £29,394,037 and £6,620,546 are also much larger than the respective excess healthcare expenditures of £366,161; £14,963,558 and £2,227,480. Hence, it follows that by reporting only on the HSU and direct medical costs observed during the post-index injury period and thereby not accounting for the expected levels of these outcome measures an additional 8,379 ED attendances, 6,891 inpatient admissions, 32,140 inpatient bed days and 33,499 outpatient contacts would be reported, equating to extra direct medical costs incurred by the ED, inpatient and outpatient sectors of £841,369, £14,430,479 and £4,393,066 respectively. Given non-injury related healthcare events form part of the HSU and direct medical costs findings, some of which will have taken place in the absence of any injury, this study proposes that the excess

HSU and direct medical cost results reported above represent a truer reflection of the scale of these outcome measures following the occurrence of an index injury.

- Related to the above point, in being able to account for the expected levels of HSU and direct medical costs associated with a given individual, based in part on the number, length and treatment costs of healthcare contacts observed during the pre-index injury period, the excess totals reported as part of this thesis make it much easier to deal with the presence of co-morbidities. Very often the specific impact of injury on healthcare needs is difficult to quantify in cases where the individual is suffering from other ongoing non-injury related conditions that lead to healthcare events being sought that cannot be distinguished from the injury related healthcare events taking place. This is especially the case for older aged and more deprived individuals. However, due to the HSU and direct medical cost models designed and developed as part of this thesis accounting for the levels of HSU and direct medical costs observed over the course of the pre- and post-index injury periods it follows that the actual HSU specifically due to the co-morbidities will have no impact on the final excess figures reported. Consequently, the potential for the presence of co-morbidities to skew the final results is greatly reduced.

10.6. Implications of study

The implications of this study are widespread and can be separated into the implications for research and the implications for policy/practice.

10.6.1. Implications for research

- The methodology for distinguishing between new and repeat injury induced healthcare events, described in the answering of research question 1 (section 9.1

of Chapter 9) and implemented as part of this study, can potentially be utilised by other studies seeking to infer the relationship between initial and subsequent injury related healthcare events. The potential for under-/over-counting the number of incident injuries in receipt of medical attention, due to the inability to effectively separate new and repeat cases, has long been recognised as a problem within the field of injury based research. The methodology devised, developed and adopted throughout this investigation provides one alternative to this predicament, with its inherent simplistic approach providing a template that can easily be adapted by other studies undertaking their investigations on alternative study populations incurring injuries within different geographical areas. Furthermore, there even exists the possibility that this methodology can be adapted to determine the relationship between healthcare events induced by other types of conditions, such as distinguishing between new and repeat cases of respiratory diseases, or cardiac conditions, for example.

- In addition to the above point another unique aspect of this study that lends itself to be implemented by other investigations seeking to determine the scale of the HSU and direct medical costs resulting from injuries, and indeed other types of conditions, concerns the reporting of findings that encompass only the excess HSU and healthcare expenditures after accounting for the expected levels of these outcome measures over the course of the follow-up period, based on pre-injury HSU and costs, age, dataset trends and length of follow-up. No other study has published its results in this way and yet this study has shown such a model represents a reliable and accurate means to fully incorporate all healthcare encounters potentially associated with an earlier incident event without overestimating the extent of these findings, by reporting only the encounters in receipt of healthcare in excess of those expected to have taken place in any case in the absence of the incident event.

  Furthermore, the excess HSU and direct medical cost model devised and implemented as part of this study will be particularly useful for any future investigation seeking to report on the burden of injury, or other conditions, associated with vulnerable individuals within the population. The older and most deprived members of society, for instance, often suffer from co-morbidities that make it difficult to separate out the actual repercussions of the injury sustained, given it is frequently not known the extent to which the healthcare contacts sought after injury are due to the injury itself or the presence of pre-existing conditions. The ability to account for the level of pre-injury healthcare as part of the expected, and hence the final excess, post-injury calculations, however, provide a means to more accurately infer the specific impact of a given condition.

- The fact that the excess HSU and direct medical cost findings reported within this study can be considered to be wholly applicable to an index injury means that estimates of the number, length and treatment costs of healthcare events specifically associated with a given index injury have been presented. As opposed to simply being able to quote the HSU and direct medical cost burden associated with all the injuries incurred within a particular area over a given timeframe, which is often all that is possible when reviewing pre-existing studies, the results from this study can be used to gain some inference as to how much of an impact a hip fracture index injury, for instance, has on long-term healthcare, in terms of both injury and non-injury related HSU and direct medical costs, compared to a spine/vertebrae index injury.

- Whilst this study has shown the benefits of routine data by revealing how it can be used to remotely track injured individuals through various treatment stages following their index injury, incorporating ED attendances, inpatient stay and outpatient contacts, it has also provided evidence of the repercussions of poor quality routine data. For instance, although GP data covering the Swansea area could be accessed as part of this study it only proved possible to use this to identify the presence of co-morbidities amongst the injured cohort. This was due to the inability to distinguish between GP/patient consultations and other types of GP related activity, such as the collection of prescriptions, the receipt of hospital discharge letters, etc, which meant the routinely collected GP data could not be used to determine the number of visits made to primary care amongst the injured cohort. Similarly, although outpatient data was available for this study the fact diagnosis codes were very poorly recorded meant it was not possible to identify index injury cases from this dataset, meaning it could only be used to count and cost outpatient contacts found to be associated with members of the injured cohort known to be in receipt of treatment for an index injury identified within either the ED or inpatient datasets. Poisoning represents another area for which the routine collection of data needs to be improved. Whilst poisoning related cases could be identified in this study it was not possible to specifically determine whether these were caused by drugs, alcohol or other chemicals. Knowing this would make it easier to more effectively target policy responses aimed at tackling poisoning. The routine recording of the influence of alcohol on injury represents a particular problem within EDs given the high number of attendances likely to be related to alcohol and the difficulty in determining whether the intake of alcohol was a contributory factor in the cause of injury.

Consequently this study demonstrates the need for the quality of routinely collected data to be improved so that it is possible to obtain even more detailed information relating to the healthcare journey of a given study population. Indeed, given the absence of such good quality routine data as part of this investigation the size of the excess HSU and direct medical costs resulting from an index injury is very likely to be underestimated. Hence, improvements in the quality of the data collected will not only improve the accuracy and reliability of future studies but will additionally increase the magnitude of the HSU and direct medical costs reported, thereby placing greater emphasis on the need to reduce the burden of injury.

10.6.2. Implications for policy/practice

- As a consequence of the excess HSU and direct medical cost results reported as part of this study being stratified according to a variety of social demographic groups within the study population, together with a wide range of different types and external causes of index injury sustained, the findings presented allow subsets of the population and injury groups associated with a high utilisation and cost of healthcare to be inferred. For instance, this study has shown the high burden of injury to the ED sector resulting from skull/brain injuries amongst males and superficial injuries amongst females. Similarly, hip fractures amongst older females have been shown to place the greatest burden on the inpatient sector, whilst this is the case for burn injuries sustained by either gender when considering the outpatient sector. Furthermore, both excess levels of HSU and direct medical costs have been shown to vary according to the socioeconomic status of the injured cohort.

Knowledge of the burden of injury in terms of the size of excess HSU and direct medical costs represents a lever for action and will assist policy makers and healthcare professionals/practitioners in their ongoing attempts to correctly determine the main priority areas in greatest need of intervention and prevention as they strive to reduce the burden of injury. Focusing on a specific injury type or age group of the population, for instance, like many past studies have done, provides no means of determining whether the scale of HSU and direct medical costs are greater after the occurrence of different injuries sustained by individuals of other ages. Whether different types and/or causes of injury lead to higher or lower levels of HSU/direct medical costs amongst individuals of different ages, genders and socioeconomic status can lead to different responses from different policy makers and healthcare professionals/practitioners. The findings of this investigation, therefore, provide the information and knowledge necessary to more appropriately target any intervention and prevention strategies being implemented.

- The magnitude of the number, length and cost of the excess healthcare events identified as part of this study clearly signify the importance of research investment into injuries and add weight to the calls for an increase in research spending on injury prevention so that it corresponds more satisfactorily to the levels directed at other major public health problems (Wise 2001). Knowing that on average an index injury may potentially lead to healthcare costs in the region of £578, which when extrapolated to the whole of Wales results in overall direct medical costs as high as £306.4 million, represents a strong argument in favour of reducing the frequency and severity of injuries. Furthermore, since the focus of this study is only on the direct medical costs associated with the occurrence of an index injury it follows that the actual total economic costs incurred, incorporating also the indirect costs of injury, will be much higher than the direct medical cost figures reported in this study. Hence, the importance of deciding on the correct allocation of resources and the appropriate setting of policy priorities is even greater when considering the overall economic burden of injuries.

10.7. Conclusion

This study has successfully reported on the extent of excess HSU and direct medical costs arising following the occurrence of an index injury. Based on a large cohort of injured individuals, encompassing all types/severities of injury and several demographic subgroups within the population, this longitudinal investigation spanning several years has utilised data linkage techniques to join together multiple large scale administrative and healthcare datasets, with the aim to trace the impact of injury across several healthcare sectors, incorporating both the treatment and rehabilitation phases.

Two particularly unique aspects of this study exist which set it apart from pre-existing investigations, thereby serving to provide an important contribution to the field of injury research. A methodology has been devised, developed and implemented which provides a means to distinguish between new and repeat injury related healthcare events in such a way that it has proved possible to estimate the scale of both injury and non-injury related HSU and direct medical costs following an index injury. In addition, the outcome measures of interest within this study have been reported in terms of the excess number, length and cost of healthcare events, accounting for the levels of these variables that would have arisen in any case in the absence of an injury. This has been achieved by estimating the extent of HSU and direct medical costs expected amongst the injured cohort had they not sustained an injury, based on the number, length and cost of healthcare events associated with these individuals in the year prior to the occurrence of their index injury, whilst additionally accounting for other demographic and clinical variables, such as age, dataset trends and length of follow-up, that will also impact on post-injury HSU and direct medical costs.

Potential improvements on this study include encompassing HSU and direct medical cost figures relating to the healthcare sectors not incorporated, including GP contacts and nursing home records, together with accounting for informal care giving provided by family and friends. By doing this the number, length and cost of healthcare events reported are likely to more accurately reflect the true burden of an index injury in relation to these specific outcome measures. It would be interesting to extend this investigation to estimate the extent of excess HSU and direct medical costs arising following the occurrence of index healthcare events induced by other conditions, such as cancer, cardiovascular diseases, respiratory conditions, and so on. In this way a direct comparison can be made between the excess number, length and cost of healthcare events taking place after an index injury case relative to the excess number, length and cost of healthcare events taking place after an index case of some other type of condition. If, following such an investigation, injuries are shown to impose an equally large, or even the greatest burden, in terms of excess HSU and direct medical costs, these findings would reinforce the argument that increased funding should be directed towards reducing the burden injuries impose on the general population.

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Appendix 1

Table A1: Morriston ED diagnosis codes used to determine the presence of an injury related ED attendance

Diagnosis code	Diagnosis description
01	Laceration
02	Sprain
03	Bruise
04A	Head Injury < GCS 15
04B	Head Injury GCS Normal
06A	Closed Fracture
06B	Open Fracture
06C	Possible Fracture
07	Subluxation
08	Dislocation
09	Abrasion
119	Penetrating Injury
11A	Burn – Electrical
11B	Burn – Chemical
11C	Burn – Sun
11D	Burn – Thermal
12	Foreign Body
120	Perforating Injury
13	Foreign body ingested
14	Tendon Injury
15	Internal Injury
16	Nerve Injury
17	Puncture Wound
18	Needlestick Injury
19	Sting
20A	An Animal Bite
20B	A Human Bite
21	Multiple Injury (Severe)
22A	Dental Injury
25A	Deliberate Overdose
25B	Accidental Poisoning
51	Burn/Scald non specific PMS
52	Bite non specific PMS
54	Head Injury non specific PMS

Appendix 2

Table A2.1: Age adjustment rates used as part of formula to calculate expected number of ED attendances

Age	Number of ED attendances	% change	Age adjustment rate (Y)
0	1,115		1.894
1	2,112	89.4	0.857
2	1,809	-14.3	0.817
3	1,478	-18.3	0.806
4	1,192	-19.4	0.991
5	1,181	-0.9	1.004
6	1,186	0.4	1.105
7	1,311	10.5	1.100
8	1,442	10.0	1.134
9	1,635	13.4	1.166
10	1,906	16.6	1.083
11	2,065	8.3	1.087
12	2,245	8.7	0.984
13	2,208	-1.6	1.041
14	2,299	4.1	0.997
15	2,291	-0.3	0.996
16	2,281	-0.4	1.188
17	2,710	18.8	1.155
18	3,131	15.5	1.012
19	3,169	1.2	0.939
20	2,977	-6.1	0.988
21	2,942	-1.2	0.921
22	2,710	-7.9	0.933
23	2,529	-6.7	0.987
24	2,496	-1.3	0.962
25	2,402	-3.8	0.910
26	2,185	-9.0	0.892
27	1,950	-10.8	0.989
28	1,929	-1.1	0.938
29	1,809	-6.2	0.944
30	1,707	-5.6	1.045
31	1,784	4.5	0.982
32	1,751	-1.8	1.065
33	1,864	6.5	0.985
34	1,836	-1.5	0.992
35	1,821	-0.8	0.959
36	1,746	-4.1	1.051
37	1,835	5.1	0.976
38	1,791	-2.4	1.017
39	1,821	1.7	0.947
40	1,725	-5.3	1.110
41	1,915	11.0	0.932
42	1,785	-6.8	0.960
43	1,713	-4.0	0.949
44	1,625	-5.1	0.951
45	1,545	-4.9	0.990
46	1,530	-1.0	0.914
47	1,398	-8.6	0.957
48	1,338	-4.3	0.989

Age	Number of ED attendances	% change	Age adjustment rate (Y)
49	1,323	-1.1	0.964
50	1,276	-3.6	0.940
51	1,199	-6.0	1.032
52	1,237	3.2	0.970
53	1,200	-3.0	0.929
54	1,115	-7.1	1.063
55	1,185	6.3	1.013
56	1,200	1.3	0.980
57	1,176	-2.0	1.088
58	1,280	8.8	0.987
59	1,263	-1.3	0.872
60	1,101	-12.8	0.884
61	973	-11.6	1.074
62	1,045	7.4	0.904
63	945	-9.6	0.992
64	937	-0.8	0.891
65	835	-10.9	1.068
66	892	6.8	0.944
67	842	-5.6	1.076
68	906	7.6	0.905
69	820	-9.5	1.126
70	923	12.6	0.956
71	882	-4.4	1.032
72	910	3.2	1.098
73	999	9.8	0.918
74	917	-8.2	1.025
75	940	2.5	1.048
76	985	4.8	1.001
77	986	0.1	1.048
78	1,033	4.8	0.969
79	1,001	-3.1	0.988
80	989	-1.2	0.959
81	948	-4.1	0.946
82	897	-5.4	0.981
83	880	-1.9	1.127
84	992	12.7	0.906
85	899	-9.4	0.843
86	758	-15.7	0.752
87	570	-24.8	0.981
88	559	-1.9	0.955
89	534	-4.5	0.884
90	472	-11.6	0.828
91	391	-17.2	0.913
92	357	-8.7	0.773
93	276	-22.7	0.717
94	198	-28.3	0.788
95	156	-21.2	0.692
96	108	-30.8	0.806
97	87	-19.4	0.483
98	42	-51.7	0.881
99	37	-11.9	0.784
100	29	-21.6	0.690
101	20	-31.0	0.600
102	12	-40.0	1.167
103	14	16.7	0.286
104	4	-71.4	10.750
105	43	975.0	1.442

