National Clinical Guideline Centre

.

Head Injury

Triage, assessment, investigation and early management of head injury in children, young people and adults

CG 176 (Partial update of NICE CG56)

Methods, evidence and recommendations

January 2014

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Contents

Explaining the changes in the partial update

This guidance partially updates and replaces NICE clinical guideline CG56, Head Injury; Triage, assessment, investigation and early management of head injury in infants, children and adults (published September 2007).

Recommendations are marked to indicate the year of the last evidence review: [2003] or [2007] if the evidence has not been updated since the original guideline, [2003, amended 2014] or [2007, amended 2014] if the evidence has not been updated since the original guideline, but changes have been made that alter the meaning of the recommendation, [2014] if the evidence has been reviewed but no change has been made to the recommendation and [new 2014] if the evidence has been reviewed and the recommendation has been added or updated.

New and updated evidence reviews and recommendations are shaded pink with 'Update 2014' in the right hand margin.

Appendix O contains recommendations from the 2007 guideline that have been consulted on for deletion from this 2014 update. Details of any replacement recommendations are included. The original NICE guideline and supporting documents are available from www.nice.org.uk/guidance/CG56

Guideline development group and project team

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Acknowledgements (2007)

The development of this guideline was greatly assisted by the following people: Dr Jennifer Hill; Linda Brittain; Kelly Dickinson; Nishanthi Talawila; Caroline Lawson, Ms Lisa Turan (Child Brain Injury trust); Matt Stevenson.

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The development of this guideline was greatly assisted by the following people: Professor Nick Black (Consultant on consensus methods), Dr Jacqueline Dutchak, Judith Hayes, Saadia John, Dr Gillian Leng, Laura Price, Christine Sealey, Professor Sir Graham Teasdale, Dr Barry Wall, Sally Williams, Jennifer Wood.

1 Background and scope

1.1 Introduction (2014)

For the purposes of this guideline, head injury is defined as any trauma to the head other than superficial injuries to the face. Head injury is the commonest cause of death and disability in people aged 1–40 years in the UK. Data for head injury are recorded in the Hospital Episode Statistics (http://www.hscic.gov.uk/hes). Each year, 1.4 million people attend emergency departments in England and Wales with a recent head injury. Between 33% and 50% of these are children aged under 15 years. Annually, about 200,000 people are admitted to hospital with head injury. Of these, one-fifth have features suggesting skull fracture or have evidence of brain damage. Most patients recover without specific or specialist intervention, but others experience long-term disability or even die from the effects of complications that could potentially be minimised or avoided with early detection and appropriate treatment.

The incidence of death from head injury is low, with as few as 0.2% of all patients attending emergency departments with a head injury dying as a result of this injury. Ninety five per cent of people who have sustained a head injury present with a normal or minimally impaired conscious level (Glasgow Coma Scale [GCS] greater than 12) but the majority of fatal outcomes are in the moderate (GCS 9–12) or severe (GCS 8 or less) head injury groups, which account for only 5% of attenders. Therefore, emergency departments see a large number of patients with minor or mild head injuries and need to identify the very small number who will go on to have serious acute intracranial complications. It is estimated that 25–30% of children aged under 2 years who are hospitalised with head injury have an abusive head injury. This guideline has updated some of the terminology used in relation to safeguarding children and vulnerable adults.[145]

Update 2014

1.1.1 Rationale for the update

The previous head injury guideline produced by NICE in 2003 (NICE clinical guideline 4) and updated in 2007 (NICE clinical guideline 56) resulted in CT scanning replacing skull radiography as the primary imaging modality for assessing head injury. It also led to an increase in the proportion of people with severe head injury having their care managed in specialist centres. This has been associated with a decline in fatality among patients with severe head injury. This update is needed because of the continuing importance of up-to-date evidence-based guidance on the initial assessment and early management of head injury. Appropriate guidance can enable early detection and treatment of life-threatening brain injury, where present, but also early discharge of patients with negligible risk of brain injury. It can therefore save lives while at the same time preventing needless crowding in emergency departments and observation wards.

Further key NHS changes have driven the scope of this update. These include the introduction in 2012 of regional trauma networks with major trauma triage tools within NHS England; the extension of indications for anticoagulation therapy; the expanding use of biomarkers to guide emergent clinical management in other conditions, such as chest pain; and the establishment of local safeguarding boards. The last of these addresses the requirement for front-line clinical staff to assess not only the severity of the head injury but also why it occurred.

This update addresses these areas, including in particular:

- indications for transporting patients with a head injury from the scene of injury directly to the nearest neuroscience centre, bypassing the nearest emergency department

- indications for and timing of CT head scans in the emergency department, with particular reference to anticoagulant therapy and levels of circulating brain injury biomarkers
- the relative cost effectiveness of different strategies for initial imaging of the cervical spine
- information that should be provided to patients, family members and carers on discharge from the emergency department or observation ward.

Within this guideline children are defined as patients less than 16, and infants less than one year of age at the time of presentation to hospital with head injury. The guideline also makes a number of recommendations in relation to concerns regarding safeguarding and the incidence of non-accidental injury. See the NICE guideline on child maltreatment for clinical features that may be associated with maltreatment: 'When to suspect child maltreatment'. NICE clinical guideline 89 (2009).[179]

Update 2014

This guideline recommends some drugs for indications for which they do not have a UK marketing authorisation at the date of publication, if there is good evidence to support that use. The prescriber should follow relevant professional guidance, taking full responsibility for the decision. The patient (or those with authority to give consent on their behalf) should provide informed consent, which should be documented. See the General Medical Council's Good practice in prescribing and managing medicines and devices for further information.[95] Where recommendations have been made for the use of drugs outside their licensed indications ('off-label use'), these drugs are marked with a footnote in the recommendations.

1.2 Introduction (2007)

This guideline was first published in June 2003. The present guideline is a partial update of only some areas where new evidence has been published since the publication of the original guideline (see CG4 website http://guidance.nice.org.uk/CG4). This guideline incorporates both the original and the updated sections. All updated sections of the guideline are not shaded in grey to allow easy identification by the reader. All shaded sections have not been updated and is the original guideline.

Hospital Episode Statistics data for the 2000/2001 annual dataset indicate that there were 112,978 admissions to hospitals in England with a primary diagnosis of head injury (ICD10 codes S00-S09). Seventy-two per cent of these were male admissions and 30% were children under 15 years of age.[60,61] Extrapolating on the basis of relative population size gives an estimate of a further 6,700 head injury admissions in Wales. There are no reliable up to date figures for the total denominator of attenders with a head injury at emergency departments. A figure of one million emergency department attenders for the United Kingdom as a whole is often quoted but this is based on figures from the late 1970s.[134] It is estimated that head injury admissions represent around 20% of all head injury attenders,[141] which would imply around 600,000 patients per annum attending emergency departments in England and Wales with a head injury. The true emergency department attendance rate may be closer to 700,000 patients however, as it is likely that the proportion of patients with head injury admitted to hospital has fallen below 20% in recent years. The poor quality of information regarding head injury attenders should improve as the use of a common emergency department dataset increases.

1.3 Introduction (2003)

The number of patients who undergo neurosurgery each year following a head injury is also unclear. A figure of around 4,000 patients per year for the UK as a whole has been quoted[248] but this may be slightly higher than is the case. Hospital Episode Statistics data for the 2000/2001 annual dataset indicate that 398 patients in England underwent an operation to drain the extradural space (OPCS code A40) and 2,048 patients underwent an operation to drain the subdural space (OPCS code

A41).[263] These figures do not include a small number of other neurosurgical procedures possible after head injury, and include some patients with a non-head injury diagnosis. Thus, the routine data available does not allow for a precise estimate of neurosurgical volume after head injury for England and Wales, but points to a figure in the low thousands.

Although the incidence of head injury is high, the incidence of death from head injury is low (6-10 per 100,000 population per annum).[141] As few as 0.2% of all patients attending emergency departments with a head injury will die as a result of this injury.[136,263] Ninety per cent of all people who have sustained a head injury will present with a minor or mild injury (Glasgow Coma Scale [GCS] greater than 12) but the majority of fatal outcomes will be in the moderate (GCS of 9 to 12) or severe (GCS less than or equal to 8) head injury groups which account for only 10% of attenders.[264] Therefore emergency departments are required to see a large number of patients with a minor/mild head injury, and identify the very small number of these that will go on to have serious acute intracranial complications.

1.3.1 UK Guidelines

The first UK-wide guidelines on identifying patients who were at high risk of intracranial complications following a head injury were drawn up by a Working Party of Neurosurgeons in 1984.[35] They were used in the UK for over 15 years and relied on various clinical factors, particularly the level of consciousness, to place patients with a head injury into different risk categories. The main investigation incorporated into these guidelines was skull radiography, reflecting the importance of skull fracture as a risk factor for intracranial complications. Modifications to this guideline have since been published by the Society of British Neurological Surgeons in 1998, the Royal College of Surgeons of England in 1999 and by the Scottish Intercollegiate Guidelines Network in 2000.[16,224,231] The assessment and imaging of patients who have sustained a head injury is also addressed by guidelines from the Royal College of Radiologists.[221]

The recent recommendations of the Scottish Intercollegiate Guidelines Network centre around the identification of patients with a high (for example, over 10%) risk of intracranial complications using the GCS, the presence of a skull fracture and various other clinical variables. These high-risk patients are recommended for computed tomography (CT) scanning. Admission for observation was considered a tool for patients with a 'medium-risk' of intracranial complications[231] but the value of this in terms of sensitivity and specificity in the detection of haematomas was not determined.

1.3.2 Role of CT imaging

An enhanced role for CT imaging after head injury was advocated by Neurosurgeons in 1990[269] and 1998[16], the 1999 guidelines from the Royal College of Surgeons of England and the 2000 guidelines from the Scottish Intercollegiate Guidelines Network. These statements recommended a more liberal CT scanning policy, while still adhering to the skull X-ray as the first line investigation in the majority of minor/mild head injuries.

This change in emphasis is reflected in an observed increase in CT scanning in the UK. Between 2002 and 2004 the number of CT brain scans requested in UK hospitals has more than doubled.[116] This move to CT reflects a general consensus that earlier definitive imaging is associated with improved outcomes.[171,269]

1.3.3 North American guidelines

Prior to the first edition of the NICE head injury guidelines, the UK used level of consciousness and skull X-ray as primary assessment tools, coupled with observation for patients with 'medium-risk' and CT for the highest risk groups. This translates to a CT scan rate of about 32% of all patients attending the emergency department with a head injury.[65,117,161,188] In contrast, rates of CT scanning in the USA

at this time were between 75% to 100% of all patients with normal GCS and some previous loss of consciousness following a head injury.[159]

In the UK, controversy over guidelines for head injury focuses on whether increased CT scanning is feasible or advisable, but in the USA the discussion is exactly the reverse. Research in the USA is directed towards attempts to reduce the very large numbers of CT scans being performed.[123,216,258]

1.3.4 The skull radiograph

Historically, in the absence of readily available CT scanning resources, skull X-ray was used to categorise patients with minor/mild head injuries into high and low risk groups. Previously in the UK up to 74% of all patients attending emergency departments with a head injury received a skull X-ray. Although only about 2% of these X-rays will show a fracture.[58,98]

An elevation of risk following positive skull X-ray is widely acknowledged and supported by UK evidence.[171] A recent meta-analysis of thirteen studies where at least 50% of the sample underwent CT was performed. The meta-analysis contained almost 13,000 patients who had recently sustained a head injury. A weighted mean prevalence of intracranial haemorrhage of 0.083 (95% CI: 0.03-0.13) was observed. The meta-analysis found that the sensitivity and specificity of a skull X-ray for predicting the presence of intracranial haemorrhage were 38% and 95% respectively.[123] The equivalent predictive values were 0.41 (positive predictive value) and 0.94 (negative predictive value). These figures imply that if there is a skull fracture diagnosed on radiography, the risk of an intracranial haemorrhage is elevated (about 4.9 times higher than before testing) but one cannot rule out an intracranial haemorrhage in patients for whom a skull X-ray does not show a skull fracture.

One reason for the low sensitivity of skull X-ray in predicting an intracranial haemorrhage is the reliability of radiographic interpretation. It has been consistently shown that clinically competent emergency department clinicians will miss between 13% and 23% of all skull fractures that are detected when radiographs are subsequently reviewed by a radiologist.[98,161,270]

As CT scanning has both sensitivities and specificities approaching 100% for detecting and locating a surgically significant focal intracranial lesion, it has been established as the definitive diagnostic investigation in patients who have sustained a head injury. The relatively low ordering rate for CT in the UK has historically been a function of availability. However, there has been a substantial investment in CT scanners in England and Wales over the last decade, increasing the capacity of modern scanners within the NHS considerably. In addition, CT technology has advanced considerably in recent years (for example, multisection helical CT), reducing the duration of an examination, improving the imaging output and reducing radiation exposure. The new scanners have greatly reduced the need for general anaesthesia and reduced the sedation rate in infants and patients rendered combative by their injuries.[139,204] Nevertheless, anaesthesia and ventilation may still be necessary in restless patients and young children.

1.3.5 Admission

Acute head injury admissions account for 320,900 bed days in hospitals in England (plus a further 19,000 in Wales by population extrapolation) representing 0.64% of all NHS bed days. [60,61]This represents a significant resource burden on the NHS. However only 1-3% of admitted patients actually go on to develop life-threatening intracranial pathology, with the remainder going home within 48 hours, having had no intervention other than observation.[136,161,263]

Also of concern is the quality of the observation that patients receive while in hospital. In a recent retrospective survey of 200,000 children in the North-East of England, only 14 children who presented with a minor head injury required neurosurgery. However, the recognition of secondary deterioration was delayed in all 14 patients, with documented routine neurological observations in

only one child. Diagnosis of an intracranial haematoma was made between 6 hours and 14 days after the head injury, with a median delay of 18 hours .[207]

This is not a problem unique to the UK, in the USA it has been found that only 50% of patients admitted with a minor head injury had documentation of neurological observations and for the majority of these, the frequency of observations was not sufficient to detect early neurological deterioration.[160] In the UK, patients with head injury have historically been observed on non-specialist wards by nurses and doctors not experienced in neurological observation. In 1999 The Royal College of Surgeons of England surveyed General Surgeons in the UK and found that although 56% of Consultants observed patients with head injury on their wards, only 48% had any neurological experience and 34% were dissatisfied with this referral process. The Royal College advised that patients with head injury should not be observed in non-specialist wards,[224] but it is unclear whether this has resulted in an increased proportion of patients with head injury being observed in appropriately staffed wards.

1.3.6 Morbidity

The incidence of morbidity after head injury is higher than had been previously appreciated[271] and far exceeds the capacity of UK neurorehabilitation services. In a study of head injury admissions in 1995/96 in Glasgow, 47% of patients followed up for one year after discharge had survived with some form of restriction to lifestyle. Surprisingly, the proportion of patients experiencing the most serious sequelae (that is, moderate or severe), did not vary according to the severity of the initial injury. The study found that 47% of patients admitted with apparently minor/mild head injuries experienced significant sequelae on follow-up, compared to 45% of patients admitted for moderate head injury, and 48% of patients admitted for severe head injury. Only 47% of survivors with sequelae were seen in hospital after discharge and only 28% received some input from rehabilitation services. A second large UK study examined the outcome of patients attending a minor head injury clinic.[105] They saw 639 patients who had originally presented with a minor head injury. Fifty-six per cent were not back to work at 2 weeks, and 12% had not returned to work at 6 weeks. In addition at 6 weeks many had persisting symptoms including headache (13%), memory loss (15%) and concentration problems (14%). These data have been reproduced in other countries.[157,213]

1.3.7 Cause of injury

In the UK 70-88% of all people that sustain a head injury are male, 10-19% are aged greater than or equal to 65 years and 40-50% are children. Falls (22-43%) and assaults (30-50%) are the most common cause of a minor head injury in the UK, followed by road traffic accidents (~25%). Alcohol may be involved in up to 65% of adult head injuries. Of note, road traffic accidents account for a far greater proportion of moderate to severe head injuries. Also there are marked regional variations, especially in assaults and the involvement of alcohol, but the incidence of penetrating head trauma remains low. The incidence of death due to head injury in the UK is 6-10 per 100,000 per annum.[60,61,134,141,263]

In the USA 65-75% of people that sustain a head injury are male. The USA has a higher rate of road traffic accidents (~50%) and a lower rate of falls (20%-30%) than the UK, reflecting the difference in car usage in the two countries. Assaults account for around 20% of injuries although again there are regional differences. Alcohol is associated with around 50% of all adult head injuries: the alcohol may have been consumed by either the injured person or the person causing the incident. Firearm trauma to the head surpassed motor vehicles as the single largest cause of death from traumatic head injury in 1990 in the USA. However, gunshot trauma to the head is not a common cause for attendance to hospital. This is largely due to the fact that 90% of gunshot wounds to the head are fatal and that two-thirds of people injured in this way will not reach hospital. The prevalence of death due to any traumatic head injury is 20 per 100,000 in the USA, which is double the rate in the UK. Firearm-related deaths accounts for 8 per 100,000 of these deaths.[1,117,140,144,159,178]

Comparisons with a Canadian population are important at this stage because of the importance of Canadian evidence to these guidelines. A large Canadian study on people with GCS greater than 12 following a head injury found that 31% of these people had sustained falls (comparable with UK estimates) and 43% had been in some form of road traffic accidents (higher than the estimate of 25% for the UK). Assaults, by contrast, accounted for only 11% of the Canadian sample, compared to estimates of 30-50% for the UK. The proportion of males in this study was similar to that observed in the UK (69%).[258] The Guideline Development Group is of the opinion that a head injury episode is more likely to have alcohol involvement in the UK than in Canada.

1.3.8 Summary of current care in the UK

For 15 years, the UK followed guidelines for minor/mild head injuries based on consciousness level, with skull X-ray as the primary investigation, and admission for observation of most patients considered to be at risk for intracranial complications. CT scanning was generally reserved for patients with moderate or severe head injuries (GCS less than 13). CT scanning of patients who have sustained a head injury has gradually increased in recent years, since the first edition of the NICE guidelines for head injury. However, there are still differences between the protocols being used in North America and the UK.

Only 1-3% of patients with head injury who are admitted to hospital in the UK for observation will go on to require neurosurgery, with the remainder being discharged. Even a small reduction in the proportion of patients requiring admission would have a substantial beneficial impact on hospital resources.

There is evidence that outcomes for severely injured patients in England and Wales, as measured by severity adjusted odds of death, improved steadily up to the mid-1990s, but have not improved since. There is also indirect evidence that trauma care for patients with severe head injury in England and Wales is delivering a lower proportion of expected survivors when compared to trauma care in the United States, although these data are confounded by case mix issues, especially the older age profile of patients with head injury in England and Wales.[152] A sub-group analysis performed by the authors of this paper found that since 1989 there has been no improvement in the age and severity adjusted odds of death for patients with severe head injury in England and Wales (Lecky F, personal communication).

The supply of emergency neurosurgical beds in the UK is limited. A recent survey revealed only 43 neurosurgical intensive care beds available for an overall estimated population of 63.6 million.[52] This shortfall can lead to delays in patient transfer, and is symptomatic of larger resource and workload issues for neurosurgery in the UK.[10] These larger resource problems have many implications for head injury care, including delays obtaining a neurosurgical opinion at night, or at the weekend.

Finally there is increasing awareness of a high level of disability following minor/mild head injury. The provision of diagnostic and treatment services could bring great benefits to patients who would otherwise spend prolonged periods off work or dependent on others. Unfortunately, neurorehabilitation services in England and Wales do not have the capacity to provide the volume of services currently required.

2 Development of the guideline

2.1 What is a NICE clinical guideline? (2014)

NICE clinical guidelines are recommendations for the care of individuals in specific clinical conditions or circumstances within the NHS – from prevention and self-care through primary and secondary care to more specialised services. We base our clinical guidelines on the best available research evidence, with the aim of improving the quality of health care. We use predetermined and systematic methods to identify and evaluate the evidence relating to specific review questions.

NICE clinical guidelines can:

- provide recommendations for the treatment and care of people by health professionals
- be used to develop standards to assess the clinical practice of individual health professionals
- be used in the education and training of health professionals
- help patients to make informed decisions
- improve communication between patient and health professional

While guidelines assist the practice of healthcare professionals, they do not replace their knowledge and skills.

We produce our guidelines using the following steps:

- Guideline topic is referred to NICE from the Department of Health.
- Stakeholders register an interest in the guideline and are consulted throughout the development process.
- The scope is prepared by the National Clinical Guideline Centre (NCGC).
- The NCGC establishes a guideline development group.
- A draft guideline is produced after the group assesses the available evidence and makes recommendations.
- There is a consultation on the draft guideline.
- The final guideline is produced.

The NCGC and NICE produce a number of versions of this guideline:

- The full guideline contains all the recommendations, plus details of the methods used and the underpinning evidence.
- The NICE guideline lists the recommendations.
- Information for the public is written using suitable language for people without specialist medical knowledge.
- The NICE pathway brings together all connected NICE guidance.

This version is the full version. The other versions can be downloaded from NICE at www.nice.org.uk

Update 2014

2.2 Remit (2003)

The remit (Appendix A) was received from the Department of Health and the National Assembly for Wales in October 2001 as part of NICE's 2nd wave programme of work. This remit has not been altered for this update.

2.3 Who developed this guideline? (2014)

A multidisciplinary Guideline Development Group (GDG) comprising professional group members and consumer representatives of the main stakeholders developed this guideline (see section on Guideline Development Group Membership and acknowledgements).

The National Institute for Health and Care Excellence (NICE).funds the National Clinical Guideline Centre (NCGC) and thus supported the development of this guideline. The GDG was convened by the NCGC and chaired by Fiona Lecky in accordance with guidance from NICE.