Age	Number of ED attendances	% change	Age adjustment rate (Y)
106	62	44.2	1.000

Table A2.2: Age adjustment rates used as part of formula to calculate expected number of inpatient admissions

Age	Number of inpatient admissions	% change	Age adjustment rate (Y)
0	48,419		0.413
1	19,984	-58.7	0.656
2	13,105	-34.4	0.814
3	10,664	-18.6	0.848
4	9,047	-15.2	0.908
5	8,218	-9.2	0.911
6	7,484	-8.9	0.910
7	6,809	-9.0	0.972
8	6,619	-2.8	0.926
9	6,127	-7.4	1.018
10	6,238	1.8	1.047
11	6,532	4.7	1.016
12	6,639	1.6	1.061
13	7,047	6.1	1.112
14	7,835	11.2	1.157
15	9,063	15.7	1.063
16	9,636	6.3	1.281
17	12,340	28.1	1.174
18	14,490	17.4	1.112
19	16,107	11.2	1.052
20	16,946	5.2	0.982
21	16,635	-1.8	1.007
22	16,756	0.7	1.016
23	17,032	1.6	1.009
24	17,180	0.9	0.999
25	17,168	-0.1	1.000
26	17,165	0.0	0.964
27	16,553	-3.6	0.953
28	15,777	-4.7	1.017
29	16,040	1.7	1.010
30	16,201	1.0	1.032
31	16,719	3.2	1.034
32	17,280	3.4	1.033
33	17,842	3.3	0.999
34	17,822	-0.1	0.990
35	17,645	-1.0	1.005
36	17,734	0.5	0.943
37	16,732	-5.7	0.962
38	16,100	-3.8	1.024
39	16,491	2.4	0.976
40	16,102	-2.4	1.054
41	16,970	5.4	0.991
42	16,819	-0.9	1.027
43	17,281	2.7	0.983

Age	Number of inpatient admissions	% change	Age adjustment rate (Y)
44	16,993	-1.7	0.978
45	16,611	-2.2	0.938
46	15,575	-6.2	1.032
47	16,070	3.2	1.064
48	17,105	6.4	0.983
49	16,809	-1.7	1.035
50	17,395	3.5	1.075
51	18,701	7.5	1.059
52	19,809	5.9	0.986
53	19,523	-1.4	1.034
54	20,191	3.4	1.090
55	22,011	9.0	1.097
56	24,150	9.7	1.046
57	25,266	4.6	1.098
58	27,754	9.8	0.975
59	27,060	-2.5	0.960
60	25,968	-4.0	1.030
61	26,746	3.0	1.019
62	27,253	1.9	0.997
63	27,170	-0.3	0.986
64	26,794	-1.4	0.975
65	26,114	-2.5	1.070
66	27,947	7.0	1.023
67	28,583	2.3	0.996
68	28,457	-0.4	1.011
69	28,774	1.1	0.999
70	28,732	-0.1	0.970
71	27,858	-3.0	1.020
72	28,407	2.0	0.967
73	27,472	-3.3	1.026
74	28,175	2.6	0.991
75	27,928	-0.9	0.995
76	27,802	-0.5	0.959
77	26,671	-4.1	0.977
78	26,052	-2.3	0.940
79	24,491	-6.0	0.998
80	24,432	-0.2	0.909
81	22,211	-9.1	0.991
82	22,010	-0.9	0.934
83	20,549	-6.6	0.967
84	19,877	-3.3	0.956
85	18,995	-4.4	0.795
86	15,093	-20.5	0.755
87	11,388	-24.5	0.824
88	9,387	-17.6	0.921
89	8,647	-7.9	0.876
90	7,574	-12.4	0.845
91	6,401	-15.5	0.832
92	5,324	-16.8	0.739
93	3,934	-26.1	0.754
94	2,968	-24.6	0.733
95	2,177	-26.7	0.713
96	1,553	-28.7	0.701
97	1,089	-29.9	0.630
98	686	-37.0	0.713
99	489	-28.7	0.548
100	268	-45.2	0.451

Age	Number of inpatient admissions	% change	Age adjustment rate (Y)
101	121	-54.9	0.876
102	106	-12.4	0.528
103	56	-47.2	0.518
104	29	-48.2	0.517
105	15	-48.3	0.733
106	11	-26.7	1.000

Table A2.3: Age adjustment rates used as part of formula to calculate expected number of inpatient bed-days

Age	Number of inpatient bed-days	% change	Age adjustment rate (Y)
0	146,728		0.145
1	21,309	-85.5	0.611
2	13,012	-38.9	0.734
3	9,556	-26.6	0.926
4	8,846	-7.4	0.918
5	8,123	-8.2	0.927
6	7,526	-7.3	1.069
7	8,042	6.9	0.907
8	7,297	-9.3	0.958
9	6,993	-4.2	1.104
10	7,720	10.4	1.265
11	9,765	26.5	1.171
12	11,434	17.1	1.130
13	12,924	13.0	1.031
14	13,327	3.1	1.297
15	17,291	29.7	1.135
16	19,620	13.5	1.401
17	27,486	40.1	1.225
18	33,660	22.5	1.043
19	35,094	4.3	1.022
20	35,861	2.2	1.053
21	37,764	5.3	1.002
22	37,844	0.2	0.978
23	37,001	-2.2	1.160
24	42,910	16.0	0.873
25	37,481	-12.7	1.123
26	42,089	12.3	0.921
27	38,746	-7.9	0.935
28	36,233	-6.5	1.186
29	42,990	18.6	1.021
30	43,889	2.1	1.070
31	46,973	7.0	0.972
32	45,636	-2.8	0.995
33	45,429	-0.5	1.020
34	46,329	2.0	1.102
35	51,036	10.2	0.936
36	47,773	-6.4	1.036
37	49,503	3.6	1.020
38	50,514	2.0	0.923

Age	Number of inpatient bed-days	% change	Age adjustment rate (Y)
39	46,611	-7.7	1.058
40	49,325	5.8	1.077
41	53,117	7.7	0.970
42	51,535	-3.0	0.970
43	50,003	-3.0	0.994
44	49,700	-0.6	1.005
45	49,971	0.5	1.030
46	51,471	3.0	1.034
47	53,234	3.4	1.027
48	54,672	2.7	0.929
49	50,808	-7.1	1.120
50	56,897	12.0	1.020
51	58,035	2.0	1.034
52	60,015	3.4	1.015
53	60,940	1.5	1.080
54	65,817	8.0	1.012
55	66,591	1.2	1.146
56	76,325	14.6	1.105
57	84,316	10.5	1.067
58	89,982	6.7	0.992
59	89,229	-0.8	0.980
60	87,444	-2.0	1.095
61	95,718	9.5	1.064
62	101,832	6.4	1.039
63	105,793	3.9	0.920
64	97,283	-8.0	1.052
65	102,348	5.2	1.138
66	116,456	13.8	1.005
67	117,080	0.5	1.086
68	127,176	8.6	1.021
69	129,887	2.1	1.151
70	149,440	15.1	0.958
71	143,158	-4.2	1.099
72	157,303	9.9	1.056
73	166,099	5.6	1.097
74	182,184	9.7	1.071
75	195,179	7.1	1.020
76	199,025	2.0	1.045
77	208,048	4.5	1.023
78	212,878	2.3	1.038
79	221,026	3.8	1.112
80	245,787	11.2	0.969
81	238,066	-3.1	1.066
82	253,873	6.6	1.001
83	254,221	0.1	1.035
84	263,054	3.5	1.026
85	269,871	2.6	0.829
86	223,644	-17.1	0.783
87	175,101	-21.7	0.863
88	151,091	-13.7	0.999
89	150,997	-0.1	0.880
90	132,901	-12.0	0.877
91	116,578	-12.3	0.864
92	100,777	-13.6	0.761
93	76,654	-23.9	0.794
94	60,899	-20.6	0.684
95	41,639	-31.6	0.761

Age	Number of inpatient bed-days	% change	Age adjustment rate (Y)
96	31,680	-23.9	0.727
97	23,047	-27.3	0.527
98	12,153	-47.3	0.628
99	7,628	-37.2	0.630
100	4,809	-37.0	0.409
101	1,968	-59.1	1.676
102	3,299	67.6	0.329
103	1,086	-67.1	0.279
104	303	-72.1	0.835
105	253	-16.5	0.063
106	16	-93.7	8.063
107	129	706.3	0.070
108	9	-93.0	3.556
109	32	255.6	0.375
110	12	-62.5	1.000

Table A2.4: Age adjustment rates used as part of formula to calculate expected number of outpatient visits

Age	Number of outpatients visits	% change	Age adjustment rate (Y)
0	30,539		1.638
1	50,021	63.8	0.830
2	41,519	-17.0	0.954
3	39,625	-4.6	1.039
4	41,166	3.9	1.094
5	45,028	9.4	1.029
6	46,340	2.9	0.943
7	43,685	-5.7	0.940
8	41,085	-6.0	0.983
9	40,395	-1.7	1.012
10	40,893	1.2	1.066
11	43,588	6.6	1.119
12	48,792	11.9	1.172
13	57,168	17.2	1.098
14	62,779	9.8	1.057
15	66,337	5.7	0.964
16	63,920	-3.6	0.927
17	59,270	-7.3	0.973
18	57,666	-2.7	1.000
19	57,686	0.0	1.023
20	58,988	2.3	1.035
21	61,062	3.5	1.024
22	62,555	2.4	1.012
23	63,330	1.2	1.033
24	65,442	3.3	1.044
25	68,322	4.4	1.007
26	68,819	0.7	0.973
27	66,939	-2.7	0.947
28	63,404	-5.3	1.010
29	64,067	1.0	1.028

Age	Number of outpatients visits	% change	Age adjustment rate (Y)
30	65,884	2.8	1.040
31	68,526	4.0	1.065
32	72,962	6.5	1.045
33	76,238	4.5	1.041
34	79,337	4.1	1.024
35	81,258	2.4	1.004
36	81,593	0.4	1.001
37	81,670	0.1	0.989
38	80,777	-1.1	0.993
39	80,241	-0.7	1.002
40	80,391	0.2	1.030
41	82,797	3.0	1.028
42	85,121	2.8	0.988
43	84,093	-1.2	0.985
44	82,815	-1.5	0.994
45	82,311	-0.6	0.993
46	81,705	-0.7	1.002
47	81,894	0.2	1.011
48	82,820	1.1	1.021
49	84,573	2.1	0.998
50	84,408	-0.2	1.006
51	84,945	0.6	1.045
52	88,740	4.5	1.031
53	91,447	3.1	1.031
54	94,318	3.1	1.053
55	99,312	5.3	1.049
56	104,191	4.9	1.085
57	113,021	8.5	1.089
58	123,131	8.9	1.041
59	128,200	4.1	0.931
60	119,307	-6.9	0.968
61	115,536	-3.2	1.037
62	119,844	3.7	1.004
63	120,356	0.4	0.978
64	117,684	-2.2	0.965
65	113,585	-3.5	1.021
66	115,929	2.1	1.023
67	118,593	2.3	1.023
68	121,267	2.3	1.008
69	122,251	0.8	1.002
70	122,496	0.2	0.993
71	121,579	-0.7	0.991
72	120,534	-0.9	0.986
73	118,815	-1.4	0.982
74	116,679	-1.8	1.021
75	119,187	2.1	0.973
76	115,969	-2.7	0.977
77	113,331	-2.3	0.967
78	109,612	-3.3	0.959
79	105,105	-4.1	0.968
80	101,709	-3.2	0.932
81	94,772	-6.8	0.931
82	88,254	-6.9	0.910
83	80,279	-9.0	0.937
84	75,235	-6.3	0.950
85	71,470	-5.0	0.832
86	59,429	-16.8	0.733

Age	Number of outpatients visits	% change	Age adjustment rate (Y)
87	43,569	-26.7	0.753
88	32,796	-24.7	0.835
89	27,394	-16.5	0.826
90	22,628	-17.4	0.783
91	17,721	-21.7	0.779
92	13,804	-22.1	0.751
93	10,369	-24.9	0.732
94	7,592	-26.8	0.670
95	5,088	-33.0	0.664
96	3,378	-33.6	0.652
97	2,203	-34.8	0.631
98	1,390	-36.9	0.587
99	816	-41.3	0.555
100	453	-44.5	0.450
101	204	-55.0	0.559
102	114	-44.1	0.947
103	108	-5.3	0.667
104	72	-33.3	0.847
105	61	-15.3	1.000

Table A2.5: Age adjustment rates used as part of formula to calculate expected direct medical costs incurred within the ED sector

Age	Direct medical ED cost	% change	Age adjustment rate (Y)
0	111,957.15		1.894
1	212,065.92	89.4	0.857
2	181,641.69	-14.3	0.817
3	148,405.98	-18.3	0.806
4	119,688.72	-19.4	0.991
5	118,584.21	-0.9	1.004
6	119,086.26	0.4	1.105
7	131,637.51	10.5	1.100
8	144,791.22	10.0	1.134
9	164,170.35	13.4	1.166
10	191,381.46	16.6	1.083
11	207,346.65	8.3	1.087
12	225,420.45	8.7	0.984
13	221,705.28	-1.6	1.041
14	230,842.59	4.1	0.997
15	230,039.31	-0.3	0.996
16	229,035.21	-0.4	1.188
17	272,111.1	18.8	1.155
18	314,383.71	15.5	1.012
19	318,199.29	1.2	0.939
20	298,920.57	-6.1	0.988
21	295,406.22	-1.2	0.921
22	272,111.1	-7.9	0.933
23	253,936.89	-6.7	0.987
24	250,623.36	-1.3	0.962
25	241,184.82	-3.8	0.910

Age	Direct medical ED cost	% change	Age adjustment rate (Y)
26	219,395.85	-9.0	0.892
27	195,799.5	-10.8	0.989
28	193,690.89	-1.1	0.938
29	181,641.69	-6.2	0.944
30	171,399.87	-5.6	1.045
31	179,131.44	4.5	0.982
32	175,817.91	-1.8	1.065
33	187,164.24	6.5	0.985
34	184,352.76	-1.5	0.992
35	182,846.61	-0.8	0.959
36	175,315.86	-4.1	1.051
37	184,252.35	5.1	0.976
38	179,834.31	-2.4	1.017
39	182,846.61	1.7	0.947
40	173,207.25	-5.3	1.110
41	192,285.15	11.0	0.932
42	179,231.85	-6.8	0.960
43	172,002.33	-4.0	0.949
44	163,166.25	-5.1	0.951
45	155,133.45	-4.9	0.990
46	153,627.3	-1.0	0.914
47	140,373.18	-8.6	0.957
48	134,348.58	-4.3	0.989
49	132,842.43	-1.1	0.964
50	128,123.16	-3.6	0.940
51	120,391.59	-6.0	1.032
52	124,207.17	3.2	0.970
53	120,492.00	-3.0	0.929
54	111,957.15	-7.1	1.063
55	118,985.85	6.3	1.013
56	120,492.00	1.3	0.980
57	118,082.16	-2.0	1.088
58	128,524.80	8.8	0.987
59	126,817.83	-1.3	0.872
60	110,551.41	-12.8	0.884
61	97,698.93	-11.6	1.074
62	104,928.45	7.4	0.904
63	94,887.45	-9.6	0.992
64	94,084.17	-0.8	0.891
65	83,842.35	-10.9	1.068
66	89,565.72	6.8	0.944
67	84,545.22	-5.6	1.076
68	90,971.46	7.6	0.905
69	82,336.20	-9.5	1.126
70	92,678.43	12.6	0.956
71	88,561.62	-4.4	1.032
72	91,373.10	3.2	1.098
73	100,309.59	9.8	0.918
74	92,075.97	-8.2	1.025
75	94,385.40	2.5	1.048
76	98,903.85	4.8	1.001
77	99,004.26	0.1	1.048
78	103,723.53	4.8	0.969
79	100,510.41	-3.1	0.988
80	99,305.49	-1.2	0.959
81	95,188.68	-4.1	0.946
82	90,067.77	-5.4	0.981

Age	Direct medical ED cost	% change	Age adjustment rate (Y)
83	88,360.80	-1.9	1.127
84	99,606.72	12.7	0.906
85	90,268.59	-9.4	0.843
86	76,110.78	-15.7	0.752
87	57,233.70	-24.8	0.981
88	56,129.19	-1.9	0.955
89	53,618.94	-4.5	0.884
90	47,393.52	-11.6	0.828
91	39,260.31	-17.2	0.913
92	35,846.37	-8.7	0.773
93	27,713.16	-22.7	0.717
94	19,881.18	-28.3	0.788
95	15,663.96	-21.2	0.692
96	10,844.28	-30.8	0.806
97	8,735.67	-19.4	0.483
98	4,217.22	-51.7	0.881
99	3,715.17	-11.9	0.784
100	2,911.89	-21.6	0.690
101	2,008.20	-31.0	0.600
102	1,204.92	-40.0	1.167
103	1,405.74	16.7	0.286
104	401.64	-71.4	10.750
105	4,317.63	975.0	1.442
106	6,225.42	44.2	1.000

Table A2.6: Age adjustment rates used as part of formula to calculate expected direct medical costs incurred within the inpatient sector

Age	Direct medical inpatient cost	% change	Age adjustment rate (Y)
0	108,646,895.89		0.203
1	22,054,605.82	-79.7	0.642
2	14,168,034.25	-35.8	0.792
3	11,220,068.09	-20.8	0.857
4	9,613,342.53	-14.3	0.918
5	8,822,666.43	-8.2	0.929
6	8,199,028.36	-7.1	0.970
7	7,954,192.46	-3.0	0.932
8	7,410,589.28	-6.8	0.933
9	6,917,411.88	-6.7	1.053
10	7,281,325.02	5.3	1.154
11	8,399,116.51	15.4	1.148
12	9,641,363.16	14.8	1.071
13	10,328,474.26	7.1	1.033
14	10,669,508.74	3.3	1.271
15	13,564,718.98	27.1	1.022
16	13,862,554.77	2.2	1.228
17	17,024,709.15	22.8	1.153
18	19,634,286.96	15.3	1.058
19	20,773,349.34	5.8	1.025
20	21,286,420.63	2.5	1.022

Age	Direct medical inpatient cost	% change	Age adjustment rate (Y)
21	21,757,837.00	2.2	1.000
22	21,750,213.22	0.0	1.006
23	21,883,551.29	0.6	1.084
24	23,715,788.24	8.4	0.923
25	21,890,596.00	-7.7	1.056
26	23,118,784.52	5.6	0.956
27	22,106,109.13	-4.4	0.952
28	21,053,780.83	-4.8	1.100
29	23,160,813.72	10.0	1.015
30	23,506,855.80	1.5	1.059
31	24,885,428.87	5.9	1.002
32	24,942,117.38	0.2	1.030
33	25,697,857.90	3.0	1.024
34	26,305,344.86	2.4	1.051
35	27,652,354.02	5.1	0.968
36	26,763,302.88	-3.2	1.002
37	26,815,337.90	0.2	0.990
38	26,553,808.56	-1.0	1.010
39	26,813,697.99	1.0	0.974
40	26,129,863.56	-2.6	1.103
41	28,811,257.26	10.3	0.991
42	28,561,309.61	-0.9	1.016
43	29,011,553.73	1.6	0.990
44	28,721,620.12	-1.0	1.011
45	29,051,912.76	1.1	0.973
46	28,266,989.02	-2.7	1.043
47	29,469,637.10	4.3	1.085
48	31,972,096.94	8.5	0.934
49	29,876,256.30	-6.6	1.088
50	32,501,654.47	8.8	1.059
51	34,403,891.15	5.9	1.049
52	36,098,221.38	4.9	0.999
53	36,059,737.35	-0.1	1.077
54	38,849,630.81	7.7	1.038
55	40,315,317.42	3.8	1.133
56	45,675,485.42	13.3	1.075
57	49,080,161.40	7.5	1.109
58	54,419,391.74	10.9	0.972
59	52,882,228.24	-2.8	0.974
60	51,507,318.01	-2.6	1.071
61	55,158,250.43	7.1	1.024
62	56,459,057.48	2.4	1.048
63	59,164,619.78	4.8	0.936
64	55,374,582.68	-6.4	1.013
65	56,119,110.07	1.3	1.115
66	62,591,970.08	11.5	0.998
67	62,445,735.57	-0.2	1.058
68	66,079,376.11	5.8	1.021
69	67,465,095.50	2.1	1.068
70	72,079,088.81	6.8	0.950
71	68,490,458.06	-5.0	1.066
72	72,990,764.78	6.6	1.014
73	73,989,300.12	1.4	1.072
74	79,316,354.97	7.2	1.015
75	80,498,617.75	1.5	1.017
76	81,867,924.40	1.7	1.003
77	82,147,370.46	0.3	1.003

Age	Direct medical inpatient cost	% change	Age adjustment rate (Y)
78	82,385,638.70	0.3	0.998
79	82,233,432.88	-0.2	1.058
80	86,999,095.50	5.8	0.949
81	82,524,987.89	-5.1	1.049
82	86,580,891.38	4.9	0.965
83	83,579,285.15	-3.5	1.033
84	86,315,772.82	3.3	0.998
85	86,178,699.58	-0.2	0.819
86	70,565,875.20	-18.1	0.770
87	54,310,365.28	-23.0	0.856
88	46,495,521.20	-14.4	0.974
89	45,270,726.03	-2.6	0.881
90	39,867,576.38	-11.9	0.872
91	34,778,633.10	-12.8	0.854
92	29,685,031.58	-14.6	0.752
93	22,330,729.07	-24.8	0.800
94	17,856,197.77	-20.0	0.681
95	12,168,642.79	-31.9	0.763
96	9,278,879.55	-23.7	0.726
97	6,733,734.01	-27.4	0.632
98	4,253,808.56	-36.8	0.534
99	2,272,031.62	-46.6	0.637
100	1,446,927.24	-36.3	0.393
101	568,467.47	-60.7	1.522
102	865,266.94	52.2	0.370
103	320,338.41	-63.0	0.279
104	89,301.68	-72.1	0.844
105	75,351.40	-15.6	0.124
106	9,381.10	-87.6	3.747
107	35,151.84	274.7	0.069
108	2,434.95	-93.1	3.826
109	9,315.53	282.6	1.206
110	11,236.32	20.6	1.000

Table A2.7: Age adjustment rates used as part of formula to calculate expected direct medical costs incurred within the outpatient sector

Age	Direct medical outpatient cost	% change	Age adjustment rate (Y)
0	5,432,386.66		1.630
1	8,854,703.68	63.0	0.761
2	6,740,088.57	-23.9	0.905
3	6,101,683.59	-9.5	0.994
4	6,064,939.48	-0.6	1.015
5	6,154,830.54	1.5	1.016
6	6,253,955.60	1.6	0.981
7	6,133,441.28	-1.9	0.999
8	6,124,608.38	-0.1	1.023
9	6,262,437.99	2.3	1.023
10	6,409,166.42	2.3	1.058
11	6,783,231.72	5.8	1.117

Age	Direct medical outpatient cost	% change	Age adjustment rate (Y)
12	7,573,784.03	11.7	1.143
13	8,656,934.08	14.3	1.089
14	9,428,246.02	8.9	1.068
15	10,070,528.85	6.8	0.936
16	9,425,461.10	-6.4	0.863
17	8,137,879.92	-13.7	0.902
18	7,342,199.24	-9.8	0.955
19	7,011,047.02	-4.5	1.003
20	7,034,683.75	0.3	1.025
21	7,214,042.45	2.5	1.024
22	7,383,632.27	2.4	1.008
23	7,441,629.23	0.8	1.035
24	7,704,007.79	3.5	1.044
25	8,043,606.73	4.4	1.006
26	8,095,306.64	0.6	0.973
27	7,876,445.28	-2.7	0.950
28	7,480,712.43	-5.0	1.007
29	7,533,722.91	0.7	1.028
30	7,741,384.17	2.8	1.044
31	8,079,171.91	4.4	1.062
32	8,582,808.43	6.2	1.048
33	8,991,113.94	4.8	1.042
34	9,372,882.11	4.2	1.025
35	9,610,703.66	2.5	1.006
36	9,667,216.63	0.6	1.004
37	9,705,425.22	0.4	0.989
38	9,603,356.54	-1.1	0.998
39	9,582,252.88	-0.2	1.001
40	9,590,117.66	0.1	1.027
41	9,850,960.86	2.7	1.026
42	10,107,840.59	2.6	0.987
43	9,973,963.68	-1.3	0.988
44	9,853,549.18	-1.2	0.993
45	9,788,613.61	-0.7	0.993
46	9,716,558.91	-0.7	1.002
47	9,734,537.79	0.2	1.010
48	9,829,169.03	1.0	1.027
49	10,097,269.86	2.7	1.000
50	10,100,748.50	0.0	1.001
51	10,111.663.93	0.1	1.048
52	10,597,963.61	4.8	1.026
53	10,871,672.36	2.6	1.027
54	11,161,658.14	2.7	1.057
55	11,795,396.12	5.7	1.054
56	12,431,955.15	5.4	1.079
57	13,409,664.24	7.9	1.090
58	14,613,176.98	9.0	1.041
59	15,216,008.89	4.1	0.931
60	14,162,960.19	-6.9	0.963
61	13,642,962.42	-3.7	1.036
62	14,129,699.20	3.6	1.004
63	14,191,103.47	0.4	0.977
64	13,865,258.37	-2.3	0.962
65	13,339,103.48	-3.8	1.019
66	13,591,042.65	1.9	1.021
67	13,872,333.00	2.1	1.015
68	14,077,214.00	1.5	1.008

Age	Direct medical outpatient cost	% change	Age adjustment rate (Y)
69	14,187,226.35	0.8	1.003
70	14,226,421.82	0.3	0.990
71	14,082,153.63	-1.0	0.988
72	13,917,360.55	-1.2	0.983
73	13,676,530.91	-1.7	0.980
74	13,401,214.34	-2.0	1.021
75	13,686,067.86	2.1	0.971
76	13,292,504.69	-2.9	0.972
77	12,926,427.33	-2.8	0.961
78	12,426,814.35	-3.9	0.952
79	11,827,707.97	-4.8	0.965
80	11,419,017.95	-3.5	0.931
81	10,628,820.35	-6.9	0.930
82	9,885,917.40	-7.0	0.906
83	8,952,825.80	-9.4	0.930
84	8,321,885.48	-7.0	0.947
85	7,877,031.28	-5.3	0.827
86	6,517,030.87	-17.3	0.733
87	4,774,411.07	-26.7	0.749
88	3,577,643.75	-25.1	0.833
89	2,979,377.93	-16.7	0.813
90	2,421,897.39	-18.7	0.790
91	1,912,889.64	-21.0	0.781
92	1,493,016.10	-21.9	0.743
93	1,109,467.65	-25.7	0.746
94	827,371.27	-25.4	0.662
95	547,462.27	-33.8	0.667
96	365,019.69	-33.3	0.635
97	231,703.68	-36.5	0.635
98	147,201.90	-36.5	0.592
99	87,109.61	-40.8	0.541
100	47,122.22	-45.9	0.456
101	21,470.43	-54.4	0.611
102	13,107.85	-38.9	0.927
103	12,157.20	-7.3	0.604
104	7,343.68	-39.6	0.777
105	5,705.16	-22.3	0.152

Appendix 3

Table A3.1: TFR2 healthcare resource unit costs used to calculate direct medical costs within the ED sector

	ED expenditure (£)	ED cases	ED unit cost (£)
All ED attendances	100,328,187	999,187	100.41

Table A3.2: TFR2 healthcare resource unit costs used to calculate direct medical costs within the inpatient sector

	Inpatients			Daycases		
Specialties	Net expenditure (£)	Patient days	Cost per day (£)	Net expenditure (£)	Patient days	Cost per day (£)
Paediatrics	63,230,258	109,300	578.50	742,045	900	824.49
Geriatrics	82,530,423	388,858	212.24	14,190	65	218.31
Cardiology	35,856,037	65,117	550.64	4,022,122	3,717	1,082.09
Dermatology	3,029,404	12,335	245.59	799,232	1,755	455.40
Infectious diseases	0	0	0.00	0	0	0.00
Medical oncology	5,806,513	10,254	566.27	43,519	77	565.19
Neurology	7,969,078	22,855	348.68	67,019	126	531.90
Rheumatology	1,938,143	4,593	421.98	94,205	75	1,256.06
Gastroenterology	7,519,931	19,852	378.80	586,263	1,031	568.64
Haematology	12,567,195	25,251	497.69	1,904,212	4,075	467.29
Clinical immunology and allergy	0	0	0.00	0	0	0.00
Thoracic medicine	14,127,378	45,493	310.54	93,488	348	268.64
Genito-urinary medicine	95,246	160	595.29	56,375	230	245.11
Nephrology	10,220,480	25,366	402.92	19,687	45	437.49
Rehabilitation medicine	32,159,432	157,613	204.04	29,806	22	1,354.82