The group met every 4 - 6 weeks during the development of the guideline. At the start of the guideline development process all GDG members declared interests including consultancies, fee-paid work, share-holdings, fellowships and support from the healthcare industry. At all subsequent GDG meetings, members declared arising conflicts of interest, which were also recorded (Appendix B).

Members were either required to withdraw completely or for part of the discussion if their declared interest made it appropriate. The details of declared interests and the actions taken are shown in Appendix B.

Staff from the NCGC provided methodological support and guidance for the development process. The team working on the guideline included a project manager, systematic reviewers, health economists and information scientists and a guideline lead. They undertook systematic searches of the literature, appraised the evidence, conducted meta-analysis and cost-effectiveness analysis where appropriate and drafted the guideline in collaboration with the GDG.

Update 2014

2.4 Scope (2003)

The National Institute for Health and Clinical Excellence (NICE) originally commissioned the National Collaborating Centre for Acute Care (NCC-AC) to produce a clinical guideline for patients and clinicians on the early management of head injury, beginning in December 2001. The guideline published in June 2003. The guideline provides advice on effective care using the best possible research evidence. The guideline is based on a scope and commissioning brief received from NICE. These documents reflected a NICE consultation with relevant stakeholders. The clinical areas outlined in the scope were as follows:

- pre-hospital management including assessment, airway management and ventilation, cervical spine protection and appropriate transfer;
- indications for referral to hospital from pre-hospital care;
- secondary care with the aim of early detection of intracranial complications, including admission for observation, skull X-ray and other imaging procedures, including CT scanning and nuclear magnetic resonance;
- criteria for transfer and discharge including circumstances when patients should be admitted to a neurosurgical unit, admitted for a short period or discharged home;
- criteria for surgical intervention;
- information for patients and their carer/s prior to and during hospital admission;

- management at home of patients who are discharged within 48 hours of admission including advice to primary care and emergency department staff on the management of patients who re-present with suspicious symptoms;.
- guidance on appropriate handover arrangements;
- information for patients and carers.

2.4.1 Population

The guideline offered best practice for the care of all patients who presented with a suspected or confirmed traumatic head injury with or without other major trauma. Separate advice was provided for adults and children (including infants) where different practices were indicated. It offered advice on the management of patients with a suspected or confirmed head injury who may have be unaware that they had sustained a head injury because of intoxication or other causes. The guideline did not provide advice on the management of patients with other traumatic injury to the head (for example, to the eye or face). It does not address the rehabilitation or long term care of patients with a head injury but the guideline does explore possible criteria for the early identification of patients who require rehabilitation.

2.4.2 Healthcare setting

The guideline covers the care received from NHS advice sources (for example, NHS 111, emergency department helplines), primary care, ambulance, and hospital staff who have direct contact with and make decisions concerning the care of patients who present with suspected or confirmed head injury. It recognises the need for care to be integrated between the primary, secondary and tertiary sectors, and the need to ensure that none of these sectors is unnecessarily overburdened. It addresses the management of patients in primary care, pre-hospital, in emergency departments or similar units, and in the different hospital settings to which they may be transferred where observation for possible deterioration is indicated.

The guideline does not address management within the intensive care or neurosurgical unit, but provides guidance on the appropriate circumstances in which to request a neurosurgical opinion.

Service configuration, competencies, skill mix and training requirements of staff are outside the scope of the guidelines, as they are the remit of the NHS Modernisation Agency, but good practice points on these matters are introduced in places.

2.5 Guideline update (2014)

2.5.1 What the update guideline covers

This guideline update has addressed the following areas in accordance with the scope (appendix C):

Pre-hospital assessment, advice and referral to hospital:

- Selection of patients with head injury, with or without cervical spine injury, for specialist neuroscience care using clinical decision rules.

Assessment in the emergency department:

- Selection of patients with head injury for imaging (with or without cervical spine injury) using clinical decision rules:
  - who have no history of amnesia or loss of consciousness.
  - who are on anticoagulant or antiplatelet therapy.
  - using diagnostic circulating biomarkers (S100B, NSE and GFAP).
- Diagnosis of cervical spine injury in patients with head injury, using computed tomography (CT) and magnetic resonance (MR) imaging scans.

Discharge and follow-up

- Information for patients and carers on discharge from the emergency department or observation ward.

Update 2014

2.5.2 What the guideline does not cover

Rehabilitation or long-term care of patients with a head injury.

Areas addressed in the 2007 guideline that will not be reviewed:

- Pre-hospital assessment, advice and referral to hospital (excluding issues in 2.5.1)
- Immediate management at the scene and transport to hospital
- Involvement of the neurosurgical department (excluding issues in 2.5.1)
- Discharge and follow-up (excluding issues in 2.5.1)
- Admission and observation
- Medical radiation

2.6 Guideline update (2007)

2.6.1 What the update guideline covers

The guideline covers best practice advice on the care of adults, children (aged 1-15 years) and infants (under one year) who present with a suspected or confirmed traumatic head injury with or without other major trauma. The guideline will offer advice on the management of patients with a suspected or confirmed head injury who may be unaware that they have sustained a head injury because of intoxication or other causes.

This update covers the following;

- The benefits of transporting patients with head injuries to a neurosciences unit compared to an emergency department.
- The benefits of secondary transfer of patients.
- The best imaging tool for identifying patients with head and cervical spine injuries
- The best clinical prediction rule for selecting patients with head and cervical spine injuries for the imaging tool selected.
- Evidence on harm associated with radiation to the head and/or spine.
- Identification of patients who should be referred to rehabilitation services following the initial management of a head injury

Only 8 clinical questions (Appendix D) are covered within this partial update; all other criteria set in the scope (Appendix C) were adhered to in this update. This guideline incorporates both the original and the updated sections. All updated sections of the guideline are marked by the relevant year of update to aid identification by the reader. All shaded sections have not been updated and is the original guideline. All recommendations are in bold within each section for reader ease, as well as a full list of recommendations at the beginning of the guideline. All recommendations are clearly stated whether they are new or amended recommendations.

2.6.2 What the guideline does not cover

The guideline does not provide advice on the management of patients with other traumatic injury to the head (for example, to the eye or face). The guideline will not address the rehabilitation or long term care of patients with a head injury but the guideline will provide criteria for the early identification of patients who would benefit from rehabilitation.

All areas outside the inclusion criteria for each clinical question are not covered within this partial update. All criteria set in the scope (Appendix C) were adhered to in this update.

There are few really good high grade studies of head injury care. One of the most relevant to those who are involved in the early management of head injured patients is the large randomised controlled trial of methyprednisolone therapy (Corticosteroid Randomisation after Significant Head Injury (CRASH) trial.[76] The results of the trial were published after the first version (2003) of this guideline. Whilst assessment of the value of such therapies is outside the remit of this update, the GDG fully endorses the conclusion of the trial, that corticosteroids are contra-indicated after traumatic brain injury, and considers that this research should be brought to the attention of readers.

2.7 Structure of the updated guideline (2014)

All updated text, including evidence reviews and recommendations are marked by a shaded pink box with 'Update 2014' in the right hand margin.

2.7.1 Chapters

The structure of the updated guideline has been kept as close to the original guideline as possible:

- Pre-hospital assessment, advice and referral to hospital
- Immediate management, advice and referral to hospital
- Immediate management at the scene and transport to hospital
- Assessment in the emergency department: imaging of the head (previously one chapter, now split in two to differentiate between head and cervical spine imaging)
- Assessment in the emergency department: imaging of the cervical spine
- Imaging practice and involvement of the neurosurgical department
- Discharge and follow-up
- Admission and observation

2.7.2 Methodology

The methodology of writing NICE guidelines has changed substantially since the previous guideline, therefore the updated sections are in a different style and clearly present evidence tables, evidence statements, recommendations and linking evidence to recommendation sections, which are detailed in Chapter 3. These aspects are not present in the sections that have not been reviewed in this update. The presentation of evidence remains the same as in the original 2003 and 2007 guideline versions for recommendations not updated.

Update 2014

2.7.3 Recommendations

Recommendations made in the original 2003 guideline and 2007 update that were not within the scope of this partial update were reviewed to check for accuracy and consistency in light of the new recommendations made. These recommendations are marked as [2003] and yellow shading in these recommendations indicates where wording changes have been made for the purposes of clarification only. Any changes to these recommendations to bring them in line with current NICE style have not been marked.

Recommendations are marked [2003, amended 2014] or [2007, amended 2014] if the evidence has not been updated since the original guideline, but changes have been made that change the meaning of the recommendation, such as incorporated guidance being updated or equality issues. Appendix O contains these changes.

Recommendations are marked as [2014] if the evidence has been reviewed but no change has been made to the recommendation or [new 2014] if the evidence has been reviewed and the recommendation has been added or updated.

Appendix O contains recommendations from the 2003 guideline and 2007 update that have been deleted or amended in the 2014 update. This is because the evidence has been reviewed and the recommendation has been updated or because NICE has updated other relevant guidance and has replaced the original recommendations. Where there is no replacement recommendation, an explanation for the proposed deletion is given.

2.8 Relationships between the guideline and other NICE guidance (2014)

Related NICE Clinical Guidelines:

Falls: The assessment and prevention of falls in older people. NICE clinical guideline 161 (2013).

Patient experience in adult NHS services. NICE clinical guideline 138 (2012)

The epilepsies: the diagnosis and management of the epilepsies in adults and children in primary and secondary care. NICE clinical guideline 137 (2012).

Alcohol-use disorders: diagnosis, assessment and management of harmful drinking and alcohol dependence. NICE clinical guideline 115 (2011).

Service user experience in adult mental health. NICE clinical guideline 136 (2011).

Organ donation for transplantation: improving donor identification and consent rates for deceased organ donation. NICE clinical guideline 135 (2011).

Delirium: diagnosis, prevention and management. NICE clinical guideline 103 (2010).

Transient loss of consciousness in adults and young people. NICE clinical guideline 109 (2010).

Sedation in children and young people: Sedation for diagnostic and therapeutic procedures in children and young people. NICE clinical guideline 112 (2010).

Strategies to prevent unintentional injuries among children and young people aged under 15. NICE public heath guidance 29 (2010).

When to suspect child maltreatment. NICE clinical guideline 89 (2009).

Medicines adherence. NICE clinical guideline 76 (2009).

Acutely ill patients in hospital. NICE clinical guideline 50 (2007).

Dementia: Supporting people with dementia and their carers in health and social care. NICE clinical guideline 42 (2006).

Post-traumatic stress disorder (PTSD): The management of PTSD in adults and children in primary and secondary care. NICE clinical guideline 26 (2005).

Related NICE Health Technology Appraisals:

Pre-hospital initiation of fluid replacement therapy in trauma. NICE technology appraisal guidance 74 (2004).

NICE Related Guidance currently in development:

Intravenous fluid therapy in hospitalised adult patients. Publication expected November 2013.

Spinal injury assessment. Publication expected May 2015.

Major trauma. Publication expected June 2015.

Trauma services. Publication expected October 2015 .

Intravenous fluids therapy in children. Publication expected November 2015.

Related NICE Interventional Procedures:

Update 2014

None identified.

Related NICE Public Health Guidance:

None identified.

Update 2014

3 Methods

3.1 Guideline update methods (2014)

This chapter sets out in detail the methods used to review the evidence and to generate the recommendations that are presented in subsequent chapters. This guidance was developed in accordance with the methods outlined in the NICE Guidelines Manual 2009.[185]

Amendments to 2003 and 2007 text

All text and recommendations from the previous guideline that have not been updated (therefore review questions have not been generated and evidence has not been searched for) have been left unchanged. Amendments to recommendations are detailed in Appendix O.

Exceptions include:

Text in previous guideline	Change made and reason for change
-	Insertion of 'safeguarding concerns' added to chapter 6, detailing non-accidental injuries in children.
Cervico-dorsal	Changed to cervico-thoracic as the GDG considered this as a more up-to-date and widely used term.
Plain films	Plain X-ray. Amended for consistency and to reflect up-to-date terminology.

Update 2014

3.2 Developing the review questions and outcomes (2014)

Review questions were developed in a framework of population, index tests, reference standard and target condition for reviews of diagnostic test accuracy; and using population, presence or absence of factors under investigation (for example prognostic factors) and outcomes for prognostic reviews. This was to guide the literature searching process, critical appraisal and synthesis of evidence, and facilitated the development of recommendations by the guideline development group (GDG). The review questions were drafted by the NCGC technical team and refined and validated by the GDG. The questions were based on the key clinical areas identified in the scope (Appendix C).

A total of 10 review questions were identified. Each question includes adults, children and infants, these groups were analysed separately (stratified by population age).

Full literature searches, critical appraisals and evidence reviews were completed for all the specified review questions.

Table 1: Summary of review questions

Chapter	Review questions	Outcomes
Chapter 6 Methods	What is the effectiveness of pre-hospital assessment tools for selecting adults, infants and children with head injury, for transport direct to specialist neuroscience care or a major trauma centre with neuroscience if the nearest hospital does not provide these?	• Diagnostic accuracy of traumatic brain injury • Diagnostic accuracy of traumatic brain injury – requiring neurosurgical intervention •
Chapter 7 Assessment in the emergency department: imaging of the head	What is the best clinical decision rule for selecting adults, infants and children with head injury for CT head scan?	• Diagnostic accuracy of need for neurosurgical intervention • Diagnostic accuracy of any intracranial abnormality
Chapter 7 Assessment in the emergency department: imaging of the head	What is the best clinical decision rule for selecting adults, infants and children with head injury for CT head scan who have no history of amnesia or loss of consciousness who are on anticoagulant or antiplatelet therapy?	• Diagnostic accuracy of need for neurosurgical intervention • Diagnostic accuracy of any intracranial abnormality
Chapter 7 Assessment in the emergency department: imaging of the head	What is the diagnostic accuracy of biomarkers (S100B, NSE, GFAP) in the emergency department for selecting adults, infants and children with head injury for CT head scan?	• Diagnostic accuracy of any intracranial abnormality • Diagnostic accuracy of need for neurosurgical intervention
Chapter 8 Assessment in the emergency department: imaging of the cervical spine	What is the best clinical decision rule for selecting adults, infants and children with head injury for initial imaging with plain X-rays or CT scan for cervical spine injury?	• Diagnostic accuracy of any significant cervical spine injury (fracture/bony injury or soft tissue/ligament damage) • Diagnostic accuracy of need for neurological intervention/spinal surgery
Chapter 8 Assessment in the emergency department: imaging of the cervical spine	What is the best clinical decision rule for selecting adults, infants and children with head injury, who have received a negative X-ray of the cervical spine, for further imaging with CT or MR imaging for cervical spine injury?	• Diagnostic accuracy of any significant cervical spine injury (fracture/bony injury or soft tissue/ligament damage) • Diagnostic accuracy of need for neurological intervention/spinal surgery
Chapter 8 Assessment in the emergency department: imaging of the cervical spine	What is the best clinical decision rule for selecting adults, infants and children with head injury, who have received a negative CT cervical spine scan, for further imaging with MR imaging for cervical spine injury?	• Diagnostic accuracy of any significant cervical spine injury (fracture/bony injury or soft tissue/ligament damage) • Diagnostic accuracy of need for neurological intervention/spinal surgery
Chapter 10 Discharge and follow-up	What information and support do patients with head injury say they want?	• Themes extracted, as reported in the papers.
Chapter 10 Discharge and follow-up	What discharge information should be given to patients with head injury?	• Themes extracted, as reported in the papers.

Update 2013

3.3 Searching for evidence (2014)

3.3.1 Clinical literature search

Systematic literature searches were undertaken to identify evidence within published literature in order to answer the review questions as per The Guidelines Manual [2009][185]. Clinical databases were searched using relevant medical subject headings, free-text terms and study type filters where appropriate. Studies published in languages other than English were not reviewed. Where possible, searches were restricted to articles published in English language. All searches were conducted on core databases, MEDLINE, Embase and The Cochrane Library. Cinahl was also searched for patient views. All searches were updated on 31 May 2013. No papers after this date were considered.

Search strategies were checked by looking at reference lists of relevant key papers, checking search strategies in other systematic reviews and asking the GDG for known studies. The questions, the study types applied, the databases searched and the years covered can be found in Appendix G.

During the scoping stage, a search was conducted for guidelines and reports on the websites listed below and on organisations relevant to the topic. Searching for other grey literature or unpublished literature was not undertaken. All references sent by stakeholders were considered.

- Guidelines International Network database (www.g-i-n.net)
- National Guideline Clearing House (www.guideline.gov)
- National Institute for Health and Care Excellence (NICE) (www.nice.org.uk)
- National Institutes of Health Consensus Development Program (consensus.nih.gov)
- NHS Evidence (www.evidence.nhs.uk)
- New Zealand Guideline Group (NZGG) (www.nzgg.org.nz)
- American College of Radiology appropriateness criteria (acsearch.acr.org)

Update 2014

3.3.2 Health economic literature search

Systematic literature searches were also undertaken to identify health economic evidence within published literature relevant to the review questions. The evidence was identified by conducting a broad search relating to head injury in the NHS economic evaluation database (NHS EED), the Health Economic Evaluations Database (HEED) and health technology assessment (HTA) databases with no date restrictions. Additionally, the search was run on MEDLINE and Embase, with a specific economic filter, from 2010, to ensure recent publications that had not yet been indexed by these databases were identified. This was supplemented by additional searches in Medline and Embase that looked for papers specifically relating to quality of life in two patient groups, patients with head injury on anticoagulants and patients with cervical spine injury. Studies published in languages other than English were not reviewed. Where possible, searches were restricted to articles published in English language.

The search strategies for health economics are included in Appendix G. The economic search was updated on 31 May 2013, the quality of life search updated 18 March 2013. No papers published after these dates were considered.

3.4 Evidence of effectiveness (2014)

The Research Fellow:

- Identified potentially relevant studies for each review question from the relevant search results by reviewing titles and abstracts – full papers were then obtained.

- Reviewed full papers against pre-specified inclusion/exclusion criteria to identify studies that addressed the review question in the appropriate population and reported on outcomes of interest (review protocols are included in Appendix D).
- Critically appraised relevant studies using the appropriate checklist as specified in The Guidelines Manual.[185]
- Extracted key information about the study's methods and placed results into evidence tables (evidence tables are included in Appendix H).
- Generated summaries of the evidence by outcome (included in the relevant chapter write-ups), which were presented them in GDG meetings:
  - Observational studies: data presented as a range of values in GRADE profiles.
  - Diagnostic studies: data presented as a range of values in adapted GRADE profiles (diagnostic test accuracy: sensitivity, specificity, positive and negative predictive value). Meta-analyses could not be conducted because the studies reported data at various thresholds or there was insufficient data to pool.
  - Prognostic studies: data were presented as a range of values, usually in terms of the relative effect as reported by the authors.
  - Qualitative studies: each study was summarised in a table where possible, otherwise information was presented in a narrative.

3.4.1 Inclusion/exclusion

The inclusion/exclusion of studies was based on the review protocols (Appendix D). The GDG were consulted about any uncertainty regarding inclusion/exclusion.

Update 2014

Conference abstracts were not automatically excluded from the review but were initially assessed against the inclusion criteria and then further processed only if no other full publication was available for that review question, in which case the authors of the selected abstracts were contacted for further information. Only one review included abstracts; clinical decision rules for the selection of children for head CT scan.

Literature reviews, letters and editorials, foreign language publications and unpublished studies were excluded.

3.4.2 Methods of combining clinical studies

Data synthesis for prognostic factor reviews.

Odds ratios, relative risks or hazard ratios, with their 95% confidence intervals, from multivariate analyses were extracted from the papers, and standard errors were calculated from the 95% confidence intervals. The log of the effect size with its standard error was entered into the generic inverse variance technique in the Cochrane Review Manager (RevMan5) software. Studies were not combined in a meta-analysis for observational studies. Sensitivity analyses were carried out on the basis of study quality and results were reported as ranges.

Data synthesis for diagnostic test accuracy review.

For diagnostic test accuracy studies (including head CT and cervical spine imaging clinical decision rules), the following measures of diagnostic accuracy were reported: sensitivity, specificity, positive predictive value, negative predictive value. In cases where the outcomes were not reported, 2 by 2 tables were constructed from raw data to allow calculation of these accuracy measures. As only two outcomes were prioritised for inclusion (diagnostic accuracy of need for neurosurgical intervention and diagnostic accuracy of any intracranial abnormality), both were considered to be critical

outcomes. Clinical evidence profiles give diagnostic accuracy data as ranges of 95% confidence intervals.

Diagnostic test accuracy measures used in the analysis were sensitivity and specificity, positive and negative predictive value. The threshold of a diagnostic test is defined as the value at which the test can best differentiate between those with and without the target condition and, in practice, it varies amongst studies. The GDG discussed the clinically relevant thresholds for biomarker tests and accepted the manufacturer's instructions. All the clinically relevant thresholds can be found in the evidence review.

Coupled forest plots of sensitivity and specificity with their 95% confidence intervals across studies were produced for each test, using Cochrane Review Manager (RevMan5) software. In order to do that, 2 by 2 tables (the number of true positives, false positives, true negatives and false negatives) were either directly taken from the study if given or derived from raw data, or were calculated from the set of test accuracy statistics.

Heterogeneity or inconsistency amongst studies was visually inspected in the forest plots, if appropriate (only when there were similar thresholds). A diagnostic meta-analysis was not conducted mainly because of the low quality of the studies. Meta-analysis of studies at risk of bias may be misleading as meta-analysis may compound the errors and produce an inaccurate result which may be misinterpreted as having reliability. Differences in thresholds across studies and in patient selection criteria may also impact on test accuracy and therefore are additional reasons why meta-analysis was not conducted.