	Inpatients			Daycases		
Specialties	Net expenditure (£)	Patient days	Cost per day (£)	Net expenditure (£)	Patient days	Cost per day (£)
Palliative medicine	6,193,280	13,094	472.99	444	1	444.00
Other medicine	331,034,950	1,223,582	270.55	4,307,471	6,547	657.93
General surgery	176,070,563	358,811	490.71	12,790,405	13,864	922.56
Urology	31,583,409	65,491	482.26	10,422,565	23,452	444.42
Orthopaedics	172,061,195	346,819	496.11	10,273,988	12,896	796.68
ENT	31,278,052	35,382	884.01	4,755,724	6,285	756.68
Ophthalmology	4,834,269	5,948	812.76	23,380,010	27,449	851.76
Gynaecology	37,926,848	65,930	575.26	10,913,697	15,174	719.24
Dental specialities	10,978,780	11,725	936.36	3,369,086	5,961	565.19
Neuro-surgery	15,925,573	25,070	635.24	66,402	145	457.94
Plastic surgery	9,543,917	15,480	616.53	798,215	1,073	743.91
Cardiothoracic	27,542,508	25,543	1,078.28	2,119	11	192.64
Paediatric surgery	3,932,574	5,704	689.44	555,487	338	1,643.45
Obstetrics	72,697,391	123,852	586.97	17,920	26	689.23
General practice (maternity)	158,507	185	856.79	9,227	27	341.74
Learning disabilities	26,967,904	49,669	542.95	0	0	0.00
Mental illness	94,288,544	316,807	297.62	0	0	0.00
Child and adolescent psychiatry	3,525,857	5,994	588.23	0	0	0.00
Forensic psychiatry	18,548,571	40,554	457.38	0	0	0.00
Psychotherapy	0	0	0.00	0	0	0.00
Old age psychiatry	81,965,897	336,532	243.56	0	0	0.00
General practice (other than maternity)	39,771,590	171,961	231.28	74,599	190	392.63
Radiotherapy	12,261,076	31,770	385.93	3,179,960	1,922	1,654.51
Pathological specialities and radiology	57,792	203	284.69	38,932	149	261.29
Anaesthetics	1,090,437	2,337	466.60	2,123,133	2,431	873.36
Younger Physically Disabled	0	0	0.00	0	0	0.00
A & E	1,938,188	2,213	875.82	6,053	3	2,017.82
Other	5,383,591	3,054	1,762.80	0	0	0.00

Table A3.3: TFR2 healthcare resource unit costs used to calculate direct medical costs within the outpatient sector

	Outpatients		
Specialties	**Net expenditure (£)**	**Total attendances**	**Cost per attendance (£)**
Paediatrics	22,524,812	99,664	226.01
Geriatrics	4,481,857	27,073	165.55
Cardiology	6,846,715	50,725	134.98
Dermatology	12,884,367	140,505	91.70
Infectious diseases	0	0	0.00
Medical oncology	3,792,620	26,077	145.44
Neurology	4,871,429	29,205	166.80
Rheumatology	12,051,576	75,674	159.26
Gastroenterology	2,134,414	15,803	135.06
Haematology	16,059,835	228,431	70.30
Clinical immunology and allergy	0	0	0.00
Thoracic medicine	1,922,034	13,667	140.63
Genito-urinary medicine	9,091,800	61,765	147.20
Nephrology	4,092,767	25,929	157.85
Rehabilitation medicine	237,737	2,108	112.78
Palliative medicine	462,322	1,404	329.29
Other medicine	54,301,620	335,511	161.85
General surgery	24,832,387	203,017	122.32
Urology	12,505,697	100,023	125.03
Orthopaedics	47,781,167	387,902	123.18
ENT	14,979,296	147,305	101.69
Ophthalmology	22,470,564	304,554	73.78
Gynaecology	12,724,179	132,174	96.27
Dental specialities	13,783,306	83,568	164.94
Neuro-surgery	1,330,470	8,045	165.38
Plastic surgery	2,291,777	16,582	138.21
Cardiothoracic	918,887	5,893	155.93
Paediatric surgery	344,780	2,567	134.31
Obstetrics	20,676,082	138,511	149.27

	Outpatients		
Specialties	**Net expenditure (£)**	**Total attendances**	**Cost per attendance (£)**
General practice (maternity)	0	0	0.00
Learning disabilities	728,749	3,756	194.02
Mental illness	14,323,625	94,747	151.18
Child and adolescent psychiatry	8,085,043	31,758	254.58
Forensic psychiatry	824,573	1,877	439.30
Psychotherapy	327,519	697	469.90
Old age psychiatry	4,050,605	29,237	138.54
General practice (other than maternity)	1,238,432	5,037	245.87
Radiotherapy	14,256,569	92,897	153.47
Pathological specialities and radiology	476,267	4,968	95.87
Anaesthetics	2,822,537	19,088	147.87
Younger Physically Disabled	0	0	0.00
A & E	491,687	3,775	130.25
Other	134,950	2,146	62.88

Appendix 4

Table A4: ICD 10 and Read version 2 codes used to identify the presence of co-morbidities amongst the study population

Co-morbidities	ICD 10 codes	Read version 2 codes
Myocardial infarction	I21.x, I22.x, I25.2	G30.., G32.., G35..
Congestive heart failure	I09.9, I11.0, I13.0, I13.2, I25.5, I42.0, I42.5-I42.9, I43.x, I50.x, P29.0	G1yz0, G2101, G2111, G21z1, G232., G234., G343., G5540, G5541, G554z, G555., G55y0, G55z., G557., G558., G58.., Q490.
Peripheral vascular disease	I70.x, I71.x, I73.1, I73.8, I73.9, I77.1, I79.0, I79.2, K55.1, K55.8, K55.9, Z95.8, Z95.9	G70.., G71.., G7310, G73y., G73z., G761., G717., G73y0, J5771
Cerebrovascular disease	G45.x, G46.x, H34.0, I60.x-I69.x	G65.., G660., G661., G662., G663., G664., G665., G666., G6…, F4237
Chronic pulmonary disease	I27.8, I27.9, J40.x-J47.x, J60.x-J67.x, J68.4, J70.1, J70.3	G4y.., G4z.., H30.., H310., H311., H313., H31z., H32.., H3y.., H33.., H34.., H35.., H40.., H41.., H42.., H43.., H44.., H45.., H450., H464., H4y1., H4y21
Diabetes	E10.x-E14.x	C10..
Dementia	F00.x-F03.x, F05.1, G30.x, G31.1	Eu00., Eu01., Eu02., Eu02z, E003., E0011, E0041, F110., F112.
Rheumatic disease	M05.x, M06.x, M31.5, M32.x-M34.x, M35.1, M35.3, M36.0	N047., N04X., N041., N0421, N040N, N0420, G5yA., G5y8., F3964, G011., G010., F3712, N040P, N04y2, N040Q, N0422, N04.., N200., N0003, N000., N004., N003X, N0031, N001., N20.., N0031
Peptic ulcer disease	K25.x-K28.x	J11.., J12.., J13.., J14..
Mild liver disease	B18.x, K70.0-K70.3, K70.9, K71.3-K71.5, K71.7, K73.x, K74.x, K76.0, K76.2-K76.4, K76.8, K76.9, Z94.4	A707., J610., J617., J6120, J612., J613., J6353, J6354, J6355, J6356, J614z, J61y4, J61y5, J61y6, J6160, J6161, J616z, J615z, Jyu71, J6151, J61y1, J636., J634., J638., J63y0, PB6y9, J61z.,ZV427
Hemiplegia or paraplegia	G04.1, G11.4, G80.1, G80.2, G81.x, G82.x, G83.0-G83.4, G83.9	F038., F141., F2301, F231., F22.., F241., F240., F242., F243., F244., F245., F246., F24z.
Renal disease	I12.0, I13.1, N03.2-N03.7, N05.2-N05.7, N18.x, N19.x, N25.0, Z49.0-Z49.2, Z94.0, Z99.2	G222., G233., K0A32, K0A33, K0A34, K0A35, K0A36, K0A37, K03V., K03U., K03X., K03W., K05.., K06.., K080., ZV561, ZV560, ZV56y, ZV420, ZV451
Any malignancy	C00.x-C26.x, C30.x-C34.x, C37.x-C41.x, C43.x, C45.x-	B0…, B1…, B2…, B30.., B32.., B232., B181., B2414, BBPX.,

Co-morbidities	ICD 10 codes	Read version 2 codes
	C58.x, C60.x-C76.x, C81.x-C85.x, C88.x, C90.x-C97.x	Byu50, Byu51, B61.., B627., B621., B622., B62x0, B62x1, B62x2, B62xX, B627W, B601., BBg2., ByuDF, BBmK., BBm6., BBmE., BBmG., B62x5, B630., BBn0., B631., B6300, B64.., B65.., B66.., B670., B671., BBrA5, BBrA0, B673., B674., BBs1., BBrA6, B675., BBrA7, B67y0, BBr5., B68.., B625., BBm3., B623., B626., BBp.., B480., B481., B482., B483., B487., B46.., B47.., B484., B485., B486., B48y., B4A0., B4A1., B4A2., B49.., B4A3., B4A4., B4Ay0, B4Az., B50.., B521., B523., B52X., B51.., B522., B525., B520., B52W., B52z., B53.., B540., B541., B542., B543., B544., B545., B54X., B54z., B55.., B62x6, BBm4., B6y.., B62.., B592., B33z0, B05z0, B59zX, B31z0, B6z0., B592X, B524., B180., B18y., B182., B31.., B34.., B35.., B451., B452., B453., B54y0, B454., B450., B41.., B431., B4302, B4303, B4301, B432., B430z, B43z., B440., B441., B442., B443., B444., B44y., B44z., B45y., B45X., B45z., B42..
Moderate or severe liver disease	I85.0, I85.9, I86.4, I98.2, K70.4, K71.1, K72.1, K72.9, K76.5, K76.6, K76.7	G850., G851., G857., G852., J6130, J6357, J637., J623., J624.
Metastatic solid tumor	C77.x-C80.x	B56.., B57.., B58.., B59..
AIDS/HIV	B20.x-B22.x, B24.x	A7890, A7891, A7892, A7893, A7894, AyuC4, A788z, A7898, A7895, A7896, A7897, A789X, Eu024, A7899, A789A, A7894

Appendix 5

Table A5.1: ICD10 codes used to classify each inpatient admission into a Meerding injury grouping

Meerding grouping	ICD 10 codes
Skull-brain injury	S02(.0-.1), S04(.0-.9), S06(.0-.9), S07(.1-.9), T02.0, T04.0
Facial fracture, eye injury	S02(.2-.6), S05(.0-.9), S07.0
Spine, vertebrae	S12(.0-.7), S12.9, S13(.0-.4), S13.6, S14(.0-.1), S16X, S22(.0-.1), S23(.0-.1), S23.3, S24(.0-.1), S29.0, S32(.0-.2), S33(.0-.3), S33(.5-.7), S34(.0-.3), T02.1, T03(.0-.1), T06.1, T08X, T09(.2-.3)
Internal organ injury	S25(.0-.9), S26(.0-.9), S27(.0-.9), S29.7, S35(.0-.9), S36(.0-.9), S37(.0-.9), S39(.6-.9), T06.5
Upper extremity fracture	S42(.0-.4), S42(.7-.9), S52(.0-.9), S62(.0-.8), T10X
Upper extremity, other injury	S43(.0-.7), S45(.0-.9) to S49(.0-.9), S53(.0-.4), S55(.0-.9) to S59(.0-.9), S63(.0-.7), S65(.0-.9) to S69(.0-.9), T04.2, T05(.0-.2), T11(.2-.9)
Hip fracture	S72(.0-.2)
Lower extremity, fracture	S72(.3-.4), S72(.7-.9), S82(.0-.9), S92(.0-.9), T12X
Lower extremity, other injury	S15.1, S73(.0-.1), S75(.0-.9) to S79(.0-.9), S83(.0-.7), S85(0.-.9) to S89(.0-.9), S93(.0-.9), S95(.0-.9) to S99(.0-.9), T04.3, T05(.3-.5), T13(.2-.9)
Superficial injury, open wounds	S00(.0-.9), S01(.0-.9), S08(.0-.9), S09.2, S10(.0-.9), S11(.0-.9), S20(.0-.9), S21(.0-.9), S30(.0-.9), S31(.0-.9), S40(.0-.9), S41(.0-.9), S50(.0-.9), S51(.0-.9), S60(.0-.9), S61(.0-.9), S70(.0-.9), S71(.0-.9), S80(.0-.9), S81(.0-.9), S90(.0-.9), S91(.0-.9), T00(.0-.9), T01(.0-.9), T09(.0-.1), T11(.0-.1), T13(.0-.1), T14(.0-.1)
Burns	T20(.0-.9) to T35(.0-.9)
Poisonings	T36(.0-.9) to T65(.0-.9)
Other injury	All other combinations

Table A5.2: Morriston ED diagnosis and anatomical area codes used to classify each ED attendance into a Meerding injury grouping

Meerding grouping	Diagnosis code*	Anatomical area code**
Skull-brain injury	04A, 04B, 06A, 06B, 06C, 16, 54	24.00
Facial fracture, eye injury	06A, 06B, 06C	18.00, 19.00, 21.00, 23.00
Spine, vertebrae	02, 06A, 06B, 06C, 08, 14, 16, 123	22.00, 25.00, 27.00, 28.00, 29.00, 30.00, 35.00
Internal organ injury	15	-
Upper extremity fracture	06A, 06B, 06C	9.00, 10.00, 11.00, 12.00, 13.00,

		14.00, 15.00, 16.00, 17.00, 36.00
Upper extremity, other injury	02, 08, 14, 19, 20A, 20B, 52	9.00, 10.00, 11.00, 12.00, 13.00, 14.00, 15.00, 16.00, 17.00, 36.00, 37.00
Hip fracture	06A, 06B, 06C	7.00
Lower extremity, fracture	06A, 06B, 06C	1.00, 2.00, 3.00, 4.00, 5.00, 6.00, 8.00, 39.00
Lower extremity, other injury	02, 08, 14, 19, 20A, 20B, 52	1.00, 2.00, 3.00, 4.00, 5.00, 6.00, 7.00, 8.00, 39.00
Superficial injury, open wounds	01, 03, 09, 17, 18	-
Burns	11A, 11B, 11C, 11D, 51	-
Poisonings	25A, 25B	-
Other injury	All other combinations	All other combinations

* The diagnosis descriptions relating to each of the diagnosis codes listed in Table A5.2 can be viewed in Table A1 of Appendix 1.

** The anatomical area descriptions relating to each of the anatomical area codes listed in Table A5.2 can be viewed in Table A5.3 below.

Table A5.3: Anatomical area descriptions of each anatomical area code used by Morriston ED

Anatomical area code	Anatomical area description
1.00	Toe
2.00	Foot
3.00	Ankle
4.00	Lower Leg
5.00	Knee
6.00	Thigh
7.00	Hip
8.00	Pelvis
9.00	Finger
10.00	Thumb
11.00	Hand
12.00	Wrist
13.00	Forearm
14.00	Elbow
15.00	Upper Arm
16.00	Shoulder
17.00	Clavicle
18.00	Mouth
19.00	Eye
20.00	Ear
21.00	Nose
22.00	Throat
23.00	Face

Anatomical area code	Anatomical area description
24.00	Head
25.00	Neck
26.00	Scalp
27.00	Cervical Spine
28.00	Thoracic Spine
29.00	L./S. Spine
30.00	Back
31.00	Chest (Wall)
32.00	Abdomen
33.00	Genitalia
34.00	Ano-Rectal
35.00	Buttock
36.00	Shoulder Girdle
37.00	Axilla
38.00	Breast
39.00	Groin
41.00	Eyelid
44.00	Retina
45.00	Vitreous

Appendix 6

In section 9.1.5 of Chapter 9 the findings relating to research question 1 are summarised and discussed. Due to their length the actual tables of results underlying these findings are presented in this section of the Appendix.

Tables A6.1 – A6.4 show the cumulative percentage of ED attendances, inpatient admissions, 'ED attendance to inpatient admission' cases and 'inpatient admission to ED attendance' cases respectively, matched on Meerding injury group as the number of days between the occurrence of the first and second of these healthcare events was incrementally increased from 1 day to 90 days.

Table A6.1: Cumulative percentage of ED attendances matched on Meerding group (up to 90 day gap between first and second ED attendance)

	Number of days between first and second ED attendances									
Meerding group	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Skull-brain injury	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Facial fracture, eye injury	91.7	84.2	78.3	75.9	75.8	75.0	75.7	72.5	69.0	70.2
Spine, vertebrae	96.6	93.3	90.0	89.3	87.0	85.6	85.8	85.4	83.1	81.4
Internal organ injury	-	-	-	-	-	-	-	-	-	-
Upper extremity fracture	88.3	87.0	85.4	83.6	84.6	83.6	82.5	82.0	81.5	81.4
Upper extremity, other injury	88.9	85.6	81.4	80.1	80.0	80.2	80.4	78.7	78.8	78.3
Hip fracture	100.0	100.0	100.0	100.0	100.0	100.0	100.0	92.3	85.7	80.0
Lower extremity, fracture	96.4	92.2	87.7	87.7	89.1	89.1	87.7	88.0	88.4	88.8
Lower extremity, other injury	90.4	88.6	86.4	87.1	85.5	85.1	84.1	84.0	84.1	84.0
Superficial injury, open wounds	88.2	85.9	85.3	84.8	84.0	83.6	83.0	82.6	82.0	81.6
Burns	-	-	-	-	-	-	-	-	-	-

Poisonings	66.7	80.0	64.3	59.4	58.8	61.9	61.9	60.0	58.7	58.3
Other injury	91.7	87.4	85.8	83.7	82.8	82.8	81.1	79.9	79.7	79.2

	Number of days between first and second ED attendances									
Meerding group	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Skull-brain injury	100.0	50.0	50.0	50.0	50.0	50.0	66.7	66.7	66.7	66.7
Facial fracture, eye injury	68.8	67.3	67.3	66.0	66.7	66.7	65.4	64.2	64.2	63.0
Spine, vertebrae	80.3	79.7	79.0	77.5	77.2	77.5	76.9	75.7	74.5	74.4
Internal organ injury	-	-	-	-	-	-	-	-	-	-
Upper extremity fracture	81.1	81.1	80.4	79.4	79.1	78.8	78.6	78.3	77.8	77.4
Upper extremity, other injury	78.2	77.4	75.9	76.0	75.7	75.8	75.3	74.7	74.3	73.3
Hip fracture	66.7	66.7	57.1	57.1	57.1	54.5	54.5	48.0	48.1	48.1
Lower extremity, fracture	87.4	87.2	86.9	86.5	86.0	85.2	85.4	85.2	84.4	83.6
Lower extremity, other injury	84.0	83.2	82.8	82.4	82.1	82.0	81.7	81.1	81.1	80.9
Superficial injury, open wounds	81.1	80.7	80.4	80.1	79.6	79.4	78.8	78.7	78.5	78.1
Burns	-	-	-	-	-	-	-	-	-	-
Poisonings	57.7	59.3	60.7	59.3	60.9	60.0	59.7	58.0	56.9	57.9
Other injury	78.6	78.2	77.3	76.9	75.9	75.3	74.5	74.2	74.4	73.9

	Number of days between first and second ED attendances									
Meerding group	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**
Skull-brain injury	66.7	66.7	66.7	66.7	66.7	66.7	66.7	66.7	66.7	66.7
Facial fracture, eye injury	61.8	61.8	61.8	61.8	59.6	60.3	60.3	60.7	60.7	61.3

	Number of days between first and second ED attendances									
Meerding group	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**
Spine, vertebrae	74.0	74.0	73.0	71.7	71.3	70.9	70.6	70.2	69.9	69.6
Internal organ injury	-	-	-	-	-	-	-	-	-	-
Upper extremity fracture	77.4	77.1	76.8	76.7	76.2	75.8	75.0	74.6	74.4	74.1
Upper extremity, other injury	72.9	72.3	72.1	71.7	71.3	70.7	70.0	70.0	69.4	68.7
Hip fracture	48.1	48.3	48.3	46.7	48.4	48.4	48.4	48.4	46.9	48.5
Lower extremity, fracture	82.9	82.9	82.4	81.9	81.6	81.4	81.5	80.4	80.0	79.6
Lower extremity, other injury	80.8	80.5	79.9	79.5	78.9	78.1	77.4	76.8	76.6	76.2
Superficial injury, open wounds	77.6	77.1	76.7	76.2	76.0	75.6	75.0	74.7	74.4	74.2
Burns	-	-	-	-	-	-	-	-	-	-
Poisonings	56.4	54.9	54.2	52.3	51.7	51.1	51.1	51.6	51.6	50.5
Other injury	73.6	72.6	72.4	72.0	70.8	70.0	69.8	69.4	68.7	68.3

	Number of days between first and second ED attendances									
Meerding group	**31**	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**
Skull-brain injury	66.7	66.7	66.7	66.7	66.7	66.7	66.7	66.7	66.7	66.7
Facial fracture, eye injury	60.3	60.3	60.3	59.4	59.4	57.6	57.6	57.6	56.7	57.4
Spine, vertebrae	69.2	68.6	67.9	66.8	66.3	66.0	65.5	65.1	64.9	64.7
Internal organ injury	-	-	-	-	-	-	-	-	-	-
Upper extremity fracture	73.2	72.8	72.5	71.8	71.5	71.1	70.4	70.2	69.8	69.5
Upper extremity, other injury	67.8	67.7	67.4	66.7	66.1	65.9	65.7	65.3	65.2	65.4
Hip fracture	48.6	50.0	50.0	48.7	48.7	47.5	47.5	46.3	47.6	48.9
Lower extremity, fracture	79.7	79.1	78.0	77.4	77.2	76.6	76.4	76.2	75.9	74.9
Lower extremity,	75.7	75.5	74.8	74.2	73.8	73.6	73.5	73.1	72.8	72.4

	Number of days between first and second ED attendances									
Meerding group	31	32	33	34	35	36	37	38	39	40
other injury										
Superficial injury, open wounds	74.3	74.0	73.4	72.9	72.5	72.3	72.1	71.7	71.5	71.1
Burns	-	-	-	-	-	-	-	-	-	-
Poisonings	50.0	48.1	48.1	48.6	46.5	46.6	45.4	45.0	45.1	44.4
Other injury	68.0	67.5	67.3	67.1	66.8	66.5	65.5	65.2	65.1	64.8

	Number of days between first and second ED attendances									
Meerding group	41	42	43	44	45	46	47	48	49	50
Skull-brain injury	66.7	66.7	66.7	66.7	66.7	66.7	66.7	66.7	66.7	66.7
Facial fracture, eye injury	57.4	56.5	55.7	55.7	55.7	54.1	53.3	53.3	53.3	52.6
Spine, vertebrae	64.1	63.6	63.1	63.3	63.4	63.4	62.9	62.1	62.1	61.6
Internal organ injury	-	-	-	-	-	-	-	-	-	-
Upper extremity fracture	69.0	69.0	68.8	68.6	68.2	67.7	67.8	67.2	66.9	66.5
Upper extremity, other injury	65.2	64.7	64.3	63.7	63.8	63.5	63.3	62.7	62.3	62.0
Hip fracture	48.9	47.8	47.8	47.9	46.9	46.0	45.1	44.2	44.2	43.4
Lower extremity, fracture	74.5	74.0	73.9	73.5	73.8	73.0	72.7	72.4	71.6	71.3
Lower extremity, other injury	71.7	71.3	71.0	70.7	70.7	70.3	69.8	69.3	68.8	68.5
Superficial injury, open wounds	70.9	70.6	70.4	70.3	70.2	69.9	69.8	69.6	69.4	69.2
Burns	-	-	-	-	-	-	-	-	-	-
Poisonings	44.4	43.8	43.1	42.4	42.5	42.5	42.5	42.5	42.2	42.4
Other injury	64.2	63.7	63.3	62.9	62.9	62.7	62.3	61.7	61.5	61.2

	Number of days between first and second ED attendances									
Meerding group	51	52	53	54	55	56	57	58	59	60
Skull-brain	66.7	66.7	66.7	66.7	66.7	66.7	66.7	66.7	66.7	66.7

	Number of days between first and second ED attendances									
Meerding group	**51**	**52**	**53**	**54**	**55**	**56**	**57**	**58**	**59**	**60**
injury										
Facial fracture, eye injury	52.6	52.6	51.9	51.3	51.3	51.3	51.3	50.6	50.0	50.0
Spine, vertebrae	61.4	60.8	61.0	60.8	60.1	60.1	60.1	60.0	59.6	59.2
Internal organ injury	-	-	-	-	-	-	-	-	-	-
Upper extremity fracture	66.1	66.1	65.8	65.5	65.1	64.5	64.4	64.1	63.9	63.8
Upper extremity, other injury	61.5	61.0	61.0	60.8	60.7	60.5	60.2	60.1	60.1	59.8
Hip fracture	42.6	40.4	40.4	41.4	40.7	40.7	39.3	39.3	38.1	39.4
Lower extremity, fracture	70.4	69.7	69.8	69.9	70.0	69.8	69.8	69.3	69.2	68.7
Lower extremity, other injury	67.9	68.1	67.9	67.7	67.2	66.5	66.3	65.7	65.4	65.1
Superficial injury, open wounds	69.0	68.9	68.7	68.4	68.0	67.8	67.5	67.3	67.2	66.9
Burns	-	-	-	-	-	-	-	-	-	-
Poisonings	42.1	43.0	43.0	43.4	43.4	43.1	43.2	43.2	42.7	42.1
Other injury	60.9	60.4	60.3	60.0	59.8	59.7	59.3	58.8	58.5	58.0

	Number of days between first and second ED attendances									
Meerding group	**61**	**62**	**63**	**64**	**65**	**66**	**67**	**68**	**69**	**70**
Skull-brain injury	66.7	66.7	66.7	66.7	66.7	66.7	66.7	66.7	66.7	66.7
Facial fracture, eye injury	50.0	50.0	50.0	50.0	49.4	49.4	49.4	48.8	48.8	48.8
Spine, vertebrae	58.4	57.9	57.8	57.6	57.2	56.7	56.6	55.9	55.5	55.4
Internal organ injury	-	-	-	-	-	-	-	-	-	-
Upper extremity fracture	63.6	63.4	63.3	63.0	62.6	62.5	62.1	61.9	61.7	61.3
Upper extremity, other injury	59.4	58.7	58.5	58.3	58.0	57.8	57.7	57.6	57.6	57.2
Hip fracture	39.4	38.8	37.7	38.0	37.5	38.4	37.8	37.7	37.7	36.7
Lower	68.2	67.9	67.6	67.5	67.1	67.1	66.7	66.9	66.5	66.4

	Number of days between first and second ED attendances									
Meerding group	**61**	**62**	**63**	**64**	**65**	**66**	**67**	**68**	**69**	**70**
extremity, fracture										
Lower extremity, other injury	64.9	64.4	64.4	64.2	63.8	63.6	63.4	63.1	63.0	62.8
Superficial injury, open wounds	66.6	66.3	66.0	65.9	65.8	65.5	65.4	65.2	65.0	64.9
Burns	-	-	-	-	-	-	-	-	-	-
Poisonings	42.5	42.9	42.9	42.9	42.9	43.6	43.7	43.4	43.8	43.8
Other injury	57.6	57.3	57.1	56.9	56.8	56.7	56.4	56.0	55.7	55.4

	Number of days between first and second ED attendances									
Meerding group	**71**	**72**	**73**	**74**	**75**	**76**	**77**	**78**	**79**	**80**
Skull-brain injury	66.7	66.7	66.7	66.7	50.0	50.0	50.0	50.0	50.0	50.0
Facial fracture, eye injury	48.8	48.8	48.2	48.2	48.2	48.2	47.6	47.6	47.6	47.1
Spine, vertebrae	55.2	54.9	55.1	54.9	54.5	54.5	54.4	54.2	54.3	53.8
Internal organ injury	-	-	-	-	-	-	-	-	-	-
Upper extremity fracture	61.1	60.9	60.7	60.5	60.4	59.9	59.8	59.4	59.4	59.0
Upper extremity, other injury	56.9	56.5	56.5	56.4	55.8	55.5	54.8	54.9	54.9	55.0
Hip fracture	36.3	35.8	35.4	35.4	34.5	33.3	33.0	33.3	32.6	33.0
Lower extremity, fracture	66.3	65.9	65.7	65.4	65.2	64.8	64.1	63.6	63.6	63.4
Lower extremity, other injury	62.6	62.5	62.3	62.1	62.0	61.6	61.2	60.8	60.9	60.9
Superficial injury, open wounds	64.7	64.5	64.3	64.0	63.7	63.6	63.4	63.4	63.2	63.2
Burns	-	-	-	-	-	-	-	-	-	-
Poisonings	43.5	43.8	43.6	43.3	43.0	42.8	42.5	42.0	41.9	42.0
Other injury	55.1	55.0	54.9	54.9	54.5	54.2	54.1	54.1	54.1	54.0

	Number of days between first and second ED attendances									
Meerding group	**81**	**82**	**83**	**84**	**85**	**86**	**87**	**88**	**89**	**90**
Skull-brain injury	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0
Facial fracture, eye injury	47.1	47.1	46.5	46.0	46.0	45.5	45.5	45.5	45.5	45.5
Spine, vertebrae	53.6	53.5	53.3	53.3	53.1	52.8	52.8	52.4	52.3	51.9
Internal organ injury	-	-	-	-	-	-	-	-	-	-
Upper extremity fracture	58.5	58.4	58.1	57.7	57.5	57.3	57.0	56.8	56.6	56.6
Upper extremity, other injury	54.9	54.6	54.6	54.6	54.4	54.2	54.1	54.1	53.8	53.5
Hip fracture	32.3	32.0	31.3	31.3	31.3	31.0	31.7	31.4	31.4	31.4
Lower extremity, fracture	62.9	62.9	62.7	62.4	62.2	62.3	62.2	61.8	61.5	61.2
Lower extremity, other injury	60.7	60.5	60.5	60.1	59.9	59.7	59.4	59.0	59.0	58.7
Superficial injury, open wounds	63.0	63.0	62.8	62.6	62.3	62.3	62.1	62.0	61.9	61.6
Burns	-	-	-	-	-	-	-	-	-	-
Poisonings	42.0	42.0	41.5	41.6	41.6	41.4	41.0	40.8	40.8	40.3
Other injury	54.0	53.9	53.6	53.7	53.4	53.3	53.1	53.1	52.8	52.5