Update 2014

Data synthesis for qualitative reviews

Themes were identified from these studies and were supplemented with data from surveys where available. Identification of themes was based on what the studies reported, no additional interpretation was conducted in order to minimise bias. Common themes relevant to the question are reported in a narrative in the guideline text. Appraising the quality of evidence by outcomes

The evidence for outcomes from the included studies were evaluated and presented using an adaptation of the 'Grading of Recommendations Assessment, Development and Evaluation (GRADE) toolbox' developed by the international GRADE working group (http://www.gradeworkinggroup.org/). The software (GRADEpro) developed by the GRADE working group was used to assess the quality of each outcome, taking into account individual study quality and meta-analysis results. The summary of findings was presented as two separate tables in this guideline. Reporting or publication bias was only taken into consideration in the quality assessment and included in the Clinical Study Characteristics table if it was apparent.

Each outcome was examined separately for the quality elements listed and defined in Table 2 and each graded using the quality levels listed in

Table 3. The main criteria considered in the rating of these elements are discussed below (see section 3.4.3 Grading the quality of evidence). Footnotes were used to describe reasons for grading a quality element as having serious or very serious problems. The ratings for each component were summed to obtain an overall assessment for each outcome in Table 4. The GRADE toolbox is currently designed only for randomised trials and observational studies but we adapted the quality assessment elements and outcome presentation for diagnostic accuracy studies.

Table 2: Description of quality elements in GRADE for intervention and diagnostic studies (adapted from quality elements for intervention studies)

Quality element	Description
Limitations	Intervention - Limitations in the study design and implementation may bias the estimates of the treatment effect. Major limitations in studies decrease the confidence in the estimate of the effect. Diagnostic - Cross sectional or cohort studies in patients with diagnostic uncertainty and direct comparison of test results with an appropriate reference standard are considered high quality. See also QUADAS-2 quality assessment checklist.
Inconsistency	Intervention - Inconsistency refers to an unexplained heterogeneity of results. Diagnostic - Unexplained inconsistency in sensitivity, specificity, or likelihood ratios (rather than relative risk or mean differences) can reduce quality of studies.
Indirectness	Intervention - Indirectness refers to differences in study population, intervention, comparator and outcomes between the available evidence and the review question, or recommendation made. Diagnostic - Quality can be reduced if • important differences exist between populations studied and those for whom the recommendation is intended (in previous testing, spectrum of disease or comorbidity). • important differences exist in test studied and diagnostic expertise of people applying them in studies compared with settings for which recommendations are intended. • tests being compared are compared to a reference standard in different studies and not directly compared in the same studies.
Imprecision	Intervention - Results are imprecise when studies include relatively few patients and few events and thus have wide confidence intervals around the estimate of the effect relative to the clinically important threshold. Diagnostic - Wide confidence intervals for estimates of test accuracy or true and false positive and negative rates can reduce quality of evidence.
Publication bias	Intervention - Publication bias is a systematic underestimate or an overestimate of the underlying beneficial or harmful effect due to the selective publication of studies. Diagnostic - High risk publication bias (for example from small studies for new intervention or test, or asymmetry in funnel plot) can lower quality of evidence.

Source: Adapted from BMJ 2008 diagnostic GRADE paper,[230] GRADE working group.[230]

Update 2014

Table 3: Levels of quality elements in GRADE

Level	Description
None	There are no serious issues with the evidence
Serious	The issues are serious enough to downgrade the outcome evidence by one level
Very serious	The issues are serious enough to downgrade the outcome evidence by two levels

Table 4: Overall quality of outcome evidence in GRADE

Level	Description
High	Further research is very unlikely to change our confidence in the estimate of effect
Moderate	Further research is likely to have an important impact on our confidence in the estimate of effect and may change the estimate
Low	Further research is very likely to have an important impact on our confidence in the estimate of effect and is likely to change the estimate
Very low	Any estimate of effect is very uncertain

3.4.3 Grading the quality of clinical evidence

The overall quality of evidence for each outcome was considered. The following procedure was adopted when using GRADE:

1. A quality rating was assigned, based on the study design. RCTs, prospective diagnostic cross sectional or cohort studies start HIGH and observational studies as LOW, uncontrolled case series as LOW or VERY LOW.
2. The rating was then downgraded or upgraded for the specified criteria: Study limitations, inconsistency, indirectness, imprecision and reporting bias. These criteria are detailed below. Observational studies were upgraded if there was: a large magnitude of effect, dose-response gradient, and if all plausible confounding would reduce a demonstrated effect or suggest a spurious effect when results showed no effect. Each quality element considered to have “serious” or “very serious” risk of bias were rated down -1 or -2 points respectively.
3. The downgraded/upgraded marks were then summed and the overall quality rating was revised. For example, all RCTs started as HIGH and the overall quality became MODERATE, LOW or VERY LOW if 1, 2 or 3 points were deducted respectively.
4. The reasons or criteria used for downgrading were specified in the footnotes.

The details of criteria used for each of the main quality element are discussed further in the following section 3.7.5.

3.4.4 Study limitations

For diagnostic accuracy studies, the Quality Assessment of Diagnostic Accuracy Studies version 2 (QUADAS-2) checklists were used. Risk of bias and applicability in primary diagnostic accuracy studies in QUADAS-2 consists of 4 domains (see Figure 1):

- Patient selection
- Index test
- Reference standard
- Flow and timing

Figure 1: Summary of QUADAS-2 with list of signalling, risk of bias and applicability questions

DOMAIN	PATIENT SELECTION	INDEX TEST	REFERENCE STANDARD	FLOW AND TIMING
Description	Describe methods of patient selection: Describe included patients (prior testing, presentation, intended use of index test and setting):	Describe the index test and how it was conducted and interpreted:	Describe the reference standard and how it was conducted and interpreted:	Describe any patients who did not receive the index test(s) and/or reference standard or who were excluded from the 2x2 table (refer to flow diagram): Describe the time interval and any interventions between index test(s) and reference standard:
Signalling questions (yes/no/unclear)	Was a consecutive or random sample of patients enrolled?	Were the index test results interpreted without knowledge of the results of the reference standard?	Is the reference standard likely to correctly classify the target condition?	Was there an appropriate interval between index test(s) and reference standard?
	Was a case-control design avoided?	If a threshold was used, was it pre-specified?	Were the reference standard results interpreted without knowledge of the results of the index test?	Did all patients receive a reference standard?
	Did the study avoid inappropriate exclusions?			Did all patients receive the same reference standard?
				Were all patients included in the analysis?
Risk of bias: High/low/unclear	Could the selection of patients have introduced bias?	Could the conduct or interpretation of the index test have introduced bias?	Could the reference standard, its conduct, or its interpretation have introduced bias?	Could the patient flow have introduced bias?
Concerns regarding applicability: High/low/unclear	Are there concerns that the included patients do not match the review question?	Are there concerns that the index test, its conduct, or interpretation differ from the review question?	Are there concerns that the target condition as defined by the reference standard does not match the review question?	

Source/Note: University of Bristol – QUADAS-2 website (http://www.bris.ac.uk/quadas/quadas-2)

An optional domain, multiple test accuracy is applicable when a single study examined more than one diagnostic test (head-to-head comparison between two or more index tests reported within the same study). This optional domain contains three items of risk of bias: 1) did all patients undergo all index tests or were the index tests appropriately randomised amongst the patients; 2) were index tests conducted within a short time interval; 3) are index test results unaffected when undertaken together on the same patient.

The GDG raised a number of issues that needed to be taken into consideration when assessing study quality and they are listed as follows:

1. Patient selection: the GDG were aware that not all questions had evidence from head injury patients alone and that evidence did exist in the broader population of trauma patients. The GDG discussed when such evidence should be included and whether it was appropriate to downgrade the evidence accordingly.
2. Index test: the GDG discussed that the biomarker review question should only include studies with well-defined index tests and that there would be variation in the thresholds and testing equipment used. The thresholds used across studies were mixed and the GDG did not pre-specify the thresholds; however, they would not be considered at high risk of bias as long as there was an adequate description of how the threshold was derived and it was not subjectively selected.
3. Reference standard: appropriate follow-up for questions regarding decision rules was considered important for example, it is not ethical to CT scan all children, but there should be an adequate follow-up for those who did not receive a CT scan to confirm that they did not have a missed injury.

Reviewers assessed the risk of bias associated with each item and then came up with an overall risk of bias (low, moderate and high) and applicability. In addition, GRADE was adapted and an overall risk of bias for each outcome was produced.

For prognostic studies, quality was assessed using the checklist for prognostic studies (NICE Guidelines Manual, 2009.[185] The quality rating (low, high, unclear) was derived by assessing the risk of bias across 6 domains: selection bias, attrition bias, prognostic factor bias, outcome measurement bias, control for confounders and appropriate statistical analysis, with the last 4 domains being assessed per outcome. A summary table on the quality of prognostic studies is presented at the beginning of each review to summarise the risk of bias across the 5 domains. More details about the quality assessment for prognostic studies are shown below:

1. The study sample represents the population of interest and the population, source of sample and inclusion/exclusion criteria adequately described.
2. Loss to follow-up is unrelated to key characteristics, sufficient to limit potential bias – reasons for loss to follow-up adequately described.
3. The prognostic factor of interest is adequately measured in study participants.
4. The outcome of interest is adequately measured in study participants.
5. Important potential confounders are appropriately accounted for.
6. The statistical analysis is appropriate for the design of the study, limiting potential for the presentation of invalid results.

3.4.5 Inconsistency

Inconsistency refers to an unexplained heterogeneity of results. When estimates of the treatment effect across studies differ widely (heterogeneity or variability in results), this suggests true differences in underlying treatment effect. When heterogeneity exists (Chi square $p<0.1$ or I- squared inconsistency statistic of >50%), but no plausible explanation can be found, the quality of evidence was downgraded by one or two levels, depending on the extent of uncertainty in the results contributed by the inconsistency in the results. In addition to the I- square and Chi square values, the decision for downgrading was also dependent on factors such as whether the intervention is associated with benefit in all other outcomes or whether the uncertainty about the magnitude of benefit (or harm) of the outcome showing heterogeneity would influence the overall judgment about net benefit or harm (across all outcomes).

If inconsistency could be explained based on pre-specified subgroup analysis, the GDG took this into account and considered whether to make separate recommendations based on the identified explanatory factors, i.e. population and intervention. Where subgroup analysis gives a plausible explanation of heterogeneity, the quality of evidence would not be downgraded.

3.4.6 Indirectness

Directness refers to the extent to which the populations, intervention, comparisons and outcome measures are similar to those defined in the inclusion criteria for the reviews. Indirectness is important when these differences are expected to contribute to a difference in effect size, or may affect the balance of harms and benefits considered for an intervention.

The GDG decided that for certain questions where there was a lack of evidence for head injury patients it was of interest to include indirect evidence from all trauma patients.

3.4.7 Imprecision

Imprecision in guidelines concerns whether the uncertainty (confidence interval) around the effect estimate means that we do not know whether there is a clinically important difference between interventions. Therefore, imprecision differs from the other aspects of evidence quality; in that it is not concerned with whether the point estimate is accurate or correct (has internal or external validity) instead we are concerned with the uncertainty about what the point estimate is. This uncertainty is reflected in the width of the confidence interval.

The 95% confidence interval is defined as the range of values that contain the population value with 95% probability. The larger the trial, the smaller the confidence interval and the more certain we are in the effect estimate.

Imprecision in the evidence reviews was assessed by considering whether the width of the confidence interval of the effect estimate is relevant to decision making, considering each outcome in isolation. Minimal important differences were not used in this guideline as no intervention reviews were included in the 2014 update.

3.4.1 Clinical evidence statements

Evidence statements are summary statements that are presented after the GRADE profiles, summarising the key features of the clinical effectiveness evidence presented. The wording of the evidence statements reflects the certainty/uncertainty in the estimate of effect. The evidence statements are presented by outcome and encompass the following key features of the evidence:

- The number of studies and the number of participants for a particular outcome.
- A brief description of the participants.
- An indication of the direction of effect (if one intervention is beneficial or harmful compared to the other, or whether there is no difference between the two tests).
- A description of the overall quality of evidence (GRADE overall quality).

3.5 Evidence of cost effectiveness (2014)

The GDG is required to make decisions based on the best available evidence of both clinical and cost effectiveness. Guideline recommendations should be based on the expected costs of the different options in relation to their expected health benefits (that is, their 'cost effectiveness') rather than the total implementation cost.[185] Thus, if the evidence suggests that a strategy provides significant health benefits at an acceptable cost per patient treated, it should be recommended even if it would be expensive to implement across the whole population.

Evidence on cost effectiveness related to the key clinical issues being addressed in the guideline was sought. The health economist undertook:

- A systematic review of the published economic literature.
- New cost-effectiveness analysis in priority areas.

3.5.1 Literature review

The Health Economist:

- Identified potentially relevant studies for each review question from the economic search results by reviewing titles and abstracts – full papers were then obtained.
- Reviewed full papers against pre-specified inclusion / exclusion criteria to identify relevant studies (see below for details).
- Critically appraised relevant studies using the economic evaluations checklist as specified in The Guidelines Manual.[185]
- Extracted key information about the studies' methods and results into evidence tables (included in Appendix I).
- Generated summaries of the evidence in NICE economic evidence profiles (included in the relevant chapter write-ups) – see below for details.

3.5.1.1 Inclusion/exclusion

Full economic evaluations (studies comparing costs and health consequences of alternative courses of action: cost-utility, cost-effectiveness, cost-benefit and cost-consequence analyses) and comparative costing studies that addressed the review question in the relevant population were considered potentially includable as economic evidence.

Studies that only reported cost per hospital (not per patient), or only reported average cost effectiveness without disaggregated costs and effects, were excluded. Abstracts, posters, reviews, letters/editorials, foreign language publications and unpublished studies were excluded. Studies judged to have an applicability rating of 'not applicable' were excluded (this included studies that took the perspective of a country outside the Organisation for Economic Co-operation and Development (OECD)).

Remaining studies were prioritised for inclusion based on their relative applicability to the development of this guideline and study limitations. For example, if a high quality, directly applicable UK analysis was available other less relevant studies may not have been included. Where exclusions occurred on this basis, this is noted in the relevant section.

For more details about the assessment of applicability and methodological quality see the economic evaluation checklist (The Guidelines Manual, 2009[185] and the health economics research protocol in Appendix D).

3.5.1.2 NICE economic evidence profiles

The NICE economic evidence profile has been used to summarise cost and cost-effectiveness estimates. The economic evidence profile shows, for each economic study, an assessment of applicability and methodological quality, with footnotes indicating the reasons for the assessment. These assessments were made by the health economist using the economic evaluation checklist from The Guidelines Manual.[185] It also shows incremental costs, incremental effects (for example, quality-adjusted life years [QALYs]) and the incremental cost-effectiveness ratio, as well as information about the assessment of uncertainty in the analysis. See Table 5 for more details.

Table 5: Content of NICE economic profile

Item	Description
Study	First author name, reference, date of study publication and country perspective.
Applicability	• An assessment of applicability of the study to the clinical guideline, the current NHS situation and NICE decision-making*: • Directly applicable – the applicability criteria are met, or one or more criteria are not met but this is not likely to change the conclusions about cost effectiveness. • Partially applicable – one or more of the applicability criteria are not met, and this might possibly change the conclusions about cost effectiveness. • Not applicable – one or more of the applicability criteria are not met, and this is likely to change the conclusions about cost effectiveness.
Limitations	An assessment of methodological quality of the study*: • Minor limitations – the study meets all quality criteria, or the study fails to meet one or more quality criteria, but this is unlikely to change the conclusions about cost effectiveness. • Potentially serious limitations – the study fails to meet one or more quality criteria, and this could change the conclusion about cost effectiveness • Very serious limitations – the study fails to meet one or more quality criteria and

Item	Description
	this is very likely to change the conclusions about cost effectiveness. Studies with very serious limitations would usually be excluded from the economic profile table.
Other comments	Particular issues that should be considered when interpreting the study.
Incremental cost	The mean cost associated with one strategy minus the mean cost of a comparator strategy.
Incremental effects	The mean QALYs (or other selected measure of health outcome) associated with one strategy minus the mean QALYs of a comparator strategy.
Cost effectiveness	Incremental cost-effectiveness ratio (ICER): the incremental cost divided by the incremental effects.
Uncertainty	A summary of the extent of uncertainty about the ICER reflecting the results of deterministic or probabilistic sensitivity analyses, or stochastic analyses of trial data, as appropriate.

*Applicability and limitations were assessed using the economic evaluation checklist from The Guidelines Manual.[185]

3.5.2 Undertaking new health economic analysis

As well as reviewing the published economic literature for each review question, as described above, new economic analysis can be undertaken by the health economist in selected areas and where there is sufficient evidence to populate the analysis. Priority areas for new health economic analysis were agreed by the GDG after formation of the review questions and consideration of the available health economic evidence.

The GDG identified diagnostic strategies for ruling out cervical spinal injury in patients with head injury as the highest priority area for original economic modelling. The main trade offs for this topic are represented by the cost of diagnostic tests (whether X-ray, CT scan and MR imaging) versus the failure to detect a cervical spine injury (false negatives) which could lead to a delay in appropriate management, high adverse health consequences and associated health resource use. Appropriate selection of patients to undergo diagnostic imaging, and further imaging in the case of indeterminate or negative initial imaging results, is key in ensuring the optimal balance of maximising health gain and NHS resource use. However, there is a limited economic evidence base to clarify these trade offs and quantify expected outcomes of different decision rules which could be used in this context. As a consequence, the GDG identified this topic as a high priority for an original economic analysis.

The following general principles were adhered to in developing the cost-effectiveness analysis:

- Methods were consistent with the NICE reference case.[183]
- The GDG was involved in the design of the model, selection of inputs and interpretation of the results.
- Model inputs were based on the systematic review of the clinical literature supplemented with other published data sources where possible.
- When published data was not available GDG expert opinion was used to populate the model.
- Model inputs and assumptions were reported fully and transparently.
- The results were subject to sensitivity analysis and limitations were discussed.
- The model was peer-reviewed by another health economist at the NCGC.

Full methods for the cost-effectiveness analysis for cervical spine injury clearance strategies are described in Appendix M.

3.5.3 Cost-effectiveness criteria

NICE's report 'Social value judgements: principles for the development of NICE guidance' sets out the principles that GDGs should consider when judging whether an intervention offers good value for money.[184,185] In general, an intervention was considered to be cost effective if either of the following criteria applied (given that the estimate was considered plausible):

a. The intervention dominated other relevant strategies (that is, it was both less costly in terms of resource use and more clinically effective compared with all the other relevant alternative strategies), or
b. The intervention cost less than £20,000 per QALY gained compared with the next best strategy.

If the GDG recommended an intervention that was estimated to cost more than £20,000 per QALY gained, or did not recommend one that was estimated to cost less than £20,000 per QALY gained, the reasons for this decision are discussed explicitly in the 'linking evidence to recommendations' section of the relevant chapter with reference to issues regarding the plausibility of the estimate or to the factors set out in the 'Social value judgements: principles for the development of NICE guidance'.[184]

When QALYs or life years gained are not used in the analysis, results are difficult to interpret unless one strategy dominates the others with respect to every relevant health outcome and cost. Where evidence, including original economic analysis, reports the cost per effect (i.e. life year gained or false negative avoided) rather than the cost per QALY gained, the limitations in interpreting the results are also explicitly discussed in the 'linking evidence to recommendations' section of the relevant chapter.

3.5.4 In the absence of economic evidence

When no relevant published studies were found, and a new analysis was not prioritised, the GDG made a qualitative judgement about cost effectiveness by considering expected differences in resource use between options and relevant UK NHS unit costs alongside the results of the clinical effectiveness evidence.

3.6 Developing recommendations (2014)

- Over the course of the guideline development process, the GDG was presented with:
- Evidence tables of the clinical and economic evidence reviewed from the literature. All evidence tables are in Appendix H and I.
- Summary of clinical and economic evidence and quality (as presented in Chapters 6 to 10).
- Forest plots (Appendix J).
- A description of the methods and results of the cost-effectiveness analysis undertaken for the guideline (Appendix M).

Recommendations were drafted on the basis of the GDG interpretation of the available evidence, taking into account the balance of benefits, harms and costs. When clinical and economic evidence was of poor quality, conflicting or absent, the GDG drafted recommendations based on their expert opinion. The considerations for making consensus based recommendations include the balance between potential harms and benefits, economic or cost implications compared to the benefits, current practices, recommendations made in other relevant guidelines, patient preferences and equality issues. The consensus recommendations were done through discussions in the GDG. The GDG may also consider whether the uncertainty is sufficient to justify delaying making a recommendation to await further research, taking into account the potential harm of failing to make a clear recommendation (See 3.6.1).

The main considerations specific to each recommendation are outlined in the 'linking evidence to recommendation sections' following the recommendations.

3.6.1 Research recommendations

When areas were identified for which good evidence was lacking, the GDG considered making recommendations for future research. Decisions about inclusion were based on factors such as:

- the importance to patients or the population
- national priorities
- potential impact on the NHS and future NICE guidance
- ethical and technical feasibility.

3.6.2 Validation process

The guidance is subject to an eight week public consultation and feedback as part of the quality assurance and peer review of the document. All comments received from registered stakeholders are responded to individually and posted on the NICE website when the pre-publication check of the full guideline occurs.

3.6.3 Updating the guideline

A formal review of the need to update a guideline is usually undertaken by NICE after its publication. NICE will conduct a review to determine whether the evidence base has progressed significantly to alter the guideline recommendations and warrant an update.