Table A6.2: Cumulative percentage of inpatient admissions matched on Meerding group (up to 90 day gap between first and second inpatient admission)

	Number of days between first and second inpatient admissions									
Meerding group	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Skull-brain injury	83.9	84.1	84.4	84.4	84.2	84.0	84.1	83.9	83.6	83.3
Facial fracture, eye	83.9	86.7	87.2	87.7	87.9	88.3	88.8	88.8	89.0	88.6

	Number of days between first and second inpatient admissions									
Meerding group	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
injury										
Spine, vertebrae	89.0	88.9	87.9	88.0	88.1	88.0	88.1	88.0	87.9	87.7
Internal organ injury	73.1	73.2	73.0	72.7	73.7	73.9	74.5	73.8	73.6	73.3
Upper extremity fracture	87.0	87.3	87.6	87.9	88.6	89.4	90.1	90.4	90.7	90.7
Upper extremity, other injury	71.2	72.2	72.3	72.7	72.5	72.7	72.7	72.7	73.1	73.1
Hip fracture	94.1	94.1	94.0	93.9	93.9	93.8	93.8	93.8	93.7	93.7
Lower extremity, fracture	84.0	84.3	84.7	84.9	85.2	85.5	85.6	85.6	85.8	85.8
Lower extremity, other injury	65.2	67.3	68.4	69.6	70.9	70.6	71.3	70.2	70.2	70.2
Superficial injury, open wounds	69.3	68.5	68.5	68.5	68.0	68.2	68.0	67.8	67.5	67.3
Burns	97.3	97.3	97.4	97.6	97.7	97.8	97.9	97.9	97.9	98.0
Poisonings	94.9	95.3	95.1	94.3	93.5	93.0	92.8	92.9	92.7	92.8
Other injury	77.4	76.8	76.4	75.8	75.0	74.6	74.2	73.9	73.0	72.6

	Number of days between first and second inpatient admissions									
Meerding group	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Skull-brain injury	83.0	82.8	82.7	82.8	82.7	82.4	82.4	82.3	82.2	82.2
Facial fracture, eye injury	88.8	89.0	88.5	87.8	88.0	88.1	87.8	87.6	86.7	86.9
Spine, vertebrae	87.7	87.9	87.9	88.0	88.0	88.0	88.0	87.8	87.9	87.5
Internal organ injury	73.0	72.9	73.1	72.6	73.0	73.0	72.5	72.5	71.8	72.0
Upper extremity fracture	90.9	91.1	91.2	91.4	91.5	91.2	91.3	91.2	91.2	91.1
Upper extremity, other injury	73.3	73.5	73.3	73.0	72.9	72.8	73.0	72.9	72.2	72.5
Hip fracture	93.6	93.5	93.4	93.4	93.4	93.3	93.3	93.3	93.2	93.2
Lower extremity, fracture	85.9	86.1	86.2	86.3	86.4	86.5	86.6	86.6	86.5	86.3
Lower	70.4	70.8	70.0	69.3	69.2	69.6	69.6	69.7	68.5	68.2

	Number of days between first and second inpatient admissions									
Meerding group	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
extremity, other injury										
Superficial injury, open wounds	66.9	66.6	66.5	66.3	66.3	66.2	66.2	66.1	66.0	65.8
Burns	98.0	97.8	97.8	97.9	97.9	97.9	97.9	97.9	98.0	97.8
Poisonings	92.5	92.3	92.0	92.1	91.7	91.6	91.6	91.6	91.4	91.3
Other injury	72.0	71.5	71.5	71.3	71.0	70.8	70.5	70.3	70.2	70.2

	Number of days between first and second inpatient admissions									
Meerding group	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**
Skull-brain injury	82.3	82.1	82.1	82.1	82.0	81.8	81.6	81.5	81.4	81.4
Facial fracture, eye injury	86.7	86.4	86.1	86.2	86.2	85.9	85.6	85.7	85.5	85.2
Spine, vertebrae	87.5	87.6	87.4	87.3	87.1	87.1	87.0	86.8	86.8	86.9
Internal organ injury	71.5	71.1	71.1	71.1	70.7	70.2	70.2	69.4	69.8	69.0
Upper extremity fracture	91.0	91.0	91.0	91.0	91.0	90.9	90.8	90.6	90.6	90.5
Upper extremity, other injury	72.4	72.3	72.4	72.4	72.3	72.2	72.2	72.2	72.2	72.2
Hip fracture	93.2	93.0	93.0	93.0	92.9	92.9	92.9	92.8	92.8	92.7
Lower extremity, fracture	86.2	86.2	86.1	86.0	86.1	86.1	86.0	85.9	85.9	85.9
Lower extremity, other injury	67.9	67.5	67.6	67.4	67.2	67.3	67.2	67.5	67.9	67.8
Superficial injury, open wounds	65.7	65.5	65.4	65.3	65.3	65.2	65.0	65.0	64.8	64.7
Burns	97.8	97.8	97.8	97.8	97.8	97.8	97.6	97.6	97.6	97.4
Poisonings	91.3	91.1	90.8	90.6	90.4	90.3	89.9	90.0	90.0	89.7
Other injury	70.1	70.1	70.1	69.9	69.7	69.5	69.3	68.9	68.8	68.6

	Number of days between first and second inpatient admissions									
Meerding group	**31**	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**

	Number of days between first and second inpatient admissions									
Meerding group	**31**	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**
Skull-brain injury	81.5	81.5	81.5	81.5	81.5	81.4	81.3	81.2	81.1	81.0
Facial fracture, eye injury	84.9	85.0	85.0	84.7	84.8	84.8	84.5	84.5	84.5	84.3
Spine, vertebrae	86.9	86.9	86.9	86.9	86.8	86.8	86.6	86.3	86.1	86.2
Internal organ injury	69.0	68.6	68.2	68.4	67.2	66.5	66.1	66.1	65.8	65.8
Upper extremity fracture	90.4	90.4	90.3	90.3	90.2	90.2	90.1	90.1	90.1	90.0
Upper extremity, other injury	71.9	71.8	71.7	71.5	71.5	71.7	71.6	71.2	71.1	71.0
Hip fracture	92.6	92.6	92.6	92.6	92.5	92.4	92.4	92.4	92.3	92.2
Lower extremity, fracture	85.7	85.7	85.6	85.6	85.4	85.4	85.3	85.3	85.2	85.1
Lower extremity, other injury	67.4	67.0	66.9	66.9	66.9	66.7	66.8	66.9	66.9	67.0
Superficial injury, open wounds	64.7	64.5	64.5	64.3	64.2	64.0	63.8	63.7	63.7	63.5
Burns	97.4	97.4	97.2	97.2	97.2	97.2	97.2	97.2	97.2	96.8
Poisonings	89.7	89.8	89.5	89.4	89.3	89.0	88.9	88.9	88.8	88.6
Other injury	68.5	68.4	68.4	68.2	68.3	68.2	68.1	67.9	67.9	67.9

	Number of days between first and second inpatient admissions									
Meerding group	**41**	**42**	**43**	**44**	**45**	**46**	**47**	**48**	**49**	**50**
Skull-brain injury	81.0	81.0	81.0	80.9	80.9	80.8	80.7	80.7	80.7	80.7
Facial fracture, eye injury	84.0	83.9	83.9	83.9	83.3	83.0	83.0	82.9	82.6	82.6
Spine, vertebrae	86.2	86.0	86.0	86.0	86.0	86.0	86.1	86.1	85.9	85.9
Internal organ injury	65.8	65.8	65.4	65.1	65.1	64.7	64.7	64.4	64.4	64.4
Upper extremity fracture	89.9	89.8	89.8	89.8	89.8	89.7	89.7	89.6	89.5	89.5
Upper extremity, other injury	70.9	70.8	70.7	70.8	70.6	70.4	70.4	70.2	70.1	70.1
Hip fracture	92.3	92.2	92.2	92.1	92.1	92.0	92.0	92.0	92.0	91.9

	Number of days between first and second inpatient admissions									
Meerding group	**41**	**42**	**43**	**44**	**45**	**46**	**47**	**48**	**49**	**50**
Lower extremity, fracture	85.1	85.0	85.0	84.8	84.7	84.6	84.6	84.6	84.5	84.4
Lower extremity, other injury	67.1	67.1	66.8	66.8	67.0	67.1	67.2	67.2	67.6	67.4
Superficial injury, open wounds	63.3	63.2	63.1	63.1	62.9	62.9	62.7	62.5	62.3	62.2
Burns	96.8	96.8	96.8	96.8	96.8	96.8	96.8	96.8	96.8	96.8
Poisonings	88.5	88.4	88.2	88.0	88.0	88.0	88.0	87.9	87.9	88.0
Other injury	67.9	67.8	67.7	67.6	67.6	67.4	67.3	67.1	66.9	66.9

	Number of days between first and second inpatient admissions									
Meerding group	**51**	**52**	**53**	**54**	**55**	**56**	**57**	**58**	**59**	**60**
Skull-brain injury	80.7	80.5	80.4	80.3	80.3	80.3	80.3	80.3	80.2	80.2
Facial fracture, eye injury	82.5	82.5	82.4	82.1	81.8	81.8	81.7	81.7	81.4	81.1
Spine, vertebrae	85.5	85.5	85.4	85.2	85.3	85.3	85.1	85.1	85.0	84.8
Internal organ injury	64.4	63.7	63.5	63.4	63.1	63.1	63.1	63.1	63.1	63.1
Upper extremity fracture	89.3	89.3	89.2	89.1	89.0	89.0	88.9	88.9	88.8	88.7
Upper extremity, other injury	69.8	69.8	69.7	69.7	69.7	69.6	69.5	69.6	69.6	69.4
Hip fracture	91.9	91.9	91.9	91.8	91.8	91.8	91.7	91.6	91.6	91.6
Lower extremity, fracture	84.3	84.3	84.2	84.2	84.1	84.1	84.1	84.1	84.0	84.0
Lower extremity, other injury	67.1	67.2	66.9	66.8	66.5	66.6	66.4	66.6	66.7	66.3
Superficial injury, open wounds	62.2	62.2	62.0	62.1	62.0	61.9	61.9	61.9	61.9	61.8
Burns	96.6	96.4	96.4	96.4	96.4	96.4	96.4	96.4	96.4	96.2
Poisonings	87.9	87.8	87.9	87.7	87.7	87.7	87.6	87.4	87.4	87.3
Other injury	66.9	66.9	66.8	66.7	66.7	66.7	66.6	66.7	66.4	66.4

	Number of days between first and second inpatient admissions									
Meerding group	**61**	**62**	**63**	**64**	**65**	**66**	**67**	**68**	**69**	**70**
Skull-brain injury	80.1	80.1	80.1	80.0	79.9	79.9	79.8	79.8	79.7	79.7
Facial fracture, eye injury	80.8	80.7	80.5	80.4	80.5	80.3	80.4	80.4	80.2	79.9
Spine, vertebrae	84.8	84.9	84.6	84.6	84.6	84.4	84.4	84.4	84.4	84.4
Internal organ injury	62.4	62.1	61.8	61.8	61.8	61.5	61.5	61.5	61.5	61.5
Upper extremity fracture	88.7	88.5	88.5	88.4	88.3	88.2	88.1	88.0	87.9	87.8
Upper extremity, other injury	69.5	69.3	69.1	68.9	68.7	68.4	68.4	68.4	68.4	68.4
Hip fracture	91.6	91.6	91.5	91.4	91.4	91.3	91.2	91.1	91.1	91.0
Lower extremity, fracture	83.9	83.9	83.9	83.9	83.8	83.8	83.6	83.6	83.6	83.6
Lower extremity, other injury	66.3	66.2	66.3	66.5	66.7	66.6	66.6	66.4	66.4	66.4
Superficial injury, open wounds	61.7	61.6	61.5	61.4	61.2	61.1	60.8	60.7	60.6	60.6
Burns	96.2	96.0	96.0	96.0	96.0	96.0	96.0	96.0	96.0	95.8
Poisonings	87.3	87.1	87.1	87.0	86.8	86.8	86.8	86.7	86.6	86.6
Other injury	66.2	66.1	65.9	65.8	65.8	65.7	65.5	65.4	65.2	65.3

	Number of days between first and second inpatient admissions									
Meerding group	**71**	**72**	**73**	**74**	**75**	**76**	**77**	**78**	**79**	**80**
Skull-brain injury	79.8	79.8	79.8	79.8	79.8	79.7	79.7	79.7	79.7	79.6
Facial fracture, eye injury	79.7	79.5	79.5	79.3	78.8	78.8	78.7	78.8	78.6	78.2
Spine, vertebrae	84.4	84.4	84.1	84.1	84.1	83.9	83.7	83.8	83.7	83.7
Internal organ injury	61.5	61.5	61.5	61.5	60.9	60.6	60.6	60.6	60.3	60.3
Upper extremity fracture	87.8	87.8	87.7	87.7	87.7	87.7	87.5	87.5	87.5	87.5
Upper extremity, other injury	68.2	68.2	67.9	68.0	67.9	68.0	68.0	68.0	68.0	67.9

	Number of days between first and second inpatient admissions									
Meerding group	**71**	**72**	**73**	**74**	**75**	**76**	**77**	**78**	**79**	**80**
Hip fracture	91.0	90.9	90.8	90.7	90.7	90.7	90.6	90.6	90.6	90.6
Lower extremity, fracture	83.5	83.5	83.4	83.4	83.4	83.4	83.3	83.3	83.3	83.2
Lower extremity, other injury	66.4	66.3	66.3	66.3	66.3	66.3	66.1	66.2	65.9	65.9
Superficial injury, open wounds	60.6	60.6	60.5	60.5	60.4	60.3	60.3	60.4	60.3	60.3
Burns	95.8	95.6	95.6	95.4	95.4	95.2	95.2	95.2	95.2	95.0
Poisonings	86.5	86.4	86.2	86.2	86.1	86.0	86.0	85.9	86.0	86.0
Other injury	65.1	65.1	65.0	64.9	64.9	64.8	64.6	64.6	64.4	64.3