3.6.4 Disclaimer

Healthcare providers need to use clinical judgement, knowledge and expertise when deciding whether it is appropriate to apply guidelines. The recommendations cited here are a guide and may not be appropriate for use in all situations. The decision to adopt any of the recommendations cited here must be made by practitioners in light of individual patient circumstances, the wishes of the patient, clinical expertise and resources.

The National Clinical Guideline Centre disclaims any responsibility for damages arising out of the use or non-use of these guidelines and the literature used in support of these guidelines.

3.6.5 Funding

The National Clinical Guideline Centre was commissioned by the National Institute for Health and Care Excellence to undertake the work on this guideline.

3.7 Guideline update methods (2007)

The guideline update was commissioned by NICE and developed in accordance with the guideline development process outlined in 'The guidelines manual' updated in April 2006[182]. Development prior to this stage (for example, development of the scope, early reviewing) was carried out using the methodology outlined in the previous version of the manual (March 2005).

3.7.1 Developing the clinical questions

Clinical questions were developed to guide the literature searching process and to facilitate the development of recommendations by the GDG.

The clinical questions were initially drafted by the review team and were refined and validated by the GDG. The questions were based on the scope (Appendix O).

3.7.2 Clinical literature search

The aim of the literature search was to identify relevant evidence within the published literature, in order to answer the clinical questions identified. Searches of clinical databases were performed using generic and specific filters, relevant medical subject heading terms and free-text terms. Non-English studies and abstracts were not included. Each database was searched up to 8 January 2007. Papers identified after this date were not routinely considered. Search strategies can be found in Appendix D. The following databases were included in the literature search to identify relevant journal articles:

- Medline (Dialog Datastar) 1951-2006
- Embase (Dialog Datastar) 1974-2006
- PsycINFO 1806-2006
- Health Economic and Evaluations Database (HEED)
- NHS Economic Evaluation Database (NHSEED)

Bibliographies of identified reports and guidelines were also checked to identify relevant literature. The internet was searched to identify guidelines and reports. The following web sites were used to help identify these:

- Members of the Guidelines International Network's web sites (http://www.g-i-n.net)
- National Institute for Health and Clinical Excellence (NICE) (www.nice.org.uk)
- National electronic Library for Health (NeLH) (http://www.nelh.nhs.uk)
- Scottish Intercollegiate Guideline Network (SIGN) (www.sign.ac.uk)
- US National Guideline Clearing House (www.guidelines.gov)
- CMA Infobase (http://mdm.ca/cpgsnew/cpgs/)
- NIH Consensus Development Program (http://consensus.nih.gov)
- New Zealand Guidelines Group (http://www.nzgg.org.nz)

3.7.3 The literature reviewing process

References identified by the systematic literature search were screened for appropriateness by title and abstract by an information scientist and systematic reviewer. The GDG also suggested further references and these were assessed in the same way.

Selected studies were ordered and assessed in full by the NCC-AC team using agreed inclusion/ exclusion criteria specific to the guideline topic, and using NICE methodology quality assessment checklists appropriate to the study design.[182]

3.7.4 Hierarchy of clinical evidence

There are many different methods of ranking the evidence and there has been considerable debate about which system is best. The system used for the update was the one developed by the Scottish Intercollegiate Guidelines Network (SIGN), shown in Table 6.

Table 6: Levels of evidence for intervention studies (reproduced with permission of the Scottish Intercollegiate Guidelines Network)

Level of evidence	Type of evidence
1++	High quality meta-analyses, systematic reviews of RCTs, or RCTs with a very low risk of bias
1+	Well-conducted meta-analyses, systematic reviews of RCTs, or RCTs with a low risk of bias
1-	Meta-analyses, systematic reviews of RCTs, or RCTs with a high risk of bias
2++	High quality systematic reviews of case–control or cohort studies High quality case–control or cohort studies with a very low risk of confounding, bias, or chance and a high probability that the relationship is causal
2+	Well-conducted case–control or cohort studies with a low risk of confounding, bias, or chance and a moderate probability that the relationship is causal
2-	Case–control or cohort studies with a high risk of confounding bias, or chance and a significant risk that the relationship is not causal
3	Non-analytic studies (For example, case reports, case series)
4	Expert opinion

For each clinical question the highest level of evidence was sought. Where an appropriate systematic review, meta-analysis or randomised controlled trial was identified, we did not search for studies of a weaker design.

Table 7: Levels of evidence for studies of the accuracy of diagnostic tests. Adapted from 'The Oxford Centre for Evidence-based Medicine Levels of Evidence' (2001) and the Centre for Reviews and Dissemination 'Report Number 4' (2001).

Levels of evidence	Type of evidence
Ia	Systematic review (with homogeneity)a of level-1 studies[a]
Ib	Level-1 studies[b]
II	Level-2 studies[c] Systematic reviews of level-2 studies
III	Level-3 studies[d] Systematic reviews of level-3 studies
IV	Consensus, expert committee reports or opinions and/or clinical experience without explicit critical appraisal; or based on physiology, bench research or 'first principles'

[a] Homogeneity means there are no or minor variations in the directions and degrees of results between individual studies that are included in the systematic review.

[b] Level-1 studies are studies:

- that use a blind comparison of the test with a validated reference standard (gold standard)
- in a sample of patients that reflects the population to whom the test would apply.

[c] Level-2 studies are studies that have only one of the following:

- narrow population (the sample does not reflect the population to whom the test would apply)
- a poor reference standard (defined as that where the 'test' is included in the 'reference', or where the 'testing' affects the 'reference')

Levels of evidence	Type of evidence
• a comparison between the test and reference standard that is not blind • case–control design. [d] Level-3 studies are studies that have at least two or three of the features listed for level-2 studies.	

3.7.5 Grading of recommendations

Following a public consultation in April 2006 NICE is no longer publishing grades alongside recommendations contained within its guidance. This full version will only contain the recommendation grading for the original sections that have not been updated.

3.7.6 Research recommendations

When areas were identified where there was a lack of evidence, the GDG considered making recommendations for future research. Decisions about inclusion were based on factors such as the importance to patients or the population, national priorities, and the potential impact on the NHS and future NICE guidance.

3.8 Methods (2003)

3.8.1 Guideline development group

A Guideline Development Group (GDG) representing all relevant professional and patient parties was formed in December 2001, under the Chairmanship of Professor David Yates from the Trauma Audit and Research Network.

3.8.2 Working principles

It was decided by the GDG to focus the full systematic reviewing methods used in these guidelines on the selection of which patients who have sustained a head injury should be referred for imaging of the head and cervical spine, given that these issues are at the heart of acute management of head injuries. It was agreed that brief literature reviews and formal consensus methods would be used to deal with the remaining topics.

For the purposes of the guidelines it was agreed that ‘infants’ are aged under 1 year, ‘children’ are 1-15 year olds and ‘adults’ are aged 16 years or more. In certain circumstances, the age group ‘infants and young children’ (that is, aged under 5 years) is used. Cut-off points of 10 years and 12 years are also used. ‘Head injury’ for the purposes of the guidelines is defined as any trauma to the head, other than superficial injuries to the face.

It was also agreed that the primary patient outcome of concern throughout the guideline development process would be defined as ‘clinically important brain injury'. It was agreed that need for neurosurgery was too limited a definition, given that the guideline scope calls for some means for the early identification of those patients that might benefit from neurorehabilitation. This deliberately broad definition of outcome also reflects the heterogeneity of brain injuries that may be experienced following a head injury.

3.8.3 Resources

The following databases were searched for literature for the period 1990 to 2002:

- Medline

- Embase
- The Cochrane Library – this includes:
- Cochrane Database of Systematic Reviews (CDSR)
- Database of Abstracts of Reviews of Effectiveness (DARE)
- Cochrane Controlled Trials Register (CCTR)
- Health Technology Assessment (HTA) Database
- NHS Economic Evaluations Database (NHS-EED)
- System for Information on Grey Literature in Europe (SIGLE)
- Health Management Information Consortium (HMIC)

In addition, reference lists of previous guidelines and key papers were used to identify other key references, including pre-1990 literature. Experts were contacted to identify other key literature. Grey literature was identified using NICE stakeholder contacts. The following web sites were also searched:

- Agency for Healthcare Research and Quality (AHRQ)
- Brain Trauma Foundation
- CMA Infobase – clinical practice guidelines
- Department of Health
- http://www.google.com
- National Guideline Clearing House (USA)
- National Research Register (NRR)
- Organising Medical Networked Information (OMNI)
- Scottish Intercollegiate Guideline Network
- Turning Research into Practice (TRIP) Database

No useful additional papers (that is, in addition to the grey literature already in our possession and the documents found during the database searches) were found using these methods, apart from a small number of documents of interest to the systematic review on radiation risks and CT of the head.

3.8.4 Consensus methods

Formal consensus methods were used to generate agreement regarding the recommendations for these guidelines. Consensus was used for all grades of recommendation, even those based on level one evidence, to ensure complete 'sign-up' by all GDG members to the final guidelines. An initial set of recommendations was circulated in questionnaire format, and GDG members rated their agreement with each recommendation on a nine point scale (strongly disagree to strongly agree). Separate ratings were made where relevant for infants, children and adults. A meeting was then held on July 25th 2002 to discuss the recommendations in the light of GDG responses to the questionnaire. A revised set of recommendations was drawn up following the meeting and again circulated to GDG members for their appraisal. At this stage there was near complete agreement with all recommendations, and only minor revisions in wording were required. The recommendations presented in this guideline are the result of the consensus exercise.

3.8.5 Systematic review of indications for CT of the head

This systematic review aimed to identify highly sensitive and specific clinical decision rules which could be used to select patients who are at high risk of clinically important brain injury, and who therefore should have CT imaging of the head.

This search produced 1454 abstracts in MEDLINE and 680 abstracts in EMBASE (after duplicates with MEDLINE were excluded). An initial screen for relevance was carried out by one systematic reviewer, which reduced the number of abstracts to 174 in MEDLINE and 68 in EMBASE. These abstracts were then independently read by two reviewers to identify those papers that should be obtained and read in full. At this point the only criteria used was the likelihood that the paper described a rule for the diagnosis of intracranial haematoma (ICH), clinically important brain injury or need for a neurosurgical intervention in patients who have recently sustained a head injury, and produced some data on the likely sensitivity and specificity of the rule. Both derivation and validation papers were selected.

The independent reviewing process produced 72 papers in MEDLINE and 20 papers in EMBASE. In total 92 papers were deemed worthy of review.

A brief description of the rule proposed was extracted. Many papers do not provide explicit description of the diagnostic strategies, inclusion criteria, or post-diagnosis management strategies (for example, eligibility for early discharge). The participant descriptions extracted were GCS levels, age, prevalence of important outcomes (especially intracranial haemorrhage) and the main inclusion and exclusion criteria. If a non-consecutive sample was described (for example, selection criteria was CT imaging where 100% CT imaging was not the rule being tested) this was noted. The outcomes extracted included the need for neurosurgery, ICH, intracranial injury and clinically important brain injury and CT ordering rate. Data on specificity and sensitivity were recorded where possible; 95% confidence intervals were also recorded or calculated if possible.

3.8.6 Systematic review of indications for imaging of the cervical spine

The systematic review aimed to identify clinical decision rules which could be used to select patients who are at high risk of clinically important cervical spine fracture, and who therefore should have three-view plain radiography followed by other imaging if these prove inadequate.

This search produced 863 abstracts in MEDLINE and 268 in EMBASE (after duplicates had been removed). An initial screen for relevance was carried out by one systematic reviewer, which reduced the number of abstracts to 142 papers in MEDLINE and 10 papers in EMBASE. These abstracts were then independently read by two reviewers to identify those papers that should be obtained and read in full. At this point the only criteria used was the likelihood that the paper described a rule for the diagnosis of cervical fracture, and produced some data on the likely sensitivity and specificity of the rule. Both derivation and validation papers were selected.

The independent reviewing process produced 78 papers in MEDLINE and 7 papers in EMBASE. In total 85 papers were deemed worthy of review.

A brief description of the rule proposed was extracted. Many papers did not provide an explicit description of the diagnostic strategies, inclusion criteria, or post-diagnosis management strategies (for example, eligibility for early discharge).

Participant details extracted included symptom status, alertness, age, number of centres, prevalence of important outcomes, the country of study and the main inclusion and exclusion criteria. The outcomes that the rule is intended to detect were noted. These included clinically important cervical fracture, unimportant cervical spine fracture, need for surgery and internal or external fixation. The radiography ordering rate was also noted as an outcome. Data on specificity and sensitivity were recorded where possible; 95% confidence intervals were also recorded or calculated if possible.

3.8.7 Systematic review of means of identifying patients at high risk of late sequelae following head injury

This systematic review aimed to identify clinical decision rules that could be used to select patients who are at high risk of late sequelae following head injury, and who therefore should be followed up so that potential long term problems can be identified.

The original search for CT algorithms for the identification of prognostic variables for intracranial haematoma produced 1454 abstracts in MEDLINE and 680 abstracts in EMBASE (after duplicates with MEDLINE were excluded). This full abstract list was reviewed to look for papers that may be of relevance to disability. After this a search was performed on Medline and Embase, listed in Appendix 1 for prognosis of minor/mild head injury. Experts were also contacted for relevant papers. The search of the 1454 abstracts revealed 152 potentially interesting papers. The additional MEDLINE and EMBASE search revealed 48 papers not previously seen of which eight abstracts looked to be of relevance. Experts provided three useful papers. These abstracts were then independently read by two reviewers to identify those papers that should be obtained and read in full. At this point the only criteria used was the likelihood that the paper might describe a rule or provide factors in the acute assessment of the patient that might predict post-concussional syndrome. After this assessment 23 papers were selected for review

A brief description of the rule proposed was extracted. Only one paper actually proposed a rule. Participant description focused on GCS levels, age, and the main inclusion and exclusion criteria. The outcome measures used were extracted. The definitions of long term disability or post-concussive were heterogeneous. Data on specificity and sensitivity were recorded where possible. As only one paper provided a rule, these figures could only be calculated for this one paper. The prevalence of important outcomes was also recorded. A previous systematic review was also available to the project team and this informed the review.

3.8.8 Systematic review of medical radiation risks

This review aimed to provide simple estimates of the radiation risks associated with CT of the head. The search produced 654 abstracts in MEDLINE and 260 in EMBASE (after duplicates had been removed). A search using the Google search engine revealed useful documents from the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) and the National Radiological Protection Board (NRPB). Personal communications with the National Radiological Protection Board also provided papers and data which contributed to the review. Following abstract review and including the papers supplied by experts, 80 full articles were obtained and were reviewed to determine relevance. This identified 16 documents considered of relevance and these contributed to the text of this guideline.

4 Guideline summary

4.1 Algorithms

Figure 2: Selection of adults for CT head scan

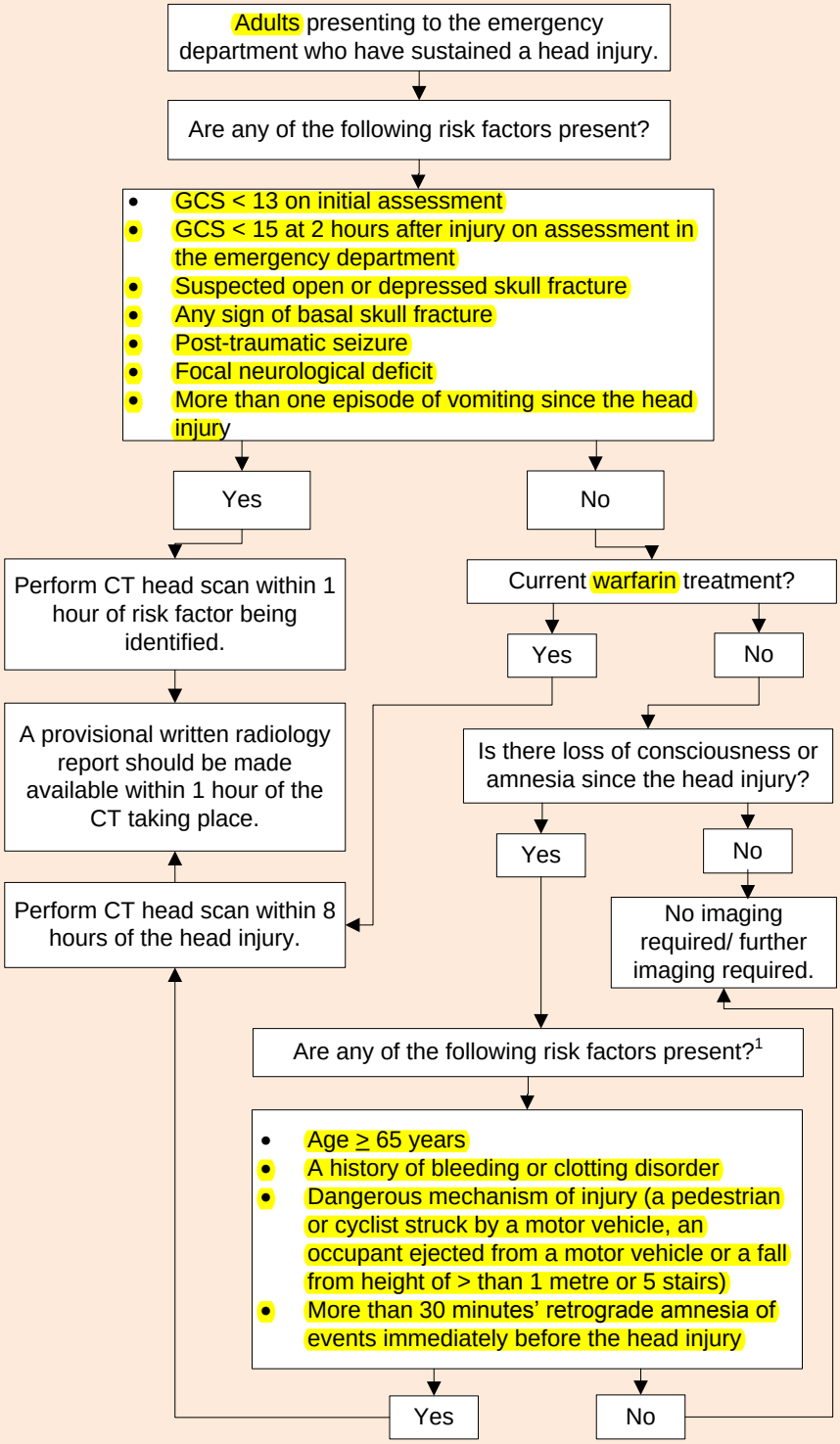


Figure 3: Selection of children for CT head scan

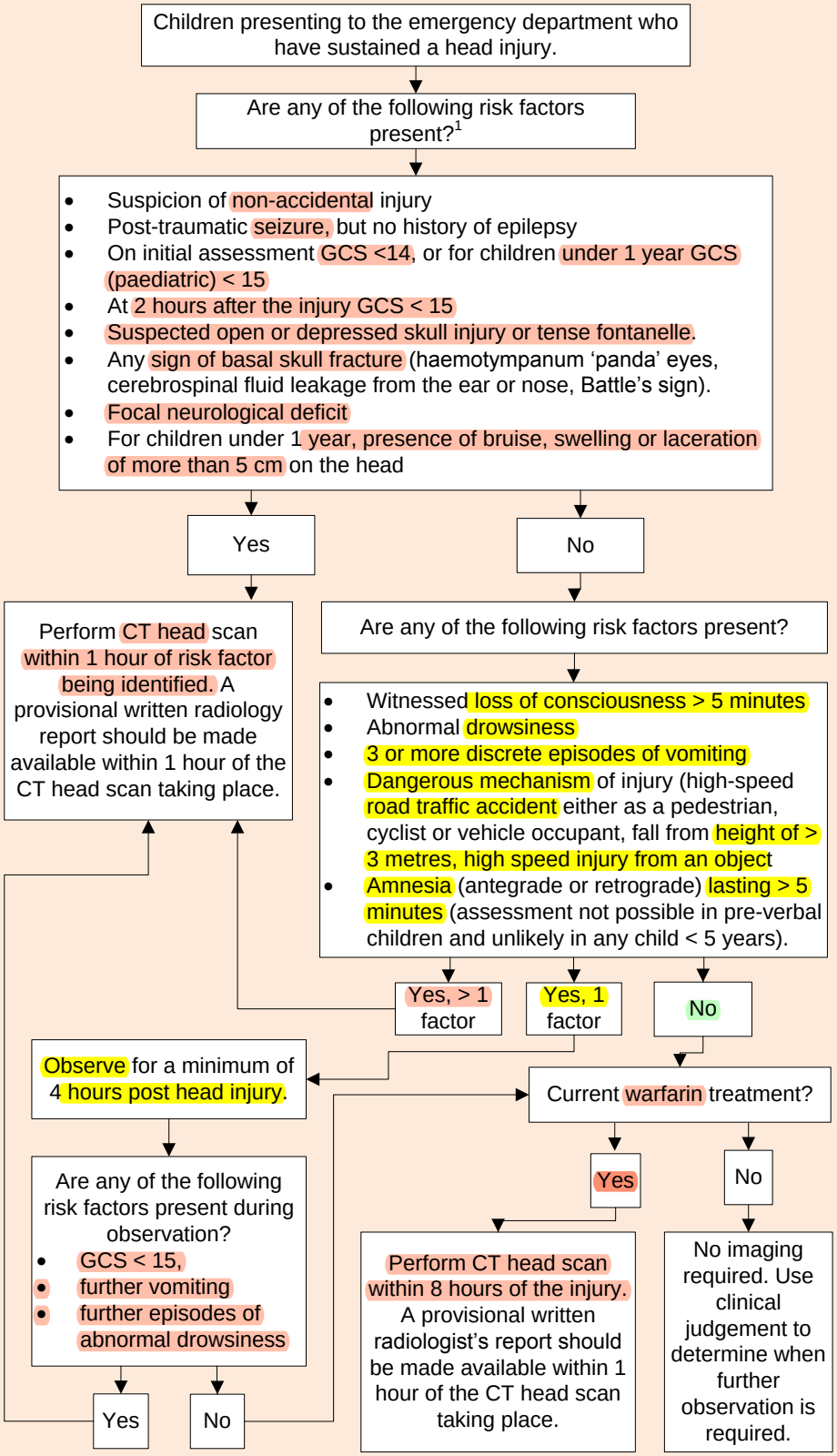


Figure 4: Selection of adults for imaging of the cervical spine

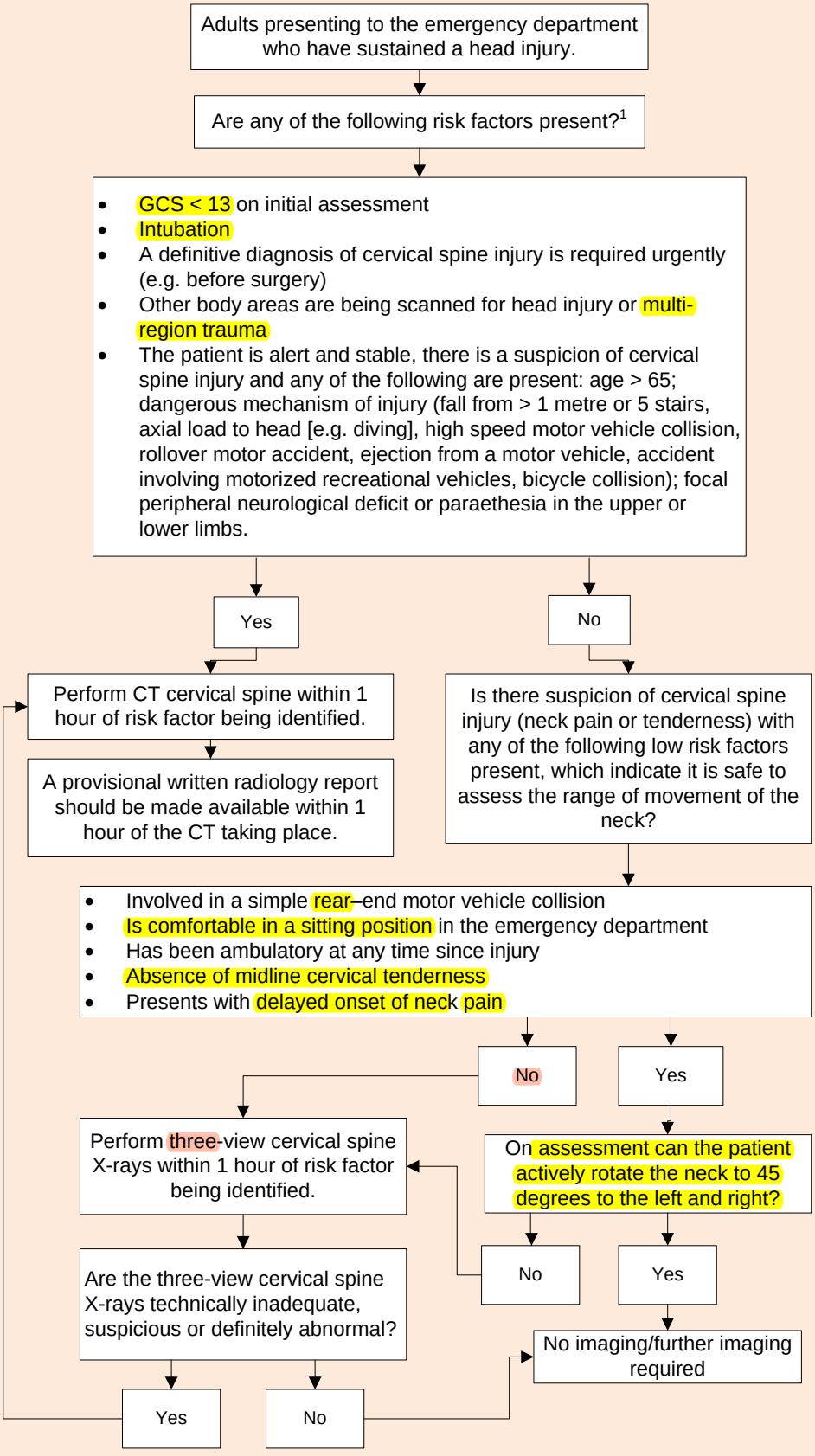
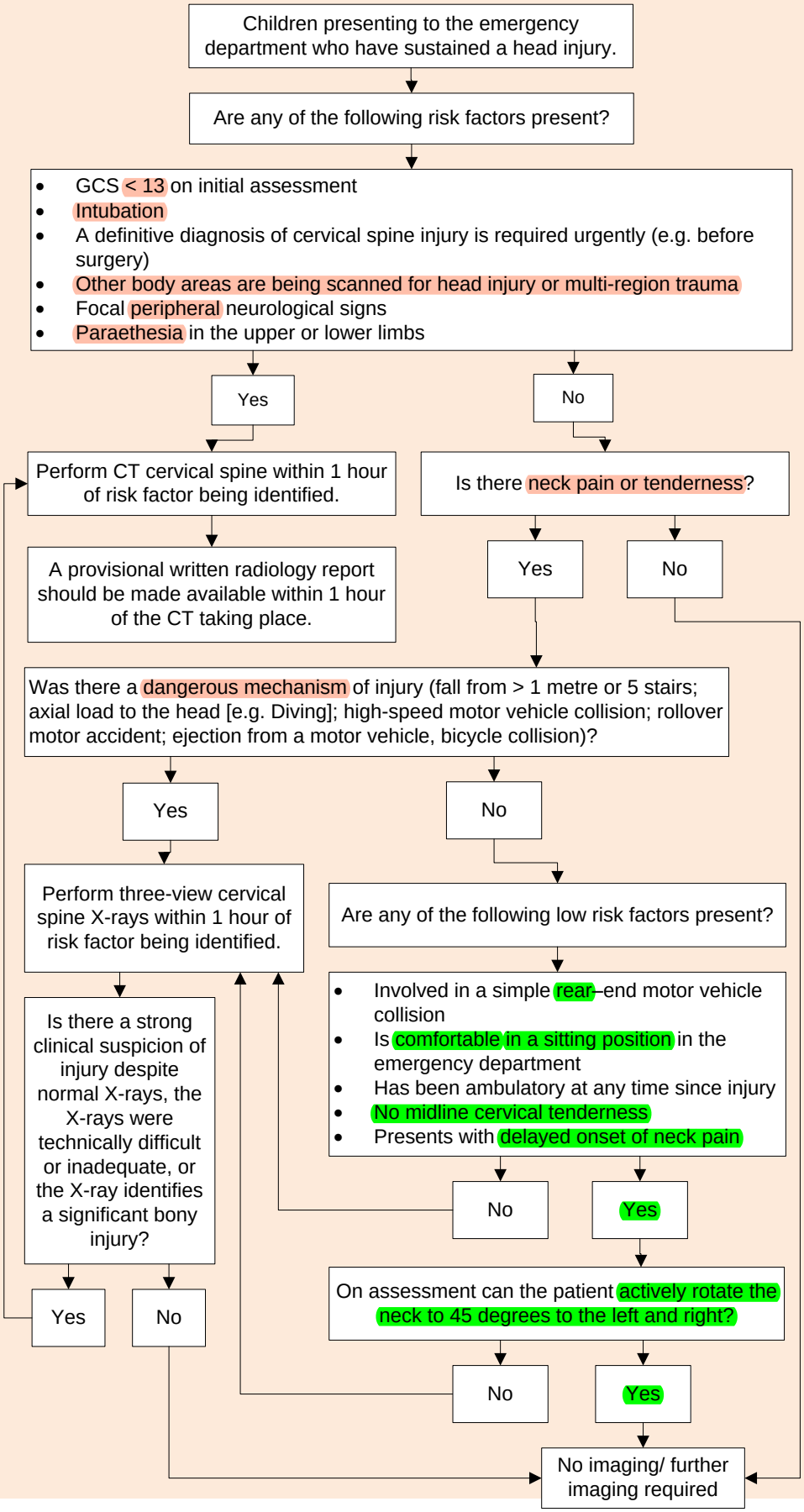


Figure 5: Selection of children for imaging of the cervical spine



4.2 Key priorities for implementation

From the full set of recommendations, the GDG selected 10 key priorities for implementation. The criteria used for selecting these recommendations are listed in detail in The Guidelines Manual.[185] The reasons that each of these recommendations was chosen are shown in the table linking the evidence to the recommendation in the relevant chapter.

25. Transport patients who have sustained a head injury directly to a hospital that has the resources to further resuscitate them and to investigate and initially manage multiple injuries. All acute hospitals receiving patients with head injury directly from an incident should have these resources, which should be appropriate for a patient's age[a]. [new 2014]

26. For adults who have sustained a head injury and have any of the following risk factors, perform a CT head scan within 1 hour of the risk factor being identified:

- **GCS less than 13 on initial assessment in the emergency department.**
- **GCS less than 15 at 2 hours after the injury on assessment in the emergency department.**
- **Suspected open or depressed skull fracture.**
- **Any sign of basal skull fracture (haemotympanum, 'panda' eyes, cerebrospinal fluid leakage from the ear or nose, Battle's sign).**
- **Post-traumatic seizure.**
- **Focal neurological deficit.**
- **More than 1 episode of vomiting.**

A provisional written radiology report should be made available within 1 hour of the scan being performed. [new 2014]

28. For patients (adults and children) who have sustained a head injury with no other indications for a CT head scan and who are having warfarin treatment, perform a CT head scan within 8 hours of the injury. A provisional written radiology report should be made available within 1 hour of the scan being performed. [new 2014]

29. For children who have sustained a head injury and have any of the following risk factors, perform a CT head scan within 1 hour of the risk factor being identified:

- **Suspicion of non-accidental injury.**
- **Post-traumatic seizure but no history of epilepsy.**
- **On initial emergency department assessment GCS less than 14, or for children under 1 year, GCS (paediatric) less than 15.**
- **At 2 hours after the injury, GCS less than 15.**
- **Suspected open or depressed skull fracture or tense fontanelle.**
- **Any sign of basal skull fracture (haemotympanum, 'panda' eyes, cerebrospinal fluid leakage from the ear or nose, Battle's sign).**
- **Focal neurological deficit.**
- **For children under 1 year, presence of bruise, swelling or laceration of more than 5 cm on the head.**

a In the NHS in England these hospitals would be Trauma Units or Major Trauma Centres. In the NHS in Wales this should be a hospital with equivalent capabilities.

A provisional written radiology report should be made available within 1 hour of the scan being performed. [new 2014]

30. For children who have sustained a head injury and have more than one of the following risk factors (and none of those in recommendation 29), perform a CT head scan within 1 hour of the risk factors being identified:

- **Loss of consciousness lasting more than 5 minutes (witnessed).**
- **Abnormal drowsiness.**
- **Three or more discrete episodes of vomiting.**
- **Dangerous mechanism of injury (high-speed road traffic accident either as pedestrian, cyclist or vehicle occupant, fall from a height of greater than 3 metres, high-speed injury from a projectile or other object).**
- **Amnesia (antegrade or retrograde) lasting more than 5 minutes.[b]**

A provisional written radiology report should be made available within 1 hour of the scan being performed. [new 2014]

31. Children who have sustained a head injury and have only 1 of the risk factors in recommendation 30 (and none of those in recommendation 29) should be observed for a minimum of 4 hours after the head injury. If during observation any of the risk factors below are identified, perform a CT head scan within 1 hour.

- **GCS less than 15.**
- **Further vomiting.**
- **A further episode of abnormal drowsiness.**

A provisional written radiology report should be made available within 1 hour of the scan being performed. If none of these risk factors occur during observation, use clinical judgement to determine whether a longer period of observation is needed. [new 2014]

37. A clinician with training in safeguarding should be involved in the initial assessment of any patient with a head injury presenting to the emergency department. If there are any concerns identified, document these and follow local safeguarding procedures appropriate to the patient's age. [2003, amended 2014]

45. For adults who have sustained a head injury and have any of the following risk factors, perform a CT cervical spine scan within 1 hour of the risk factor being identified:

- **GCS less than 13 on initial assessment.**
- **The patient has been intubated.**
- **Plain X-rays are technically inadequate (for example, the desired view is unavailable).**
- **Plain X-rays are suspicious or definitely abnormal.**
- **A definitive diagnosis of cervical spine injury is needed urgently (for example, before surgery).**
- **The patient is having other body areas scanned for head injury or multi-region trauma.**
- **The patient is alert and stable, there is clinical suspicion of cervical spine injury and any of the following apply:**

i. age 65 years or older

b Assessment of amnesia will not be possible in preverbal children and is unlikely to be possible in children aged under 5 years.

ii. **dangerous mechanism of injury (fall from a height of greater than 1 metre or 5 stairs; axial load to the head, for example, diving; high-speed motor vehicle collision; rollover motor accident; ejection from a motor vehicle; accident involving motorised recreational vehicles; bicycle collision)**

iii. **focal peripheral neurological deficit**

iv. **paraesthesia in the upper or lower limbs.**

A provisional written radiology report should be made available within 1 hour of the scan being performed. [new 2014]

86. **Give verbal and printed discharge advice to patients with any degree of head injury who are discharged from an emergency department or observation ward, and their families and carers. Follow recommendations in Patient experience in adult NHS services [NICE clinical guideline 138] about providing information in an accessible format). [new 2014]**

87. **Printed advice for patients, family members and carers should be age-appropriate and include:**

- **Details of the nature and severity of the injury.**
- **Risk factors (see recommendation 4 and 5) that mean patients need to return to the emergency department.**
- **A specification that a responsible adult should stay with the patient for the first 24 hours after their injury**
- **Details about the recovery process, including the fact that some patients may appear to make a quick recovery, but later experience difficulties or complications.**
- **Contact details of community and hospital services in case of delayed complications.**
- **Information about return to everyday activities, including school, work, sports and driving.**
- **Details of support organisations. [new 2014]**

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4.3 Full list of recommendations

1. **Public health literature and other non-medical sources of advice (for example, St John Ambulance, police officers) should encourage people who have any concerns following a head injury to themselves or to another person, regardless of the injury severity, to seek immediate medical advice. [2003]**

2. **Telephone advice services (for example, NHS 111, emergency department helplines) should refer patients who have sustained a head injury to the emergency ambulance services (that is, 999) for emergency transport to the emergency department if they have experienced any of the following:**
   - **Unconsciousness or lack of full consciousness (for example, problems keeping eyes open).**
   - **Any focal neurological deficit since the injury.**
   - **Any suspicion of a skull fracture or penetrating head injury.**
   - **Any seizure ('convulsion' or 'fit') since the injury.**
   - **A high-energy head injury.**
   - **The injured person or their carer is incapable of transporting the injured person safely to the hospital emergency department without the use of ambulance services (providing any other risk factor indicating emergency department referral is present; see recommendation 3). [2003, amended 2007 and 2014]**

3. **Telephone advice services (for example, NHS 111 or emergency department helplines) should refer patients who have sustained a head injury to a hospital emergency department if they have any of the following risk factors:**
   - **Any loss of consciousness ('knocked out') as a result of the injury, from which the person has now recovered.**
   - **Amnesia for events before or after the injury ('problems with memory').[c]**
   - **Persistent headache since the injury.**
   - **Any vomiting episodes since the injury.**
   - **Any previous brain surgery.**
   - **Any history of bleeding or clotting disorders.**
   - **Current anticoagulant therapy such as warfarin.**
   - **Current drug or alcohol intoxication.**
   - **There are any safeguarding concerns (for example, possible non-accidental injury or a vulnerable person is affected).**
   - **Irritability or altered behaviour ('easily distracted', 'not themselves', 'no concentration', 'no interest in things around them') particularly in infants and children aged under 5 years.**
   - **Continuing concern by helpline staff about the diagnosis. [2003, amended 2014]**

4. **Community health services (GPs, ambulance crews, NHS walk-in centres, dental practitioners) and NHS minor injury clinics should refer patients who have sustained a head injury to a hospital emergency department, using the ambulance service if deemed necessary, if any of the following are present:**
   - **Glasgow Coma Scale (GCS) score of less than 15 on initial assessment.**
   - **Any loss of consciousness as a result of the injury.**
   - **Any focal neurological deficit since the injury.**

[c] Assessment of amnesia will not be possible in preverbal children and is unlikely to be possible in children aged under 5 years.

- **Any suspicion of a skull fracture or penetrating head injury since the injury.**
- **Amnesia for events before or after the injury.**[d]
- **Persistent headache since the injury.**
- **Any vomiting episodes since the injury (clinical judgement should be used regarding the cause of vomiting in those aged 12 years or younger and the need for referral).**
- **Any seizure since the injury.**
- **Any previous brain surgery.**
- **A high-energy head injury.**
- **Any history of bleeding or clotting disorders.**
- **Current anticoagulant therapy such as warfarin.**
- **Current drug or alcohol intoxication.**
- **There are any safeguarding concerns (for example, possible non-accidental injury or a vulnerable person is affected).**
- **Continuing concern by the professional about the diagnosis. [2003, amended 2007 and 2014]**

5. **In the absence of any risk factors in recommendation 4, consider referral to an emergency department if any of the following factors are present, depending on judgement of severity:**
   - **Irritability or altered behaviour, particularly in infants and children aged under 5 years.**
   - **Visible trauma to the head not covered in recommendation 4 but still of concern to the professional.**
   - **No one is able to observe the injured person at home.**
   - **Continuing concern by the injured person or their family or carer about the diagnosis. [2003, amended 2014]**

6. **Patients referred from community health services and NHS minor injury clinics should be accompanied by a competent adult during transport to the emergency department. [2003]**

7. **The referring professional should determine if an ambulance is required, based on the patient's clinical condition. If an ambulance is deemed not required, public transport and car are appropriate means of transport providing the patient is accompanied. [2003]**

8. **The referring professional should inform the destination hospital (by phone) of the impending transfer and in non-emergencies a letter summarising signs and symptoms should be sent with the patient. [2003]**

9. **GPs, nurse practitioners, dentists and ambulance crews should receive training, as necessary, to ensure that they are capable of assessing the presence or absence of the risk factors listed in recommendations 4 and 5. [2003, amended 2007]**

10. **Initially assess adults who have sustained a head injury and manage their care according to clear principles and standard practice, as embodied in the:**
    - **Advanced Trauma Life Support (ATLS) course/European Trauma course.**
    - **International Trauma Life Support (ITLS) course.**
    - **Pre-hospital Trauma Life Support (PHTLS) course.**
    - **Advanced Trauma Nurse Course (ATNC).**
    - **Trauma Nursing Core Course (TNCC).**

[d] Assessment of amnesia will not be possible in preverbal children and is unlikely to be possible in children aged under 5 years.

- **Joint Royal Colleges Ambulance Service Liaison Committee (JRCALC) Clinical Practice Guidelines for Head Trauma. [2003, amended 2007]**

11. **Initially assess children who have sustained a head injury and manage their care according to clear principles outlined in the:**
    - **Advanced Paediatric Life Support (APLS)/European Paediatric Life Support (EPLS) course.**
    - **Pre-hospital Paediatric Life Support (PHPLS) course.**
    - **Paediatric Education for Pre-hospital Professionals (PEPP) course. [2003, amended 2007]**
12. **Ambulance crews should be fully trained in the use of the adult and paediatric versions of the GCS and its derived score. [2003]**
13. **Ambulance crews should be trained in the safeguarding of children and vulnerable adults and should document and verbally inform emergency department staff of any safeguarding concerns. [2003, amended 2014]**
14. **When administering immediate care, treat first the greatest threat to life and avoid further harm. [2003]**
15. **Attempt full cervical spine immobilisation for patients who have sustained a head injury and present with any of the following risk factors unless other factors prevent this:**
    - **GCS less than 15 on initial assessment by the healthcare professional.**
    - **Neck pain or tenderness.**
    - **Focal neurological deficit.**
    - **Paraesthesia in the extremities.**
    - **Any other clinical suspicion of cervical spine injury. [2003, amended 2007]**
16. **Maintain cervical spine immobilisation until full risk assessment including clinical assessment (and imaging if deemed necessary) indicates it is safe to remove the immobilisation device. [2003, amended 2007]**
17. **Make standby calls to the destination emergency department for all patients with GCS 8 or less to ensure appropriately experienced professionals are available for their treatment and to prepare for imaging. [2003]**
18. **Manage pain effectively because it can lead to a rise in intracranial pressure. Provide reassurance, splintage of limb fractures and catheterisation of a full bladder, where needed.. [2007, amended 2014]**
19. **Base monitoring and exchange of information about individual patients on the three separate responses on the GCS (for example, a patient scoring 13 based on scores of 4 on eye-opening, 4 on verbal response and 5 on motor response should be communicated as E4, V4, M5). [2003]**
20. **If a total score is recorded or communicated, base it on a sum of 15, and to avoid confusion specify this denominator (for example, 13/15). [2003]**
21. **Describe the individual components of the GCS in all communications and every note and ensure that they always accompany the total score. [2003]**
22. **In the paediatric version of the GCS, include a 'grimace' alternative to the verbal score to facilitate scoring in preverbal children. [2003]**
23. **In some patients (for example, patients with dementia, underlying chronic neurological disorders or learning disabilities) the pre-injury baseline GCS may be less than 15. Establish this where possible, and take it into account during assessment. [new 2014]**

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24. Follow at all times best practice in paediatric coma observation and recording as detailed by the National Paediatric Neuroscience Benchmarking Group. [2003]

25. Transport patients who have sustained a head injury directly to a hospital that has the resources to further resuscitate them and to investigate and initially manage multiple injuries. All acute hospitals receiving patients with head injury directly from an incident should have these resources, which should be appropriate for a patient's age[e]. [new 2014]

26. For adults who have sustained a head injury and have any of the following risk factors, perform a CT head scan within 1 hour of the risk factor being identified:

- **GCS less than 13 on initial assessment in the emergency department.**
- **GCS less than 15 at 2 hours after the injury on assessment in the emergency department.**
- **Suspected open or depressed skull fracture.**
- **Any sign of basal skull fracture (haemotympanum, 'panda' eyes, cerebrospinal fluid leakage from the ear or nose, Battle's sign).**
- **Post-traumatic seizure.**
- **Focal neurological deficit.**
- **More than 1episode of vomiting.**

A provisional written radiology report should be made available within 1 hour of the scan being performed. [new 2014]

27. For adults with any of the following risk factors who have experienced some loss of consciousness or amnesia since the injury, perform a CT head scan within 8 hours of the head injury:

- **Age 65 years or older.**
- **Any history of bleeding or clotting disorders.**
- **Dangerous mechanism of injury (a pedestrian or cyclist struck by a motor vehicle, an occupant ejected from a motor vehicle or a fall from a height of greater than 1 metre or 5 stairs).**
- **More than 30 minutes' retrograde amnesia of events immediately before the head injury.**

A provisional written radiology report should be made available within 1 hour of the scan being performed. [new 2014]

28. For patients (adults and children) who have sustained a head injury with no other indications for a CT head scan and who are having warfarin treatment, perform a CT head scan within 8 hours of the injury. A provisional written radiology report should be made available within 1 hour of the scan being performed. [new 2014]

29. For children who have sustained a head injury and have any of the following risk factors, perform a CT head scan within 1 hour of the risk factor being identified:

- **Suspicion of non-accidental injury.**
- **Post-traumatic seizure but no history of epilepsy.**
- **On initial emergency department assessment, GCS less than 14, or for children under 1 year GCS (paediatric) less than 15.**
- **At 2 hours after the injury, GCS less than 15.**

e In the NHS in England these hospitals would be Trauma Units or Major Trauma Centres. In the NHS in Wales this should be a hospital with equivalent capabilities.