	Number of days between first and second inpatient admissions									
Meerding group	**81**	**82**	**83**	**84**	**85**	**86**	**87**	**88**	**89**	**90**
Skull-brain injury	79.5	79.5	79.4	79.3	79.3	79.1	79.1	79.1	78.9	78.9
Facial fracture, eye injury	78.2	78.2	78.1	78.1	78.0	77.8	77.7	77.7	77.7	77.6
Spine, vertebrae	83.7	83.7	83.7	83.7	83.7	83.7	83.6	83.6	83.4	83.2
Internal organ injury	60.0	60.0	60.0	60.0	60.0	60.4	60.4	60.3	60.3	60.0
Upper extremity fracture	87.5	87.4	87.4	87.3	87.3	87.2	87.2	87.2	87.2	87.1
Upper extremity, other injury	67.6	67.5	67.3	67.4	67.2	67.2	67.2	67.2	67.1	67.0
Hip fracture	90.5	90.5	90.4	90.3	90.3	90.3	90.3	90.3	90.2	90.2
Lower extremity, fracture	83.2	83.2	83.1	83.1	83.1	83.1	83.1	83.1	83.0	83.0
Lower extremity, other injury	66.0	65.9	65.7	65.9	65.7	65.6	65.5	65.6	65.6	65.4
Superficial injury, open wounds	60.2	60.1	60.0	59.9	59.7	59.7	59.7	59.5	59.5	59.3
Burns	95.0	95.0	95.0	95.0	95.0	95.1	95.1	95.1	94.9	94.9
Poisonings	86.0	85.9	85.9	85.8	85.7	85.7	85.7	85.6	85.5	85.4
Other injury	64.3	64.3	64.1	63.9	63.8	63.7	63.7	63.5	63.2	63.1

Table A6.3: Cumulative percentage of 'ED attendance to inpatient admission' cases matched on Meerding group (up to 90 day gap between initial ED attendance and subsequent inpatient admission)

	Number of days between ED to inpatient cases									
Meerding group	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Skull-brain injury	77.1	77.1	77.1	77.1	77.1	77.1	77.1	77.1	77.1	77.1
Facial fracture, eye injury	92.4	92.8	92.8	93.0	93.2	93.4	93.3	93.4	93.6	93.6
Spine, vertebrae	59.8	58.3	58.0	58.4	58.2	57.7	57.9	57.1	57.1	57.3
Internal organ injury	-	-	-	-	-	-	-	-	-	-
Upper extremity fracture	83.7	83.8	84.0	84.0	84.0	84.0	83.9	83.9	83.9	84.1
Upper extremity, other injury	54.6	53.7	53.7	54.2	54.0	53.7	53.8	53.6	53.7	53.4
Hip fracture	89.5	89.5	89.5	89.4	89.4	89.3	89.3	89.3	89.3	89.3
Lower extremity, fracture	84.2	84.2	84.2	84.2	84.1	84.1	84.0	84.0	84.0	84.0
Lower extremity, other injury	43.3	42.5	41.9	40.9	39.9	39.4	39.3	38.7	38.0	37.7
Superficial injury, open wounds	54.0	53.9	53.7	53.6	53.4	53.4	53.2	53.2	53.0	52.9
Burns	-	-	-	-	-	-	-	-	-	-
Poisonings	98.9	98.7	98.6	98.6	98.6	98.6	98.6	98.6	98.6	98.6
Other injury	33.7	33.6	33.4	33.4	33.4	33.3	33.5	33.4	33.3	33.2

	Number of days between ED to inpatient cases									
Meerding group	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Skull-brain injury	77.1	77.1	77.1	77.1	77.1	77.1	77.1	77.1	77.1	77.1
Facial fracture, eye injury	93.8	93.7	93.7	93.8	93.8	93.7	93.7	93.7	93.5	93.5
Spine, vertebrae	57.3	57.3	57.5	57.7	57.4	57.4	57.4	57.4	57.2	57.2
Internal organ	-	-	-	-	-	-	-	-	-	-

	Number of days between ED to inpatient cases									
Meerding group	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
injury										
Upper extremity fracture	84.2	84.2	84.2	84.2	84.3	84.2	84.2	84.2	84.1	84.0
Upper extremity, other injury	53.4	53.0	53.0	52.9	52.8	52.8	52.8	52.8	52.7	52.7
Hip fracture	89.3	89.3	89.3	89.3	89.3	89.3	89.3	89.3	89.3	89.3
Lower extremity, fracture	83.9	83.9	83.9	83.9	83.9	83.9	83.8	83.8	83.8	83.7
Lower extremity, other injury	37.5	37.5	37.3	36.9	36.9	36.5	36.3	36.3	36.1	36.1
Superficial injury, open wounds	52.9	52.8	52.7	52.7	52.5	52.5	52.4	52.4	52.2	52.3
Burns	-	-	-	-	-	-	-	-	-	-
Poisonings	98.6	98.6	98.6	98.6	98.6	98.6	98.6	98.6	98.6	98.6
Other injury	33.1	33.1	33.0	33.0	32.9	32.9	32.9	32.8	32.8	32.7

	Number of days between ED to inpatient cases									
Meerding group	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**
Skull-brain injury	77.4	77.4	77.4	77.4	77.4	77.4	77.4	77.4	77.4	77.4
Facial fracture, eye injury	93.5	93.5	93.5	93.5	93.5	93.5	93.5	93.5	93.5	93.5
Spine, vertebrae	57.0	57.0	57.0	56.7	56.7	56.7	57.1	57.1	56.9	56.9
Internal organ injury	-	-	-	-	-	-	-	-	-	-
Upper extremity fracture	84.0	84.0	84.0	84.0	84.0	84.0	84.0	84.0	84.0	84.0
Upper extremity, other injury	52.7	52.7	52.2	52.0	51.9	51.9	51.9	52.0	52.0	52.0
Hip fracture	89.3	89.3	89.3	89.3	89.3	89.3	89.3	89.4	89.4	89.3
Lower extremity, fracture	83.7	83.7	83.7	83.7	83.7	83.7	83.7	83.7	83.6	83.6
Lower extremity, other injury	36.1	36.4	36.3	36.0	36.2	36.0	36.0	36.0	35.9	35.7
Superficial injury, open	52.2	52.2	52.1	52.1	52.0	52.0	52.0	52.0	51.9	51.9

	Number of days between ED to inpatient cases									
Meerding group	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**
wounds										
Burns	-	-	-	-	-	-	-	-	-	-
Poisonings	98.6	98.6	98.6	98.6	98.6	98.6	98.6	98.6	98.6	98.5
Other injury	32.8	32.8	32.8	32.8	32.8	32.7	32.7	32.7	32.6	32.6

	Number of days between ED to inpatient cases									
Meerding group	**31**	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**
Skull-brain injury	77.4	77.4	77.4	77.4	77.4	77.4	77.4	77.4	77.4	77.4
Facial fracture, eye injury	93.5	93.5	93.5	93.3	93.3	93.3	93.3	93.3	93.3	93.3
Spine, vertebrae	56.9	56.6	56.8	56.6	56.4	56.2	55.9	55.9	55.7	55.7
Internal organ injury	-	-	-	-	-	-	-	-	-	-
Upper extremity fracture	83.9	83.8	83.8	83.7	83.7	83.7	83.7	83.6	83.6	83.6
Upper extremity, other injury	51.8	51.7	51.7	51.7	51.5	51.5	51.5	51.4	51.2	51.1
Hip fracture	89.3	89.3	89.3	89.3	89.3	89.3	89.3	89.3	89.3	89.3
Lower extremity, fracture	83.6	83.6	83.5	83.5	83.5	83.4	83.4	83.4	83.4	83.4
Lower extremity, other injury	35.7	35.7	35.5	35.5	35.7	35.3	35.4	35.4	35.3	35.0
Superficial injury, open wounds	51.9	51.9	51.9	51.9	51.9	51.7	51.7	51.7	51.7	51.7
Burns	-	-	-	-	-	-	-	-	-	-
Poisonings	98.5	98.5	98.5	98.5	98.5	98.5	98.5	98.5	98.5	98.5
Other injury	32.6	32.6	32.6	32.6	32.5	32.5	32.5	32.5	32.5	32.5

	Number of days between ED to inpatient cases									
Meerding group	**41**	**42**	**43**	**44**	**45**	**46**	**47**	**48**	**49**	**50**
Skull-brain injury	77.4	77.4	77.4	77.4	77.4	77.4	77.4	77.4	77.4	77.4
Facial fracture, eye	93.3	93.3	93.3	93.3	93.3	93.3	93.3	93.3	93.3	93.3

	Number of days between ED to inpatient cases									
Meerding group	**41**	**42**	**43**	**44**	**45**	**46**	**47**	**48**	**49**	**50**
injury										
Spine, vertebrae	55.7	55.5	55.5	55.5	55.3	55.1	55.1	55.1	55.1	55.1
Internal organ injury	-	-	-	-	-	-	-	-	-	-
Upper extremity fracture	83.5	83.5	83.6	83.6	83.6	83.5	83.5	83.5	83.4	83.4
Upper extremity, other injury	51.2	51.2	51.2	51.0	51.0	51.0	51.0	51.0	51.2	51.2
Hip fracture	89.3	89.3	89.3	89.3	89.3	89.3	89.3	89.3	89.3	89.3
Lower extremity, fracture	83.4	83.4	83.4	83.4	83.3	83.2	83.2	83.2	83.2	83.2
Lower extremity, other injury	34.9	34.6	34.3	34.2	34.1	34.1	33.9	33.9	33.4	33.3
Superficial injury, open wounds	51.6	51.6	51.6	51.6	51.5	51.5	51.5	51.5	51.5	51.4
Burns	-	-	-	-	-	-	-	-	-	-
Poisonings	98.5	98.5	98.5	98.5	98.5	98.5	98.5	98.5	98.5	98.5
Other injury	32.5	32.5	32.5	32.4	32.5	32.5	32.5	32.5	32.6	32.6

	Number of days between ED to inpatient cases									
Meerding group	**51**	**52**	**53**	**54**	**55**	**56**	**57**	**58**	**59**	**60**
Skull-brain injury	77.4	77.4	77.4	77.4	77.4	77.4	77.4	77.4	77.4	77.4
Facial fracture, eye injury	93.3	93.3	93.3	93.3	93.3	93.3	93.3	93.3	93.3	93.3
Spine, vertebrae	55.1	55.1	55.1	55.1	54.6	54.4	54.4	54.4	54.4	54.4
Internal organ injury	-	-	-	-	-	-	-	-	-	-
Upper extremity fracture	83.4	83.4	83.4	83.4	83.4	83.4	83.3	83.3	83.3	83.3
Upper extremity, other injury	51.2	51.3	51.3	51.2	51.2	51.2	51.0	51.0	50.9	50.9
Hip fracture	89.3	89.3	89.4	89.4	89.4	89.4	89.4	89.4	89.4	89.4
Lower extremity, fracture	83.1	83.1	83.1	83.0	83.0	83.0	83.0	83.0	83.0	83.0
Lower	33.3	33.3	33.2	33.4	33.6	33.4	33.2	33.2	33.1	33.2

	Number of days between ED to inpatient cases									
Meerding group	**51**	**52**	**53**	**54**	**55**	**56**	**57**	**58**	**59**	**60**
extremity, other injury										
Superficial injury, open wounds	51.4	51.4	51.3	51.3	51.3	51.2	51.2	51.2	51.1	51.1
Burns	-	-	-	-	-	-	-	-	-	-
Poisonings	98.5	98.5	98.5	98.5	98.5	98.5	98.5	98.4	98.4	98.4
Other injury	32.6	32.5	32.5	32.5	32.5	32.5	32.5	32.5	32.5	32.4

	Number of days between ED to inpatient cases									
Meerding group	**61**	**62**	**63**	**64**	**65**	**66**	**67**	**68**	**69**	**70**
Skull-brain injury	77.4	77.4	77.4	77.4	77.4	77.4	77.4	77.4	77.4	77.4
Facial fracture, eye injury	93.3	93.3	93.3	93.3	93.3	93.3	93.3	93.3	93.3	93.3
Spine, vertebrae	54.4	54.2	54.0	54.0	53.8	53.6	53.6	53.6	53.5	53.3
Internal organ injury	-	-	-	-	-	-	-	-	-	-
Upper extremity fracture	83.3	83.3	83.2	83.2	83.2	83.2	83.2	83.2	83.1	83.1
Upper extremity, other injury	50.9	50.6	50.6	50.6	50.6	50.6	50.6	50.6	50.7	50.6
Hip fracture	89.4	89.4	89.4	89.4	89.4	89.4	89.4	89.4	89.4	89.4
Lower extremity, fracture	82.9	82.9	82.9	82.9	82.9	82.9	82.9	82.9	82.9	82.9
Lower extremity, other injury	33.0	32.9	32.9	32.8	32.8	32.8	32.8	32.6	32.6	32.6
Superficial injury, open wounds	51.1	51.1	51.0	51.0	51.0	51.0	51.0	50.9	50.9	50.9
Burns	-	-	-	-	-	-	-	-	-	-
Poisonings	98.4	98.4	98.4	98.4	98.4	98.4	98.4	98.4	98.4	98.4
Other injury	32.4	32.3	32.3	32.3	32.3	32.3	32.3	32.3	32.3	32.3

	Number of days between ED to inpatient cases									
Meerding group	**71**	**72**	**73**	**74**	**75**	**76**	**77**	**78**	**79**	**80**

	Number of days between ED to inpatient cases									
Meerding group	**71**	**72**	**73**	**74**	**75**	**76**	**77**	**78**	**79**	**80**
Skull-brain injury	77.4	77.4	77.4	77.4	77.4	77.4	77.4	77.4	77.4	77.4
Facial fracture, eye injury	93.3	93.3	93.3	93.3	93.3	93.3	93.3	93.3	93.3	93.3
Spine, vertebrae	53.3	53.1	53.1	53.1	52.5	52.3	52.3	52.5	52.5	52.5
Internal organ injury	-	-	-	-	-	-	-	-	-	-
Upper extremity fracture	83.1	83.1	83.1	83.1	83.1	83.1	83.0	83.0	83.0	83.0
Upper extremity, other injury	50.4	50.3	50.1	50.1	50.0	50.0	49.7	49.7	49.7	49.7
Hip fracture	89.4	89.4	89.4	89.4	89.4	89.4	89.4	89.4	89.4	89.4
Lower extremity, fracture	82.9	82.9	82.9	82.9	82.9	82.9	82.9	82.8	82.8	82.8
Lower extremity, other injury	32.6	32.4	32.3	32.3	32.2	32.0	31.9	31.7	31.7	31.6
Superficial injury, open wounds	50.8	50.8	50.8	50.8	50.8	50.8	50.8	50.8	50.7	50.7
Burns	-	-	-	-	-	-	-	-	-	-
Poisonings	98.4	98.4	98.4	98.3	98.3	98.2	98.2	98.1	98.1	98.1
Other injury	32.3	32.3	32.2	32.2	32.2	32.1	32.1	32.1	32.0	32.0