- **Suspected open or depressed skull fracture or tense fontanelle.**
- **Any sign of basal skull fracture (haemotympanum, 'panda' eyes, cerebrospinal fluid leakage from the ear or nose, Battle's sign).**
- **Focal neurological deficit.**
- **For children under 1 year, presence of bruise, swelling or laceration of more than 5 cm on the head.**

A provisional written radiology report should be made available within 1 hour of the scan being performed. [new 2014]

30. For children who have sustained a head injury and have more than one of the following risk factors (and none of those in recommendation 29), perform a CT head scan within 1 hour of the risk factors being identified:

- **Loss of consciousness lasting more than 5 minutes (witnessed).**
- **Abnormal drowsiness.**
- **Three or more discrete episodes of vomiting.**
- **Dangerous mechanism of injury (high-speed road traffic accident either as pedestrian, cyclist or vehicle occupant, fall from a height of greater than 3 metres, high-speed injury from a projectile or other object).**
- **Amnesia (antegrade or retrograde) lasting more than 5 minutes.**[f]

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A provisional written radiology report should be made available within 1 hour of the scan being performed. [new 2014]

31. Children who have sustained a head injury and have only 1 of the risk factors in recommendation 30 (and none of those in recommendation 29) should be observed for a minimum of 4 hours after the head injury. If during observation any of the risk factors below are identified, perform a CT head scan within 1 hour.

- **GCS less than 15.**
- **Further vomiting.**
- **A further episode of abnormal drowsiness.**

A provisional written radiology report should be made available within 1 hour of the scan being performed. If none of these risk factors occur during observation, use clinical judgement to determine whether a longer period of observation is needed. [new 2014]

32. The current primary investigation of choice for the detection of acute clinically important brain injuries is CT imaging of the head. [2003]

33. For safety, logistic and resource reasons, do not perform magnetic resonance imaging (MRI) scanning as the primary investigation for clinically important brain injury in patients who have sustained a head injury, although it is recognised that additional information of importance to the patient's prognosis can sometimes be detected using MRI. [2003]

34. Ensure that there is appropriate equipment for maintaining and monitoring the patient within the MRI environment and that all staff involved are aware of the dangers and necessary precautions for working near an MRI scanner. [2003]

[f] Assessment of amnesia will not be possible in preverbal children and is unlikely to be possible in children aged under 5 years.

35. **Do not use plain X-rays of the skull to diagnose significant brain injury without prior discussion with a neuroscience unit. However, they are useful as part of the skeletal survey in children presenting with suspected non-accidental injury. [2007]**

36. **If CT imaging is unavailable because of equipment failure, patients with GCS 15 may be admitted for observation. Arrangements should be in place for urgent transfer to a centre with CT scanning available should there be a clinical deterioration that indicates immediate CT scanning is necessary. [2007]**

37. **A clinician with training in safeguarding should be involved in the initial assessment of any patient with a head injury presenting to the emergency department. If there are any concerns identified, document these and follow local safeguarding procedures appropriate to the patient's age. [2003, amended 2014]**

38. **Be aware that, as a minimum, CT should cover any areas of concern or uncertainty on X-ray or clinical grounds. [2003]**

39. **Ensure that facilities are available for multiplanar reformatting and interactive viewing of CT cervical spine scans. [2003, amended 2014]**

40. **MR imaging is indicated if there are neurological signs and symptoms referable to the cervical spine. If there is suspicion of vascular injury (for example, vertebral malalignment, a fracture involving the foramina transversaria or lateral processes, or a posterior circulation syndrome), CT or MRI angiography of the neck vessels may be performed to evaluate for this.[2003, amended 2014]**

41. **Be aware that MRI may add important information about soft tissue injuries associated with bony injuries demonstrated by X-ray and/or CT. [2003]**

42. **MRI has a role in the assessment of ligamentous and disc injuries suggested by X-ray, CT or clinical findings. [2003]**

43. **In CT, routinely review on 'bone windows' the occipital condyle region for patients who have sustained a head injury. Reconstruction of standard head images onto a high-resolution bony algorithm is readily achieved with modern CT scanners. [2003]**

44. **In patients who have sustained high-energy trauma or are showing signs of lower cranial nerve palsy, pay particular attention to the region of the foramen magnum. If necessary, perform additional high-resolution imaging for coronal and sagittal reformatting while the patient is on the scanner table. [2003]**

45. **For adults who have sustained a head injury and have any of the following risk factors, perform a CT cervical spine scan within 1 hour of the risk factor being identified:**
    - **GCS less than 13 on initial assessment.**
    - **The patient has been intubated.**
    - **Plain X-rays are technically inadequate (for example, the desired view is unavailable).**
    - **Plain X-rays are suspicious or definitely abnormal.**
    - **A definitive diagnosis of cervical spine injury is needed urgently (for example, before surgery).**
    - **The patient is having other body areas scanned for head injury or multi-region trauma.**
    - **The patient is alert and stable, there is clinical suspicion of cervical spine injury and any of the following apply:**
        i. **age 65 years or older**

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ii. dangerous mechanism of injury (fall from a height of greater than 1 metre or 5 stairs; axial load to the head, for example, diving; high-speed motor vehicle collision; rollover motor accident; ejection from a motor vehicle; accident involving motorised recreational vehicles; bicycle collision)

iii. focal peripheral neurological deficit

iv. paraesthesia in the upper or lower limbs.

A provisional written radiology report should be made available within 1 hour of the scan being performed. [new 2014]

46. For adults who have sustained a head injury and have neck pain or tenderness but no indications for a CT cervical spine scan (see recommendation 45), perform 3-view cervical spine X-rays within 1 hour if either of these risk factors are identified:

- **It is not considered safe to assess the range of movement in the neck (see recommendation 47).**
- **Safe assessment of range of neck movement shows that the patient cannot actively rotate their neck to 45 degrees to the left and right.**

The X-rays should be reviewed by a clinician trained in their interpretation within 1 hour of being performed. [new 2014]

47. Be aware that in adults and children who have sustained a head injury and in whom there is clinical suspicion of cervical spine injury, range of movement in the neck can be assessed safely before imaging ONLY if no high-risk factors (see recommendations 45, 48 and 49) and at least one of the following low-risk features apply. The patient:

- **was involved in a simple rear-end motor vehicle collision**
- **is comfortable in a sitting position in the emergency department**
- **has been ambulatory at any time since injury**
- **has no midline cervical spine tenderness**
- **presents with delayed onset of neck pain. [new 2014]**

48. For children who have sustained a head injury, perform a CT cervical spine scan only if any of the following apply (because of the increased risk to the thyroid gland from ionising radiation and the generally lower risk of significant spinal injury):

- **GCS less than 13 on initial assessment.**
- **The patient has been intubated.**
- **Focal peripheral neurological signs.**
- **Paraesthesia in the upper or lower limbs.**
- **A definitive diagnosis of cervical spine injury is needed urgently (for example, before surgery).**
- **The patient is having other body areas scanned for head injury or multi-region trauma.**
- **There is strong clinical suspicion of injury despite normal X-rays.**
- **Plain X-rays are technically difficult or inadequate.**
- **Plain X-rays identify a significant bony injury.**

The scan should be performed within 1 hour of the risk factor being identified. A provisional written radiology report should be made available within 1 hour of the scan being performed. [new 2014]

49. **For children who have sustained a head injury and have neck pain or tenderness but no indications for a CT cervical spine scan (see recommendation 48), perform 3-view cervical spine X-rays before assessing range of movement in the neck if either of these risk factors are identified:**
    - **Dangerous mechanism of injury (that is, fall from a height of greater than 1 metre or 5 stairs; axial load to the head, for example, diving; high-speed motor vehicle collision; rollover motor accident; ejection from a motor vehicle; accident involving motorised recreational vehicles; bicycle collision).**
    - **Safe assessment of range of movement in the neck is not possible (see recommendation 47).**

    The X-rays should be carried out within 1 hour of the risk factor being identified and reviewed by a clinician trained in their interpretation within 1 hour of being performed. [new 2014]

50. **If range of neck movement can be assessed safely (see recommendation 47) in a child who has sustained a head injury and has neck pain or tenderness but no indications for a CT cervical spine scan, perform 3-view cervical spine X-rays if the child cannot actively rotate their neck 45 degrees to the left and right. The X-rays should be carried out within 1 hour of this being identified and reviewed by a clinician trained in their interpretation within 1 hour of being performed. [new 2014]**

51. **In children who can obey commands and open their mouths, attempt an odontoid peg view. [2003, amended 2014]**

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52. **Be aware that the priority for all emergency department patients is the stabilisation of airway, breathing and circulation (ABC) before attention to other injuries. [2003]**

53. **Ascribe depressed conscious level to intoxication only after a significant brain injury has been excluded. [2003]**

54. **All emergency department clinicians involved in the assessment of patients with a head injury should be capable of assessing the presence or absence of the risk factors for CT head and cervical spine imaging (recommendations 27 - 32 and recommendations 45 - 50). Training should be made available as required to ensure that this is the case. [2003]**

55. **Patients presenting to the emergency department with impaired consciousness (GCS less than 15) should be assessed immediately by a trained member of staff. [2003]**

56. **In patients with GCS 8 or less, ensure there is early involvement of an anaesthetist or critical care physician to provide appropriate airway management, as described in recommendations 69 and 70, and to assist with resuscitation. [2003]**

57. **A trained member of staff should assess all patients presenting to an emergency department with a head injury within a maximum of 15 minutes of arrival at hospital. Part of this assessment should establish whether they are high risk or low risk for clinically important brain injury and/or cervical spine injury. Use recommendations 26 - 31 and recommendations 45 - 50 on patient selection and urgency for imaging (head and neck cervical spine). [2003]**

58. **In patients considered to be at high risk for clinically important brain injury and/or cervical spine injury, extend assessment to full clinical examination to establish the need to request CT imaging of the head and/or imaging of the cervical spine and other body areas. Use recommendations 26 - 31 and recommendations 45 - 50 as the basis for the final decision on imaging after discussion with the radiology department. [2003, amended 2007]**

59. **Patients who, on initial assessment, are considered to be at low risk for clinically important brain injury and/or cervical spine injury should be re-examined within a further hour by an emergency department clinician. Part of this assessment should fully establish the need to**

request CT imaging of the head and/or imaging of the cervical spine. Use recommendations 26 - 31 and recommendations 45 - 50 as the basis for the final decision on imaging after discussion with the radiology department. [2003, amended 2007]

60. Manage pain effectively because it can lead to a rise in intracranial pressure. Provide reassurance, splintage of limb fractures and catheterisation of a full bladder, where needed. Treat significant pain with small doses of intravenous opioids[g] titrated against clinical response and baseline cardiorespiratory measurements. [2007]

61. Throughout the hospital episode, use a standard head injury proforma in documentation when assessing and observing patients with a head injury. This form should be of a consistent format across all clinical departments and hospitals in which a patient might be treated. Use a separate proforma for those under 16 years. Areas to allow extra documentation should be included (for example, in cases of non-accidental injury). Examples of proforma that should be used in patients with head injury are provided in appendix O of the full guideline. [2003, amended 2007]

62. Discuss with a neurosurgeon the care of all patients with new, surgically significant abnormalities on imaging. The definition of 'surgically significant' should be developed by local neurosurgical centres and agreed with referring hospitals, along with referral procedures. [2003, amended 2014]

63. Regardless of imaging, other reasons for discussing a patient's care plan with a neurosurgeon include:

- **Persisting coma (GCS 8 or less) after initial resuscitation.**
- **Unexplained confusion which persists for more than 4 hours.**
- **Deterioration in GCS score after admission (greater attention should be paid to motor response deterioration).**
- **Progressive focal neurological signs.**
- **A seizure without full recovery.**
- **Definite or suspected penetrating injury.**
- **A cerebrospinal fluid leak. [2003]**

64. Local guidelines on the transfer of patients with head injuries should be drawn up between the referring hospital trusts, the neuroscience unit and the local ambulance service, and should recognise that:

- **transfer would benefit all patients with serious head injuries (GCS 8 or less) irrespective of the need for neurosurgery**
- **if transfer of those who do not require neurosurgery is not possible, ongoing liaison with the neuroscience unit over clinical management is essential. [2003, amended 2007]**

65. The possibility of occult extracranial injuries should be considered for adults with multiple injuries, and they should not be transferred to a service that is unable to deal with other aspects of trauma. [2007]

66. There should be a designated consultant in the referring hospital with responsibility for establishing arrangements for the transfer of patients with head injuries to a neuroscience unit and another consultant at the neuroscience unit with responsibility for establishing

[g] At the time of publication (January 2014), intravenous opioids did not have a UK marketing authorisation for this indication. The prescriber should follow relevant professional guidance, taking full responsibility for the decision. Informed consent should be obtained and documented. See the General Medical Council's Good practice in prescribing and managing medicines and devices for further information.

arrangements for communication with referring hospitals and for receipt of patients transferred. [2003]

67. Patients with head injuries requiring emergency transfer to a neuroscience unit should be accompanied by a doctor with appropriate training and experience in the transfer of patients with acute brain injury. They should be familiar with the pathophysiology of head injury, the drugs and equipment they will use and working in the confines of an ambulance (or helicopter if appropriate). They should have a dedicated and adequately trained assistant. They should be provided with appropriate clothing for the transfer, medical indemnity and personal accident insurance. Patients requiring non-emergency transfer should be accompanied by appropriate clinical staff. [2003, amended 2007]

68. Provide the transfer team responsible for transferring a patient with a head injury with a means of communicating changes in the patient's status with their base hospital and the neurosurgical unit during the transfer. [2003, amended 2014]

69. Although it is understood that transfer is often urgent, complete the initial resuscitation and stabilisation of the patient and establish comprehensive monitoring before transfer to avoid complications during the journey. Do not transport a patient with persistent hypotension, despite resuscitation, until the cause of the hypotension has been identified and the patient stabilised. [2003, amended 2007]

70. Intubate and ventilate all patients with GCS 8 or less requiring transfer to a neuroscience unit, and any patients with the indications detailed in recommendation 71. [2003]

71. Intubate and ventilate the patient immediately in the following circumstances:

- **Coma – not obeying commands, not speaking, not eye opening (that is, GCS 8 or less).**
- **Loss of protective laryngeal reflexes.**
- **Ventilatory insufficiency as judged by blood gases: hypoxaemia (PaO_2 < 13 kPa on oxygen) or hypercarbia ($PaCO_2$ > 6 kPa).**
- **Spontaneous hyperventilation causing $PaCO_2$ < 4 kPa.**
- **Irregular respirations. [2003, amended 2007]**

72. Use intubation and ventilation before the start of the journey in the following circumstances:

- **Significantly deteriorating conscious level (1 or more points on the motor score), even if not coma.**
- **Unstable fractures of the facial skeleton.**
- **Copious bleeding into mouth (for example, from skull base fracture).**
- **Seizures. [2003, amended 2007]**

73. Ventilate an intubated patient with muscle relaxation and appropriate short-acting sedation and analgesia. Aim for a PaO_2 greater than 13 kPa, $PaCO_2$ 4.5 to 5.0 kPa unless there is clinical or radiological evidence of raised intracranial pressure, in which case more aggressive hyperventilation is justified. If hyperventilation is used, increase the inspired oxygen concentration. Maintain the mean arterial pressure at 80 mm Hg or more by infusion of fluid and vasopressors as indicated. In children, maintain blood pressure at a level appropriate for the child's age. [2003, amended 2007]

74. Education, training and audit are crucial to improving standards of transfer; appropriate time and funding for these activities should be provided. [2003]

75. **Give family members and carers as much access to the patient as is practical during transfer. If possible, give them an opportunity to discuss the reasons for transfer and how the transfer process works with a member of the healthcare team. [2003, amended 2014]**

76. **Recommendations 64 - 75 were written for adults, but apply these principles equally to children and infants, providing that the paediatric modification of the GCS is used. [2003]**

77. **Service provision in the area of paediatric transfer to tertiary care should also follow the principles outlined in the National Service Framework for Paediatric Intensive Care. These do not conflict with the principles outlined in this section. [2003]**

78. **The possibility of occult extracranial injuries should be considered for children with multiple injuries. Do not transfer them to a service that is unable to deal with other aspects of trauma. [2007]**

79. **Transfer of a child or infant to a specialist neurosurgical unit should be undertaken by staff experienced in the transfer of critically ill children. [2003]**

80. **Give family members and carers as much access to their child as is practical during transfer. If possible, give them an opportunity to discuss the reasons for transfer and how the transfer process works with a member of the healthcare team. [2003, amended 2014]**

81. **If CT is not indicated on the basis of history and examination the clinician may conclude that the risk of clinically important brain injury to the patient is low enough to warrant transfer to the community, as long as no other factors that would warrant a hospital admission are present (for example, drug or alcohol intoxication, other injuries, shock, suspected non-accidental injury, meningism, cerebrospinal fluid leak) and there are appropriate support structures for safe transfer to the community and for subsequent care (for example, competent supervision at home). [2003]**

82. **After normal imaging of the head, the clinician may conclude that the risk of clinically important brain injury requiring hospital care is low enough to warrant transfer to the community, as long as the patient has returned to GCS equal to 15, and no other factors that would warrant a hospital admission are present (for example, drug or alcohol intoxication, other injuries, shock, suspected non-accidental injury, meningism, cerebrospinal fluid leak) and there are appropriate support structures for safe transfer to the community and for subsequent care (for example, competent supervision at home). [2003]**

83. **After normal imaging of the cervical spine the clinician may conclude that the risk of injury to the cervical spine is low enough to warrant transfer to the community, as long as the patient has returned to GCS equal to 15 and their clinical examination is normal, and no other factors that would warrant a hospital admission are present (for example, drug or alcohol intoxication, other injuries, shock, suspected non-accidental injury, meningism, cerebrospinal fluid leak) and there are appropriate support structures for safe transfer to the community and for subsequent care (for example, competent supervision at home). [2003]**

84. **Patients admitted after a head injury may be discharged after resolution of all significant symptoms and signs providing they have suitable supervision arrangements at home. [2003]**

85. **Do not discharge patients presenting with head injury until they have achieved GCS equal to 15, or normal consciousness in infants and young children as assessed by the paediatric version of the GCS. [2003]**

86. Give verbal and printed discharge advice to patients with any degree of head injury who are discharged from an emergency department or observation ward, and their families and carers. Follow recommendations in Patient experience in adult NHS services [NICE clinical guideline 138] about providing information in an accessible format. [new 2014]

87. Printed advice for patients, families and carers should be age-appropriate and include:

- **Details of the nature and severity of the injury.**
- **Risk factors that mean patients need to return to the emergency department (see recommendation 4 and 5).**
- **A specification that a responsible adult should stay with the patient for the first 24 hours after their injury**
- **Details about the recovery process, including the fact that some patients may appear to make a quick recovery but later experience difficulties or complications.**
- **Contact details of community and hospital services in case of delayed complications.**
- **Information about return to everyday activities, including school, work, sports and driving.**
- **Details of support organisations. [new 2014]**

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88. Offer information and advice on alcohol or drug misuse to patients who presented to the emergency department with drug or alcohol intoxication when they are fit for discharge. [2003]

89. Inform patients and their families and carers about the possibility of persistent or delayed symptoms following head injury and whom to contact if they experience ongoing problems. [new 2014]

90. For all patients who have attended the emergency department with a head injury, write to their GP within 48 hours of discharge, giving details of clinical history and examination. This letter should also be shared with health visitors (for pre-school children) and school nurses (school-age children). If appropriate, provide a copy of the letter for the patient and their family or carer. [new 2014]

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91. All patients with any degree of head injury should only be transferred to their home if it is certain that there is somebody suitable at home to supervise the patient. Discharge patients with no carer at home only if suitable supervision arrangements have been organised, or when the risk of late complications is deemed negligible. [2003]

92. When a patient who has undergone imaging of the head and/or been admitted to hospital experiences persisting problems, ensure that there is an opportunity available for referral from primary care to an outpatient appointment with a professional trained in assessment and management of sequelae of brain injury (for example, clinical psychologist, neurologist, neurosurgeon, specialist in rehabilitation medicine). [2003]

93. Patients who return to an emergency department within 48 hours of transfer to the community with any persistent complaint relating to the initial head injury should be seen by or discussed with a senior clinician experienced in head injuries, and considered for a CT scan. [2003]

94. Use the criteria below for admitting patients to hospital following a head injury:

- **Patients with new, clinically significant abnormalities on imaging.**
- **Patients whose GCS has not returned to 15 after imaging, regardless of the imaging results.**
- **When a patient has indications for CT scanning but this cannot be done within the appropriate period, either because CT is not available or because the patient is not sufficiently cooperative to allow scanning.**
- **Continuing worrying signs (for example, persistent vomiting, severe headaches) of concern to the clinician.**
- **Other sources of concern to the clinician (for example, drug or alcohol intoxication, other injuries, shock, suspected non-accidental injury, meningism, cerebrospinal fluid leak). [2003]**

95. Be aware that some patients may require an extended period in a recovery setting because of the use of general anaesthesia during CT imaging. [2003, amended 2007]

96. Admit patients with multiple injuries under the care of the team that is trained to deal with their most severe and urgent problem. [2003]

97. In circumstances where a patient with a head injury requires hospital admission, admit the patient only under the care of a team led by a consultant who has been trained in the management of this condition during their higher specialist training. The consultant and their team should have competence (defined by local agreement with the neuroscience unit) in assessment, observation and indications for imaging (see recommendations 26 - 31 and 45 - 50); inpatient management; indications for transfer to a neuroscience unit (see recommendations 64 to 80); and hospital discharge and follow-up (see recommendations 82 - 93). [2003, amended 2007]

98. In-hospital observation of patients with a head injury should only be conducted by professionals competent in the assessment of head injury. [2003]

99. For patients admitted for head injury observation the minimum acceptable documented neurological observations are: GCS; pupil size and reactivity; limb movements; respiratory rate; heart rate; blood pressure; temperature; blood oxygen saturation. [2003]

100. Perform and record observations on a half-hourly basis until GCS equal to 15 has been achieved. The minimum frequency of observations for patients with GCS equal to 15 should be as follows, starting after the initial assessment in the emergency department:

- **Half-hourly for 2 hours.**
- **Then 1-hourly for 4 hours.**
- **Then 2-hourly thereafter. [2003]**

101. Should the patient with GCS equal to 15 deteriorate at any time after the initial 2-hour period, observations should revert to half-hourly and follow the original frequency schedule. [2003]

102. Any of the following examples of neurological deterioration should prompt urgent reappraisal by the supervising doctor.

- **Development of agitation or abnormal behaviour.**
- **A sustained (that is, for at least 30 minutes) drop of 1 point in GCS score (greater weight should be given to a drop of 1 point in the motor response score of the GCS).**
- **Any drop of 3 or more points in the eye-opening or verbal response scores of the GCS, or 2 or more points in the motor response score.**
- **Development of severe or increasing headache or persisting vomiting.**
- **New or evolving neurological symptoms or signs such as pupil inequality or asymmetry of limb or facial movement. [2003, amended 2007]**

103. To reduce inter-observer variability and unnecessary referrals, a second member of staff competent to perform observation should confirm deterioration before involving the supervising doctor. This confirmation should be carried out immediately. Where a confirmation cannot be performed immediately (for example, no staff member available to perform the second observation) the supervising doctor should be contacted without the confirmation being performed. [2003]

104. If any of the changes noted in recommendation 102 are confirmed, an immediate CT scan should be considered, and the patient's clinical condition re-assessed and managed appropriately. [2003, amended 2007]

105. In the case of a patient who has had a normal CT-scan but who has not achieved GCS equal to 15 after 24 hours' observation, a further CT scan or MRI scanning should be considered and discussed with the radiology department. [2003]

106. Observation of infants and young children (that is, aged under 5 years) is a difficult exercise and therefore should only be performed by units with staff experienced in the observation of infants and young children with a head injury. Infants and young children may be observed in normal paediatric observation settings, as long as staff have the appropriate experience. [2003]

107. Medical, nursing and other staff caring for patients with head injury admitted for observation should all be capable of performing the observations listed in 99, 102 and 103 above. [2003]

108. The acquisition and maintenance of observation and recording skills require dedicated training and this should be made available to all relevant staff. [2003]

109. Specific training is required for the observation of infants and young children. [2003]

110. Staff caring for patients with a head injury should introduce themselves to family members or carers and briefly explain what they are doing. [2003, amended 2014] Update 2014

111. Ensure that information sheets detailing the nature of head injury and any investigations likely to be used are made available in the emergency department. NICE's 'Information for the public' about this guideline may be helpful. [2003]

112. Staff should consider how best to share information with children and introduce them to the possibility of long-term complex changes in their parent or sibling. Literature produced by patient support groups may be helpful. [2003]

113. Encourage family members and carers to talk and make physical contact (for example, holding hands) with the patient. However, it is important that relatives and friends do not feel obliged to spend long periods at the bedside. If they wish to stay with the patient, encourage them to take regular breaks. [2003, amended 2007]

114. Ensure there is a board or area displaying leaflets or contact details for patient support organisations either locally or nationally to enable family members and carers to gather further information. [2003]

115. In line with good radiation exposure practice, make every effort to minimise radiation dose during imaging of the head and cervical spine, while ensuring that image quality and coverage is sufficient to achieve an adequate diagnostic study. [2003]

4.4 Key research recommendations

1. **Is the clinical outcome of patients with head injury with a reduced level of consciousness improved by direct transport from the scene of injury to a tertiary centre with neuroscience facilities compared with the outcome of those who are transported initially to the nearest hospital without neurosurgical facilities?**

2. **What is the clinical and cost effectiveness of the 2014 NICE guideline recommendation on CT head scanning versus clinical decision rules including CHALICE, CATCH and PECARN for selection of children and infants for head CT scan?**

3. **In patients with head injury does the use of antiplatelet and anticoagulant drugs increase the risk of intracranial haemorrhage over and above factors included in the current recommendations for CT head scans?**

4. **In adults with medium risk indications for brain injury under current NICE CT head injury guidance, what is the clinical and cost effectiveness of using the diagnostic circulating biomarker S100B to rule out significant intracranial injury?**

5. **Research is needed to summarise and identify the optimal predictor variables for long-term sequelae following mild traumatic brain injury. A systematic review of the literature could be used to derive a clinical decision rule to identify relevant patients at the time of injury. This would in turn lay the foundation for a derivation cohort study.**

5 Pre-hospital assessment, advice and referral to hospital

5.1 Predictor variables (2003)

A large number of people sustain head injuries each year many of which are sufficiently minor to not require medical attention. Advice to the public and community services should focus on the variables known to elevate the risk of clinically important brain injury or another head wound that may require surgical repair. A large number of variables have been identified as elevating the risk of these outcomes after head injury.

5.2 Loss of consciousness (2003)

A history of altered consciousness after a head injury increases the risk of intracranial complications although the absolute risk remains low.[233,269] There is controversy regarding the importance of momentary loss of consciousness, and the variable is, by definition, difficult to measure when no independent observer is available. There is evidence that intracranial complications can occur even when no loss of consciousness has occurred, but most studies in this area exclude patients who have not experienced a loss of consciousness, resulting in a paucity of literature on this aspect of risk.

5.3 Amnesia (2003)

Amnesia after head injury increases the risk of intracranial complications, although the length and type of amnesia are controversial.[233,269] Amnesia is usually defined as post-traumatic (anterograde – for events after the trauma) in the literature but a recent important study has suggested that retrograde amnesia (that is, for memories before the trauma) is a more important risk factor.[258] Amnesia is a less useful predictor variable in infants and young children, simply because it is difficult to measure.

5.4 Neurological signs (2003)

Post-traumatic neurological signs such as focal neurological deficits or seizure are highly associated with the risk of an intracranial complication[268] and the risk is so large that these patients are commonly excluded from studies developing clinical decision rules for the management of acute head injury.

5.5 Bleeding disorders and use of anticoagulants (2003)

Patients with coagulopathy have an elevated risk of intracranial complications but the exact strength of this relationship has not been established.[127,227]

5.6 Skull fracture (2003)

It is accepted that the risk of intracranial complications is higher in patients with a diagnosis of skull fracture. It can be estimated that the risk of developing an intracranial haematoma is about 12 times higher in patients with a radiographically detected skull fracture than in patients without this diagnosis, based on an estimate of 38% sensitivity and 95% specificity produced by a meta-analysis of the value of the radiological diagnosis of skull fracture.[123] There is variation in diagnostic practice for skull fracture. Some guidelines advocate the use of skull X-ray in the diagnosis of skull fracture,[231]

while others advocate the use of signs alone (for example, cerebrospinal fluid leak, periorbital haematoma, depressed or open skull injury, penetrating injury).[258]

5.7 Age (2003)

An exact age threshold for identifying patients at high risk of intracranial complications following a head injury has not been identified, but it is clear that increasing age is associated with an increased risk and a poorer prognosis.[176] Commonly used thresholds are 60 years[8,117] and 65 years.[176,258] To avoid confusion, the GDG chose to adopt a standard age threshold throughout these guidelines of greater than or equal to 65 years. An odds ratio of 4.1 (95% CI: 2.8-6.1) for clinically important brain injury has been quoted with this threshold, providing the patient has experienced loss of consciousness or amnesia.[258]

There is evidence that the prevalence of intracranial complications in children and infants is much lower than in adults. However, this should be weighed against the fact that an unknown, but significant, proportion of head injuries in children are non-accidental. These injuries may result in a different pattern of morbidity to that seen in adults, and obviously require investigation regardless of cause.

5.8 Mechanism of injury (2003)

High energy injury mechanisms have an intuitive appeal in determining the risk of intracranial complications but there are difficulties with providing an exact definition of 'high energy'. Terms such as 'assault' or 'road traffic accident' cover a great heterogeneity of circumstance. A recent level two study has proposed the following criteria as high risk factors for clinically important brain injuries after head injury: pedestrian struck by motor vehicle, occupant ejected from motor vehicle, or a fall from a height of greater than three feet or more than five stairs.[258] A further study has defined 'axial load to head' as a high risk factor for cervical spine injury after an accident.[117,259] This covers the following areas: diving; high-speed motor vehicle collision; rollover motor accident; ejection from a motor vehicle; accident involving motorized recreational vehicles; bicycle collision. In addition, there are many other high energy mechanism injuries which cannot be covered in an exhaustive list (for example, the variety of blunt instruments that could be used in a violent assault) which were considered to be important by the GDG.

5.9 Mechanism of injury (2007)

The height threshold for a high-risk fall is sometimes defined as greater than three feet, and sometimes as greater than 1 metre. For the sake of consistency, this guideline will use the term '1 metre'. The recent CHALICE[74] rule recognises falls of greater than 3 metres were highly associated with the development of intracranial lesions.

5.10 Drug or alcohol intoxication (2003)

Drug or alcohol intoxication can result in signs and symptoms which are risk factors for intracranial complications (for example, vomiting, headache, amnesia, impaired consciousness) but have also been identified as independent risk factors following head injury, making a differential diagnosis difficult. [50,117] In addition, alcohol abuse can lead to hypoglycaemia, which can in turn lead to impaired consciousness. This may lead to the incorrect diagnosis of a developing intracranial trauma complication.

5.11 Headache (2003)

Headache is a controversial variable in the evaluation of risk for intracranial complications. In some studies the variable has been an important predictor [117,170] but not in others.[135,258] Headache can be difficult to define both in terms of duration and severity, particularly in infants and young children.

5.12 Vomiting (2003)

Vomiting is consistently identified as a high risk variable, but there is some controversy regarding the number of episodes required to qualify as high-risk.[117,135,170,258] Vomiting is also quite common in infants and children and its predictive power is controversial in this age group. It has been estimated that around 16% of infants and children aged 12 years or less vomit after minor head injury, and the cause of vomiting often seems to be related to individual intrinsic factors (for example, previous tendency to vomit) rather than specific features of the head injury.[37] There are inconsistencies between the various pre-hospital advice services in their choice of the timescales and number of vomits which would arouse concern in children. This is a reflection of the lack of evidence on which to make a judgment. The GDG considered that in a child under 12 years who has sustained a head injury 3 vomits within a 4 hour period should be cause for concern even when there are no other signs or symptoms.

5.13 Irritability and altered behaviour (2003)

Irritability and altered behaviour are non-specific terms which are sometimes used in clinical guidelines for acute head injury management with little empirical evidence to support their use.[231] However, they may be an important sign in the pre-verbal child, where other problems like amnesia or headaches cannot be detected.

5.14 History of cranial neurosurgical interventions (2003)

Previous cranial neurosurgical interventions have an intuitive relationship with risk of intracranial complications and were considered worthy of inclusion by the GDG despite a dearth of empirical evidence on the variable.

5.15 Public health literature (2003)

1. **Public health literature and other non-medical sources of advice (for example, St John Ambulance, police officers) should encourage people who have any concerns following a head injury to themselves or to another person, regardless of the injury severity, to seek immediate medical advice. [2003]**

This is a grade D recommendation based on evidence level five.

5.16 Telephone advice lines (2007)

2. **Telephone advice services (for example, NHS 111, emergency department helplines) should refer patients who have sustained a head injury to the emergency ambulance services (that is, 999) for emergency transport to the emergency department if they have experienced any of the following:**
   - **Unconsciousness or lack of full consciousness (for example, problems keeping eyes open).**
   - **Any focal neurological deficit since the injury.**
   - **Any suspicion of a skull fracture or penetrating head injury.**
   - **Any seizure ('convulsion' or 'fit') since the injury.**
   - **A high-energy head injury.**
   - **The injured person or their carer is incapable of transporting the injured person safely to the hospital emergency department without the use of ambulance services (providing any other risk factor indicating emergency department referral is present; see recommendation 3). [2003, amended 2007 and 2014]**

3. **Telephone advice services (for example, NHS 111 or emergency department helplines) should refer patients who have sustained a head injury to a hospital emergency department if they have any of the following risk factors:**
   - **Any loss of consciousness ('knocked out') as a result of the injury, from which the person has now recovered.**
   - **Amnesia for events before or after the injury ('problems with memory').**[h]
   - **Persistent headache since the injury.**
   - **Any vomiting episodes since the injury.**
   - **Any previous brain surgery.**
   - **Any history of bleeding or clotting disorders.**
   - **Current anticoagulant therapy such as warfarin.**
   - **Current drug or alcohol intoxication.**
   - **There are any safeguarding concerns (for example, possible non-accidental injury or a vulnerable person is affected).**
   - **Irritability or altered behaviour ('easily distracted', 'not themselves', 'no concentration', 'no interest in things around them') particularly in infants and children aged under 5 years.**
   - **Continuing concern by helpline staff about the diagnosis. [2003, amended 2014]**

These recommendations are based on level five evidence and are considered to be grade D recommendations.

5.17 Community health services and NHS minor injury clinics (2003)

4. **Community health services (GPs, ambulance crews, NHS walk-in centres, dental practitioners) and NHS minor injury clinics should refer patients who have sustained a head injury to a hospital emergency department, using the ambulance service if deemed necessary, if any of the following are present:**
   - **Glasgow Coma Scale (GCS) score of less than 15 on initial assessment.**

[h] Assessment of amnesia will not be possible in preverbal children and is unlikely to be possible in children aged under 5 years.

- **Any loss of consciousness as a result of the injury.**
- **Any focal neurological deficit since the injury.**
- **Any suspicion of a skull fracture or penetrating head injury since the injury.**
- **Amnesia for events before or after the injury.**[h]
- **Persistent headache since the injury.**
- **Any vomiting episodes since the injury (clinical judgement should be used regarding the cause of vomiting in those aged 12 years or younger and the need for referral).**
- **Any seizure since the injury.**
- **Any previous brain surgery.**
- **A high-energy head injury.**
- **Any history of bleeding or clotting disorders.**
- **Current anticoagulant therapy such as warfarin.**
- **Current drug or alcohol intoxication.**
- **There are any safeguarding concerns (for example, possible non-accidental injury or a vulnerable person is affected).**
- **Continuing concern by the professional about the diagnosis. [2003, amended 2007 and 2014]**

5.18 Community health services and NHS minor injury clinics (2007)

5. **In the absence of any risk factors in recommendation 4, consider referral to an emergency department if any of the following factors are present, depending on judgement of severity:**
   - **Irritability or altered behaviour, particularly in infants and children aged under 5 years.**
   - **Visible trauma to the head not covered in recommendation 4 but still of concern to the professional.**
   - **No one is able to observe the injured person at home.**
   - **Continuing concern by the injured person or their family or carer about the diagnosis. [2003, amended 2014]**

These recommendations are based on level five evidence and are considered to be grade D recommendations.

5.19 Transport from community health services and NHS minor injury clinics and pre-hospital management (2003)

6. **Patients referred from community health services and NHS minor injury clinics should be accompanied by a competent adult during transport to the emergency department. [2003]**

7. **The referring professional should determine if an ambulance is required, based on the patient's clinical condition. If an ambulance is deemed not required, public transport and car are appropriate means of transport providing the patient is accompanied. [2003]**

8. **The referring professional should inform the destination hospital (by phone) of the impending transfer and in non-emergencies a letter summarising signs and symptoms should be sent with the patient. [2003]**

These recommendations are based on level five evidence and are considered to be grade D recommendations.

5.20 Training in risk assessment (2003)

There is some evidence that ambulance crews using written triage guidelines in a United States context may fall short of acceptable levels of triage accuracy.[209] The GDG is under the impression that the triage skills of other community professionals may sometimes be below a desirable standard.

9. **GPs, nurse practitioners, dentists and ambulance crews should receive training, as necessary, to ensure that they are capable of assessing the presence or absence of the risk factors listed in recommendations 4 and 5. [2003, amended 2007]**

This recommendation is based on level five evidence and is considered to be grade D recommendations.

6 Immediate management at the scene and transport to hospital

6.1 Introduction (2014)

Following the primary head injury (the original traumatic insult), it is important to prevent any secondary brain injury at the scene of the primary injury, on route to the emergency care facility, in hospital and, where or when required, the specialist neurosurgical unit. Techniques used to prevent this secondary insult include high quality advanced trauma life support measures with attention to good management of the airway (and cervical spine immobilisation management), breathing, oxygenation and ventilation and satisfactory circulation, to name just a few. The 2007 update of CG56 made a research recommendation to try and establish the evidence regarding the issue of direct transport to a neuroscience centre and maintained the recommendation from the 2003 guideline. The feasibility of a trial in this area is currently being addressed by the HITS-NS trial (http://www.nets.nihr.ac.uk/projects/hta/0811685).

Since the NICE Head Injury guideline update published in 2007, much has changed in the United Kingdom regarding options and opportunities to address the treatment of head injuries at the scene and onwards. These changes include the increasing numbers of enhanced care teams available in the pre-hospital arena and the introduction of Trauma Networks which include all local emergency departments (not designated to receive major trauma and head injury), Trauma Units (designated to receive major trauma and head injury without specialist neuroscience capability) and Major Trauma Centres (designated to receive major trauma and head injury with specialist definitive neuroscience centres).

In light of these two aspects, (the clinical requirements in the management of the patient with traumatic brain injury and the necessity to reduce secondary brain injury, and the changes and differences of the acute facilities within Trauma Networks) the GDG wished to establish the benefit or risk of a longer, primary transfer of the patient from the scene to a definitive neurosciences centre against that of transfer to a closer acute hospital with a subsequent secondary transfer in a group of patients who go on to require the centre with neurosciences capability. The GDG wished to understand whether there were any clinical prediction tools or scoring systems that could support decision making at the scene to ensure transfer to the appropriate setting (a specialist neuroscience care or a major trauma centre with neuroscience if the nearest hospital does not provide these).

6.2 Pre-hospital management (2003)

The following principles should be adhered to in the immediate care of patients who have sustained a head injury.

10. Initially assess adults who have sustained a head injury and manage their care according to clear principles and standard practice, as embodied in the:

- **Advanced Trauma Life Support (ATLS) course/European Trauma course.**
- **International Trauma Life Support (ITLS) course.**
- **Pre-hospital Trauma Life Support (PHTLS) course.**
- **Advanced Trauma Nurse Course (ATNC).**
- **Trauma Nursing Core Course (TNCC).**
- **Joint Royal Colleges Ambulance Service Liaison Committee (JRCALC) Clinical Practice Guidelines for Head Trauma. [2003, amended 2007]**

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11. Initially assess children who have sustained a head injury and manage their care according to clear principles outlined in the:

- **Advanced Paediatric Life Support (APLS)/European Paediatric Life Support (EPLS) course.**
- **Pre-hospital Paediatric Life Support (PHPLS) course.**
- **Paediatric Education for Pre-hospital Professionals (PEPP) course. [2003, amended 2007]**

12. Ambulance crews should be fully trained in the use of the adult and paediatric versions of the GCS and its derived score. [2003]

13. Ambulance crews should be trained in the safeguarding of children and vulnerable adults and should document and verbally inform emergency department staff of any safeguarding concerns when the relevant signs and symptoms arise. [2003, amended 2014]

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14. When administering immediate care, treat first the greatest threat to life and avoid further harm. [2003]

15. Attempt full cervical spine immobilisation for patients who have sustained a head injury and present with any of the following risk factors unless other factors prevent this:

- **GCS less than 15 on initial assessment by the healthcare professional.**
- **Neck pain or tenderness.**
- **Focal neurological deficit.**
- **Paraesthesia in the extremities.**
- **Any other clinical suspicion of cervical spine injury. [2003, amended 2007]**

16. Maintain cervical spine immobilisation until full risk assessment including clinical assessment (and imaging if deemed necessary) indicates it is safe to remove the immobilisation device. [2003, amended 2007]

17. Make standby calls to the destination emergency department for all patients with GCS 8 or less to ensure appropriately experienced professionals are available for their treatment and to prepare for imaging. [2003]

These recommendations are based on level five evidence and are considered to be grade D recommendations.