	Number of days between ED to inpatient cases									
Meerding group	**81**	**82**	**83**	**84**	**85**	**86**	**87**	**88**	**89**	**90**
Skull-brain injury	77.4	77.4	77.4	77.4	77.4	77.4	77.4	77.4	77.4	77.4
Facial fracture, eye injury	93.3	93.3	93.3	93.1	93.1	93.1	93.1	93.1	93.1	93.1
Spine, vertebrae	52.5	52.5	52.5	52.5	52.5	52.5	52.3	52.3	52.3	51.9
Internal organ injury	-	-	-	-	-	-	-	-	-	-
Upper extremity fracture	83.0	83.0	83.0	83.0	83.0	83.0	83.0	82.9	82.9	82.9
Upper extremity, other injury	49.7	49.7	49.6	49.4	49.4	49.2	49.2	49.0	48.9	48.8
Hip fracture	89.4	89.4	89.4	89.4	89.4	89.4	89.4	89.4	89.4	89.4

	Number of days between ED to inpatient cases									
Meerding group	**81**	**82**	**83**	**84**	**85**	**86**	**87**	**88**	**89**	**90**
Lower extremity, fracture	82.8	82.8	82.8	82.8	82.8	82.8	82.8	82.8	82.7	82.7
Lower extremity, other injury	31.6	31.6	31.4	31.3	31.1	30.7	30.6	30.5	30.6	30.8
Superficial injury, open wounds	50.7	50.7	50.7	50.7	50.6	50.6	50.5	50.5	50.5	50.4
Burns	-	-	-	-	-	-	-	-	-	-
Poisonings	97.9	97.9	97.9	97.9	97.9	97.9	97.9	97.9	97.9	97.9
Other injury	32.0	32.0	32.0	32.0	31.9	31.9	31.9	31.9	31.9	31.9

Table A6.4: Cumulative percentage of 'inpatient admission to ED attendance' cases matched on Meerding group (up to 90 day gap between initial inpatient admission and subsequent ED attendance)

	Number of days between inpatient to ED cases									
Meerding group	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Skull-brain injury	50.0	50.0	25.0	25.0	25.0	20.0	14.3	14.3	14.3	14.3
Facial fracture, eye injury	42.9	42.9	42.9	42.9	42.9	42.9	42.9	42.9	42.9	42.9
Spine, vertebrae	0.0	0.0	0.0	33.3	33.3	33.3	33.3	25.0	25.0	40.0
Internal organ injury	-	-	-	-	-	-	-	-	-	-
Upper extremity fracture	95.0	96.3	96.6	97.1	97.4	97.6	95.7	93.6	93.8	91.8
Upper extremity, other injury	0.0	33.3	33.3	33.3	25.0	16.7	14.3	25.0	25.0	25.0
Hip fracture	68.8	68.8	68.8	68.8	68.8	70.6	70.6	70.6	70.6	70.6
Lower extremity, fracture	76.9	80.0	75.0	78.9	81.0	81.0	81.8	83.3	84.6	84.6
Lower extremity, other injury	25.0	20.0	33.3	33.3	28.6	28.6	37.5	37.5	37.5	37.5
Superficial	55.6	57.9	59.1	58.3	58.3	56.0	57.1	58.6	60.0	58.1

	Number of days between inpatient to ED cases									
Meerding group	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
injury, open wounds										
Burns	-	-	-	-	-	-	-	-	-	-
Poisonings	100.0	100.0	90.9	83.3	73.3	66.7	68.4	70.0	70.0	70.0
Other injury	41.7	46.7	41.2	42.1	38.1	36.4	36.4	32.0	34.6	34.6

	Number of days between inpatient to ED cases									
Meerding group	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Skull-brain injury	14.3	14.3	14.3	14.3	12.5	12.5	12.5	12.5	12.5	11.1
Facial fracture, eye injury	50.0	50.0	50.0	50.0	50.0	55.6	55.6	50.0	50.0	50.0
Spine, vertebrae	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0
Internal organ injury	-	-	-	-	-	-	-	-	-	-
Upper extremity fracture	92.0	92.0	92.3	92.3	92.3	92.3	92.5	92.6	92.6	92.6
Upper extremity, other injury	25.0	22.2	22.2	22.2	30.0	30.0	30.0	30.0	30.0	30.0
Hip fracture	70.6	70.6	70.6	70.6	70.6	66.7	66.7	66.7	66.7	66.7
Lower extremity, fracture	85.2	85.7	86.2	86.2	86.2	86.2	87.1	87.1	87.1	87.1
Lower extremity, other injury	37.5	37.5	44.4	44.4	44.4	44.4	44.4	44.4	44.4	44.4
Superficial injury, open wounds	59.4	59.4	58.8	58.8	58.8	55.3	55.3	55.3	56.4	56.4
Burns	-	-	-	-	-	-	-	-	-	-
Poisonings	72.7	69.6	65.4	60.7	60.7	58.6	58.1	57.6	57.6	55.9
Other injury	34.6	34.6	34.6	34.6	34.6	34.6	34.6	32.1	30.0	29.0

	Number of days between inpatient to ED cases									
Meerding group	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**
Skull-brain injury	11.1	11.1	10.0	9.1	8.3	8.3	8.3	8.3	7.7	7.7
Facial	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	45.5

	Number of days between inpatient to ED cases									
Meerding group	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**
fracture, eye injury										
Spine, vertebrae	40.0	40.0	40.0	40.0	40.0	33.3	33.3	33.3	33.3	33.3
Internal organ injury	-	-	-	-	-	-	-	-	-	-
Upper extremity fracture	92.9	92.9	92.9	92.9	93.0	93.0	93.0	91.4	91.4	91.5
Upper extremity, other injury	30.0	30.0	30.0	30.0	30.0	30.0	30.0	25.0	25.0	25.0
Hip fracture	66.7	66.7	66.7	63.2	60.0	60.0	60.0	60.0	60.0	60.0
Lower extremity, fracture	84.4	81.8	79.4	79.4	80.0	80.0	80.6	80.6	80.6	80.6
Lower extremity, other injury	44.4	44.4	44.4	44.4	40.0	40.0	40.0	40.0	40.0	40.0
Superficial injury, open wounds	55.0	53.7	54.8	54.8	54.8	53.5	54.5	54.3	54.3	53.2
Burns	-	-	-	-	-	-	-	-	-	-
Poisonings	55.9	54.3	52.6	52.6	51.3	51.3	50.0	50.0	48.8	48.8
Other injury	31.3	31.3	31.3	30.3	30.3	30.3	30.3	29.4	29.4	29.4

	Number of days between inpatient to ED cases									
Meerding group	**31**	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**
Skull-brain injury	7.7	7.7	7.7	7.7	7.7	7.1	7.1	7.1	7.1	7.1
Facial fracture, eye injury	45.5	45.5	45.5	45.5	45.5	45.5	45.5	45.5	45.5	45.5
Spine, vertebrae	33.3	33.3	33.3	33.3	33.3	33.3	33.3	33.3	33.3	33.3
Internal organ injury	-	-	-	-	-	-	-	-	-	-
Upper extremity fracture	91.5	90.2	90.2	90.2	90.2	90.2	90.2	90.2	90.2	90.2
Upper extremity, other injury	25.0	25.0	25.0	23.1	23.1	23.1	23.1	28.6	28.6	28.6
Hip fracture	60.0	60.0	57.1	57.1	57.1	54.5	54.5	54.5	54.5	54.5
Lower extremity, fracture	80.6	80.6	80.6	80.6	80.6	78.4	78.4	78.4	78.4	78.4

	Number of days between inpatient to ED cases									
Meerding group	**31**	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**
Lower extremity, other injury	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0
Superficial injury, open wounds	52.1	51.0	50.0	49.0	48.1	48.1	48.1	47.2	47.2	47.2
Burns	-	-	-	-	-	-	-	-	-	-
Poisonings	48.8	48.8	48.8	48.8	47.7	46.7	45.7	42.0	41.2	40.4
Other injury	29.4	29.4	29.4	29.4	31.4	33.3	33.3	33.3	33.3	33.3

	Number of days between inpatient to ED cases									
Meerding group	**41**	**42**	**43**	**44**	**45**	**46**	**47**	**48**	**49**	**50**
Skull-brain injury	7.1	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7
Facial fracture, eye injury	41.7	41.7	41.7	38.5	38.5	35.7	33.3	33.3	33.3	33.3
Spine, vertebrae	33.3	33.3	33.3	33.3	33.3	33.3	33.3	33.3	33.3	33.3
Internal organ injury	-	-	-	-	-	-	-	-	-	-
Upper extremity fracture	88.7	88.7	88.9	87.5	87.5	86.2	84.8	85.1	83.8	83.8
Upper extremity, other injury	28.6	28.6	28.6	28.6	28.6	28.6	28.6	28.6	31.3	31.3
Hip fracture	54.5	54.5	54.5	54.5	54.5	54.5	54.5	54.5	56.5	56.5
Lower extremity, fracture	78.4	78.4	74.4	74.4	74.4	74.4	74.4	74.4	74.4	72.5
Lower extremity, other injury	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0
Superficial injury, open wounds	48.1	48.1	47.3	47.3	48.2	48.3	48.3	48.3	48.3	48.3
Burns	-	-	-	-	-	-	-	-	-	-
Poisonings	40.7	40.7	40.7	40.7	40.0	40.0	39.3	39.3	39.3	37.3
Other injury	33.3	33.3	33.3	32.4	32.4	33.3	33.3	32.5	34.1	34.1

	Number of days between inpatient to ED cases									
Meerding group	**51**	**52**	**53**	**54**	**55**	**56**	**57**	**58**	**59**	**60**
Skull-brain injury	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7
Facial fracture, eye injury	33.3	33.3	33.3	33.3	33.3	33.3	33.3	33.3	33.3	33.3
Spine, vertebrae	33.3	33.3	33.3	33.3	33.3	33.3	28.6	28.6	28.6	28.6
Internal organ injury	-	-	-	-	-	-	-	-	-	-
Upper extremity fracture	83.8	83.8	83.8	83.8	83.8	83.8	83.8	83.8	83.8	83.8
Upper extremity, other injury	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4
Hip fracture	56.5	56.5	56.5	56.5	56.5	56.5	56.0	56.0	56.0	56.0
Lower extremity, fracture	73.2	73.2	73.2	69.8	69.8	69.8	69.8	69.8	66.7	66.7
Lower extremity, other injury	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0
Superficial injury, open wounds	47.5	50.0	50.0	49.2	49.2	50.8	51.5	51.5	51.5	50.7
Burns	-	-	-	-	-	-	-	-	-	-
Poisonings	37.3	37.7	38.7	38.7	40.0	39.4	39.7	39.1	38.6	38.0
Other injury	32.6	32.6	32.6	32.6	32.6	31.8	31.1	31.1	30.4	29.8

	Number of days between inpatient to ED cases									
Meerding group	**61**	**62**	**63**	**64**	**65**	**66**	**67**	**68**	**69**	**70**
Skull-brain injury	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7
Facial fracture, eye injury	33.3	31.3	31.3	31.3	29.4	29.4	29.4	27.8	27.8	27.8
Spine, vertebrae	28.6	28.6	25.0	25.0	25.0	25.0	25.0	25.0	25.0	22.2
Internal organ injury	-	-	-	-	-	-	-	-	-	-
Upper extremity fracture	84.1	84.1	84.1	82.9	82.9	81.9	81.9	81.9	80.8	80.8
Upper extremity, other injury	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4

	Number of days between inpatient to ED cases									
Meerding group	**61**	**62**	**63**	**64**	**65**	**66**	**67**	**68**	**69**	**70**
Hip fracture	56.0	56.0	56.0	56.0	56.0	56.0	56.0	56.0	56.0	56.0
Lower extremity, fracture	66.7	66.7	66.7	66.7	66.7	67.4	67.4	67.4	67.4	67.4
Lower extremity, other injury	40.0	40.0	40.0	40.0	40.0	40.0	36.4	36.4	36.4	36.4
Superficial injury, open wounds	50.7	50.7	51.5	51.5	51.5	51.5	51.5	50.7	50.7	50.7
Burns	-	-	-	-	-	-	-	-	-	-
Poisonings	38.4	37.3	37.3	37.3	37.3	37.3	37.3	36.8	35.9	35.4
Other injury	29.8	29.8	29.2	29.2	29.2	28.0	28.0	28.0	28.0	27.5

	Number of days between inpatient to ED cases									
Meerding group	**71**	**72**	**73**	**74**	**75**	**76**	**77**	**78**	**79**	**80**
Skull-brain injury	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7
Facial fracture, eye injury	26.3	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0
Spine, vertebrae	22.2	22.2	22.2	22.2	22.2	22.2	22.2	22.2	22.2	22.2
Internal organ injury	-	-	-	-	-	-	-	-	-	-
Upper extremity fracture	80.8	80.8	81.1	81.1	80.0	80.0	78.9	78.9	78.9	77.9
Upper extremity, other injury	29.4	33.3	33.3	33.3	33.3	33.3	33.3	33.3	33.3	31.6
Hip fracture	56.0	56.0	56.0	56.0	53.8	53.8	53.8	51.9	51.9	51.9
Lower extremity, fracture	67.4	67.4	64.6	64.6	64.6	64.6	64.6	64.6	64.6	64.6
Lower extremity, other injury	33.3	33.3	33.3	33.3	33.3	33.3	33.3	33.3	33.3	33.3
Superficial injury, open wounds	50.7	50.7	50.0	50.0	49.3	47.9	47.9	47.9	47.9	48.0
Burns	-	-	-	-	-	-	-	-	-	-
Poisonings	35.0	35.0	34.6	34.1	34.1	33.3	33.3	33.3	33.3	34.1
Other injury	27.5	27.5	27.5	27.5	27.5	26.9	26.9	26.9	28.3	28.3

	Number of days between inpatient to ED cases									
Meerding group	**81**	**82**	**83**	**84**	**85**	**86**	**87**	**88**	**89**	**90**
Skull-brain injury	6.7	6.7	6.3	6.3	6.3	5.9	5.9	5.6	5.6	5.6
Facial fracture, eye injury	25.0	25.0	25.0	25.0	25.0	23.8	23.8	23.8	23.8	23.8
Spine, vertebrae	22.2	22.2	22.2	22.2	22.2	22.2	22.2	22.2	22.2	22.2
Internal organ injury	-	-	-	-	-	-	-	-	-	-
Upper extremity fracture	75.9	75.9	75.9	75.9	75.9	75.9	75.9	75.9	75.9	75.9
Upper extremity, other injury	30.0	30.0	30.0	30.0	30.0	30.0	30.0	28.6	28.6	28.6
Hip fracture	51.9	51.9	51.9	51.9	51.9	51.9	53.6	53.6	55.2	55.2
Lower extremity, fracture	64.6	64.6	65.3	65.3	65.3	65.3	65.3	65.3	65.3	65.3
Lower extremity, other injury	33.3	33.3	33.3	33.3	33.3	33.3	33.3	33.3	33.3	33.3
Superficial injury, open wounds	48.0	47.4	47.4	46.8	46.3	45.7	45.1	45.1	46.4	47.1
Burns	-	-	-	-	-	-	-	-	-	-
Poisonings	34.1	34.1	33.7	33.0	32.6	32.6	32.3	32.3	32.3	32.0
Other injury	28.3	27.8	27.8	26.8	26.8	26.3	25.4	25.4	25.4	25.4