18. Manage pain effectively because it can lead to a rise in intracranial pressure. Provide reassurance, splintage of limb fractures and catheterisation of a full bladder, where needed. [2007, amended 2014]

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6.3 Glasgow Coma Score (2003)

The Glasgow Coma Scale and its derivative the Glasgow Coma Score are widely used in the assessment and monitoring of patients who have sustained a head injury.[266,279]

The assessment and classification of patients who have sustained a head injury should be guided primarily by the adult and paediatric versions of the Glasgow Coma Scale and its derivative the Glasgow Coma Score.[133,267,268] Recommended versions are shown in Appendix M and Appendix N. Good practice in the use of the Glasgow Coma Scale and Score should be adhered to at all times, following the principles below.

19. Base monitoring and exchange of information about individual patients on the three separate responses on the GCS (for example, a patient scoring 13 based on scores of 4 on eye-opening, 4 on verbal response and 5 on motor response should be communicated as E4, V4, M5). [2003]

20. If a total score is recorded or communicated, base it on a sum of 15, and to avoid confusion specify this denominator (for example, 13/15). [2003]

21. Describe the individual components of the GCS in all communications and every note and ensure that they always accompany the total score. [2003]

22. In the paediatric version of the GCS, include a 'grimace' alternative to the verbal score to facilitate scoring in preverbal children. [2003]

Recommendations	**23. In some patients (for example, patients with dementia, underlying chronic neurological disorders or learning disabilities) the pre-injury baseline GCS may be less than 15. Establish this where possible, and take it into account during assessment. [new 2014]**
Relative values of different outcomes	No formal evidence review was conducted.
Trade off between clinical benefits and harms	The benefits of assessment using the Glasgow Coma Scale (GCS) mean that the appropriate investigations and management can be instigated in a timely fashion in patients who have sustained a trauma. Harms may result from incorrect assessment. The responses to commands that make up the assessment against the GCS may be limited by pre-existing conditions such as dementia or underlying cognitive impairment. Similarly deterioration in condition may be inaccurately reported if the initial assessment does not reflect an appropriate initial interpretation.
Economic considerations	No formal evidence review conducted.
Quality of evidence	No formal evidence review conducted.
Other considerations	The GDG noted that for some groups of patients, formal assessment of GCS following head injury may be of limited relevance because of the difficulties that particular patient groups may have in responding to commands or because of the difficulties healthcare professionals may have in interpreting any incoherence in response which may be independent of any trauma. The GDG however wished to acknowledge its obligations in relation to the relevant equalities legislation in this update of the guideline by making a recommendation that sought to encourage clinicians to be aware of the impact of some underlying conditions in assessing GCS score. They noted some particular examples that may be of relevance such as the impact of dementia, underlying chronic neurological problems as well learning disabilities in effectively assessing a GCS status, among others. The GDG felt that in these groups it would be important to try and establish pre-injury function in assessing GCS status. They noted that any verbal and motor responses should be considered alongside knowledge of any pre-existing conditions that may affect the patient's ability to respond. They felt that, where possible, reports from someone who knows the patient (such as a family member or carer) affected by such conditions may be helpful in establishing a baseline assessment. They also noted that it may not always be possible to establish such underlying conditions and that it would also be inappropriate to make assumptions in this regard. They felt on balance that it would be important that healthcare professionals make individual assessments in practice that would establish whether any adaptations in assessment or interpretation of GCS should be made in these circumstances.

24. Follow at all times best practice in paediatric coma observation and recording as detailed by the National Paediatric Neuroscience Benchmarking Group. [2003]

These recommendations are based on level five evidence and are considered to be grade D recommendations.

6.4 Glasgow Coma Scale score (2003)

It is well established that the risk of intracranial complications and of subsequent need for surgery increases as GCS score declines.[233,258,269] A recent study estimated that the rate of clinically important brain injury in hospital attenders who had experienced some loss of consciousness and/or amnesia since their head injury increased from 5% with an initial GCS equal to 15, to 17% for GCS equal to 14, and to 41% for GCS equal to 13.[133] A further study on paediatric head injury found that a GCS less than 13 was a significant predictor of an abnormal CT scan in children with head injury aged 14 years or younger.[190]

6.5 Immediate management of patients with severe head injuries (2003)

There are specific questions regarding the early management of patients with severe head injuries (that is, GCS less than or equal to 8). Exhaustive systematic reviews have examined evidence on the management of severe traumatic brain injury.[31,94] These reviews found evidence for only a small number of "standards" (that is, recommendations generally based on class one evidence or strong class two evidence of therapeutic effectiveness) and concluded that there was a paucity of well-designed studies examining the efficacy of pre-hospital interventions in severe head injury.

Given these findings, no changes to current practice were recommended in the pre-hospital management of patients who have sustained a severe head injury.

6.6 The benefits of direct transport from the scene to a specialist neurosciences centre compared to transport to the nearest district general hospital (2007)

6.6.1 Introduction and rationale for the clinical question

This question has been included in this update because many healthcare professionals, especially ambulance staff, may be uncertain when deciding on the most appropriate destination for a patient with severe head injury. This is pertinent as the severity of head injury may not be known at the scene and the nearest neuroscience unit may be further away than the emergency department. There is also some confusion amongst hospital staff with regards to interhospital transfer of head injured patients. This is because patients who do not require surgery but do require neurosurgical care may remain in the district general hospital (DGH) and receive treatment there, when they actually require specialist treatment at a neuroscience unit. For interhospital transfers please see Chapter 7.

An emergency department is described as a local, regional DGH with no neurosciences unit or a non specialist centre whereas a neurosciences unit is described as a specialist centre or a unit that has neurosurgical and neurointensive care facilities.

The outcome measures for including studies for this review were either mortality, neurological outcome, disability and hospital duration. Studies were excluded where:

- data on head injury patients was not provided,
- the patient group was less than 50% non head injured patients,
- intervention was pre hospital care rather than transfer and
- the outcomes reported only duration of transfer and no other outcomes.

6.6.2 Clinical evidence

The first study[111] was a retrospective observational cohort study (evidence level 2+), that obtained data from the New York State Trauma Registry from 1996-1998. This study examined patients who were transported to a regional/area trauma centre compared with patients transferred to non trauma centre. The patients in the latter group were assessed via the American Triage system (pre hospital care) and referred directly to a non trauma centre. The population were adults (over 13 years) with a GCS less than 14. Sub group data of 2763 head injured patients from a data set of 5419 trauma patients were analysed. Group 1 (n=2272 (82.2%)) patients were transported to regional/area trauma centre. These patients were assessed via American Triage system (pre hospital care) and referred directly to the emergency department of either a regional or area trauma centre. Group 2 (n=491 (17.8%)) patients were assessed via American Triage system (pre hospital care) and referred directly to a non trauma centre. The limitations of this study were that patients were categorised as head injured from data reported in trauma registry however the extent of head injury was unknown, because the GCS was classified as less than14. The results of this study[111] showed that the mortality rate of immediate transfer to a neurosciences centre versus transfer to a non trauma centre were in favour of transfer to neuroscience centre with an odds ratio 0.88, CI (0.64-1.22) which did not reach statistical significance.

The second study[71] (evidence level 2+) described a cohort of paediatric patients aged under 20 years old using a large national US paediatric trauma registry, admitted to one of ninety paediatric hospitals or trauma centres. The cohort compared 3 sub groups defined by the site of intubation; in the field, in the trauma centre (n=1874) or in a non-trauma centre (n=1647). Taking the data from the latter two branches, risk stratification was performed in patients whose degree of head injury was measured using the New Injury Severity Score (NISS), and the Relative Head Injury Severity Scale (RHISS). The main outcomes were unadjusted mortality rates and functional outcomes. Patients who were assessed using the different scales had no significant differences in outcome or the place of intubation. Mortality (observed vs. expected) rate in group 1 was 16.5% and in group 2 was 13.3%. Stratification of injury by NISS or degree of head injury showed that higher mortality rates were not only observed in the severely head injured patients who were intubated in a non trauma but also the mild and moderate head injured patients. Some doubt remains over the definition of head injured patients as it is unclear if these were isolated injury or part of a multiple trauma. This affects the conclusions one can draw from this study.

6.6.3 Economics evidence from 2007 update

See economics Chapter 13.

6.6.4 Summary of evidence from 2007 update

With one study[71] it is difficult to draw rational conclusions as to the benefits of direct transport of patients from the scene to either a neurosciences unit or a DGH as there is doubt over the definition of head injured patients. The other study[111] showed that the mortality rate of immediate transfer to a neurosciences centre versus DGH were in favour of transport to a neuroscience centre. From this evidence review there is limited evidence for direct transport of head injured patients from the scene to a neurosciences unit being beneficial.

A simulation model[255] showed improved survival from directly transporting patients to a neurosciences hospital. However, a number of parameters were based on expert judgement rather than strong evidence. A cost-effectiveness analysis based on this model showed that direct transport is likely to be cost-effective.

6.6.5 Rationale behind recommendation

There is no strong evidence to suggest a change in the previous recommendation (see bullet 5 within section 5.1). The GDG recognises that the transported patients with head injury directly to a neuroscience unit rather than a DGH would require a major shift of resources of between an additional 84,000 and 105,000 bed days to neurosurgery from the existing general surgical, orthopaedic, emergency department, paediatric and geriatric services that currently care for these patients. The GDG recognize that further research is needed in this area in order to identify benefits in transporting patients with head injury to a neuroscience unit or a district general hospital. Therefore the GDG propose a research recommendation for this question (see section 5.6).

6.6.6 Recommendations for research

The GDG identified the following priority area for research.

6.6.6.1 Research question

1. **Is the clinical outcome of patients with head injury with a reduced level of consciousness improved by direct transport from the scene of injury to a tertiary centre with neuroscience facilities compared with the outcome of those who are transported initially to the nearest hospital without neurosurgical facilities?**

6.6.6.2 Why this is important

Although this research recommendation was set in 2007, the GDG felt that it is still a high priority for research following this guideline update. No evidence review was conducted specifically for this question, but the GDG suggested that there is minimal evidence to support patients with signs suggestive of severe head injury being taken from the scene directly to neuroscience care, when this involves bypassing their nearest emergency department. They noted that this issue would be likely to be discussed in the HTA report discussing the HITS-NS (Head Injury Transportation Straight to Neurosurgery) trial (http://www.nets.nihr.ac.uk/projects/hta/0811685).). Nevertheless, within current NHS England trauma systems some patients with apparent severe head injury are bypassing their nearest emergency department and experiencing prolonged journey times of up to 45 minutes in order to be taken directly to a neuroscience centre. For pre-hospital healthcare workers, and for the effective functioning of the new NHS trauma systems, it is important to define which, if any, patients would do better by being transported directly to a neuroscience centre.

Guidance will be required to define the patient population – for example, researchers may focus on age, or isolated head injury versus apparent multiple trauma. Further specification is needed about what level of consciousness would indicate the need for primary transfer to a neuroscience centre. Researchers should look at the impact of the duration of transport on study outcome, for example, less than 20 minutes, or where the additional journey time is less than 10 minutes.

6.7 What is the effectiveness of pre-hospital assessment tools for selecting adults, infants and children with head injury, for transport direct to specialist neuroscience care or a major trauma centre with neuroscience if the nearest hospital does not provide these? (2014)

As no pre-hospital assessment tools were identified relating to the transfer of patients with suspected head injury to a neuroscience centre the review was broadened out to include any major trauma study provided it reported data relating to patients with suspected head injury.

For full details see review protocol in Appendix D.

6.7.1 Clinical evidence

We searched for any cohort studies investigating the diagnostic accuracy of decision rules or triage tools in selecting which people with suspected head injury should be directly transported to a centre with neuroscience facilities.

No direct evidence was identified. Further detail of excluded indirect evidence can be found in the exclusion list and in the Linking evidence to recommendation section.

6.7.2 Economic evidence

No relevant economic evaluations comparing pre-hospital assessment tools were identified. There were no excluded studies.

6.7.3 Evidence statements

Clinical

- No evidence identified.

Economic

- No evidence identified.

6.8 Recommendations and link to evidence (2014)

Recommendations	**25. Transport patients who have sustained a head injury directly to a hospital that has the resources to further resuscitate them and to investigate and initially manage multiple injuries[i]. All acute hospitals receiving patients with head injury directly from an incident should have these resources, which should be appropriate for a patient's age. [new 2014]**
Relative values of different outcomes	The aim of the question was to identify a decision rule that could discriminate between patients who need specialist neuroscience capability from others. Therefore, the main outcome is diagnostic accuracy of the incidence of the need for specialist neurosurgical intervention. Other outcomes include the diagnostic accuracy of the incidence of intracranial lesions, the deterioration of a patient's ABC (airway, breathing and circulation), quality of life at 3 months, mortality at 30 days, an objectively applied disability score at 3 months or more and length of stay in survivors at 30 days.
Trade off between clinical benefits and harms	No data were identified for this review. The GDG noted that the benefits of direct transport to an appropriate centre may improve outcomes for some patients requiring neuroscience services rather than a secondary transfer from an initial admitting hospital once the need had been identified. They also noted that for some patients, it would be important to ensure stabilising of condition particularly in relation to management of the airway (and cervical spine immobilisation management), breathing, oxygenation and ventilation, and circulation, and that transferring them to a facility (with or without neuroscience services) that could primarily address these issues would be essential for some patients. The GDG decided that as there still no decision rule or triage tool to determine who should go directly to a neurosciences centre the current recommendation should remain with some minor edits.
Economic considerations	No economic evidence was identified for this review. In order to qualitatively assess the trade off between health benefit and costs associated with a decision rule it is necessary to consider not only the resource use associated with the triage tool itself, but also the long term implications of what happens to the patients appropriately and inappropriately referred. The GDG acknowledged that this area had high economic importance. Triage of large numbers of patients who do not require any neurosurgical intervention (over triage) to a specialist centre carries a significant monetary cost, for ambulance services and emergency/radiology departments in neuroscience centres. There is also the potential for patients requiring stabilisation of the airway, breathing and circulation to deteriorate during prolonged transportation to hospital. On the other hand, transportation of patients to the nearest ED without on-site neurosciences hospital incurs the further costs of secondary transfer to a specialist centre, and risks an incremental health loss through delays in time critical neurosurgical interventions. For children and young people in particular, consideration should also be given to transporting a child direct to a paediatric tertiary centre if stable as this will save later transfer for paediatric intensive care or neurosurgery if required. However, without any information on the accuracy of the tool used and limited data on prevalence of critical versus non critical patients, the proportion of appropriate and inappropriate referral is difficult to assess or to quantify. In the absence of evidence regarding a referral tool, the GDG briefly considered the model constructed for the 2007 guideline, to guide discussion on longer term implications of appropriate and inappropriate referral to a specialist centre – that is the costs and benefits of transfer or direct transport to a specialist centre (see

[i] A trauma unit or major trauma centre.

	Chapter 13.6). The model also presented a threshold sensitivity analysis to determine the impact of different proportions of patients referred to a specialist centre versus a local provider. Unfortunately, these estimates were not thought useful as the data sources which informed this model were outdated and not applicable in the current context of today's trauma services. Overall, the GDG decided that there were insufficient data to usefully quantify the trade offs highlighted above, and as such a substantial change to the current recommendation could not be justified in light of discussion regarding the economic implications.
Quality of evidence	No studies were identified.
Other considerations	The GDG considered writing a research recommendation to inform practice as a result of the lack of evidence identified in this review. However, they decided that as there is an ongoing study which directly addresses this question there would be no value in producing a new protocol for research until this had reported (see "Head Injury Transportation Straight to Neurosurgery (HITS-NS) trial - a feasibility study" (http://www.hta.ac.uk/project/2223.asp)). The GDG made a consensus adaptation to the original recommendation that indicated that patients should be taken to a hospital facility that had resources to further resuscitate them and to investigate and initially manage multiple injuries. The GDG also noted that before transfer to hospital, consideration should be given to the fact that resources should be available at that hospital that is appropriate for a patient's age. This would particularly be relevant for children and young people, with consideration to whether there is a paediatric emergency and inpatient facility.

6.9 Advanced life support training for ambulance crews (2003)

The value of advanced life support (ALS) training for ambulance crews over basic life support training (BLS) is controversial. ALS trained ambulance crews receive extra training in endotracheal intubation, intravenous cannulation, the administration of intravenous fluids and the use of selected drugs. A recent Cochrane systematic review concluded that insufficient evidence existed on the effectiveness of ALS training for ambulance crews.[234]

Given this finding no change to current practice in ALS training for ambulance crews is recommended in these guidelines. This stance will be reviewed in forthcoming versions of these guidelines depending on advances in the literature.

6.10 Priority dispatch of emergency ambulances (2003)

The use of an emergency medical dispatch (EMD) system is controversial. The EMD system requires a form of telephone assessment carried out by ambulance dispatchers to determine the urgency of the emergency. A recent systematic review found little evidence on the effectiveness of EMD in terms of improved clinical outcomes.[285] However, a recent study on the acceptability of EMD in a UK context found increased satisfaction among callers to the 999 service. The amount of first aid advice and general information received by the service users increased while satisfaction with response times was maintained.[195]

Given these findings no change to current practice in EMD is recommended in these guidelines. This stance will be reviewed in forthcoming versions of these guidelines depending on advances in the literature.

7 Assessment in the emergency department: imaging of the head

7.1 Introduction (2014)

Head injuries are very common, but the majority will have no consequences and need no specific treatment. However, some patients have on-going symptoms (known as the post-concussion syndrome) and a minority will require urgent intervention (such as neurosurgery). It is essential that injuries requiring such intervention are detected and acted on quickly to prevent further injury to the brain. Because most do not need any intervention it is neither feasible nor sensible to perform a CT head scan on everyone who has a head injury. A number of clinical decision rules have therefore been developed that help clinicians to identify patients at risk who require a CT head scan. This approach is especially important in children due to the technical difficulties of a CT head scan and the risks from ionising radiation. Since the previous version of this guideline in 2007, a number of studies have attempted to either validate or derive clinical decision rules for adults and children. The GDG wished to evaluate evidence regarding clinical decision rules in order to provide recommendations that would maximise the chances of detecting clinically important traumatic brain injury and intervening rapidly, while minimising the number of unnecessary CT head scans that are performed.

In this update, a new question was asked relating to selection of patients for CT head scan who are on anticoagulant or antiplatelet therapy – specifically that group who have no history of amnesia or loss of consciousness. The derivation study of the Canadian CT rule (on which the 2007 version of this guideline was based) excluded patients with no history of amnesia or loss of consciousness but who were on anticoagulant or antiplatelet therapy. However, clinical experience suggests that these patients appear at risk of undetected bleeding from low energy injuries and may re-present after initial discharge. Such injuries can cause rupture of subdural space bridging vessels or intracerebral blood vessels. Usually the body's haemostatic processes (formation of a platelet plug, followed by a firm clot) stop such bleeding and prevent significant haematomas. However, in patients on antiplatelet or anticoagulant drugs these processes are impaired, leading to delayed occurrence or slow expansion of a significant haematoma. Such patients may appear well and be discharged, only to return following deterioration, unless these risks are appropriately addressed in the emergency department. It is therefore important to provide advice to clinicians regarding the management of this specific group.

This update also prioritised a review question on diagnostic circulating biomarkers including S100B, Neuron Specific Enolase (NSE) and Glial Fibrillary Acidic Protein (GFAP). Brain injury causes these biomarker proteins to be released into the bloodstream, with raised serum levels suggesting that damage to cerebral tissue and intracranial haemorrhage (ICH) may be occurring. High levels of the protein may correspond to a greater severity of bleeding and may be useful for the selection of patients for CT head scan. If sufficiently discriminative in this patient group, biomarker assays may reduce the need for CT head scan and hospital admissions.

UPDATE 2007:

Hospitals designated to accept patients with any severity of head injury should have the following facilities available at all times:

- A communication system with the ambulance service to enable advanced warning to be given of an injured patient.
- A Trauma Response Team (trained to Advanced Trauma Life Support standards) and medical and nursing staff who have the ability to provide a full range of acute resuscitation procedures and who have all necessary equipment for resuscitation and monitoring.
- A clinician trained in the emergency care of head injured children.
- Direct access to 24 hour CT scanning on site.
- An effective CT image reporting service and an image transfer facility linked to the regional neuroscience unit.
- Head injury management agreements which clearly set out roles and responsibilities of the admitting hospital and the neuroscience unit.
- A patient transfer team trained and equipped to standards described in chapter 10. (NB This refers to the section on inter-hospital transfers).

7.2 Focus of emergency department assessment in patients with a head injury (2003)

The main risk to patients who have sustained a recent head injury is the development of a clinically important brain injury. Some brain injuries require early neurosurgical intervention (for example, intracranial haematoma requiring evacuation) but the life threatening nature of the injury makes early detection essential. Other clinically important brain injuries do not provide an immediate threat to the patient and may produce late sequelae. Early identification of these latter injuries should assist in rehabilitation.

7.2.1 Good practice in emergency department assessment

The main focus of emergency department assessment for patients who have sustained a head injury should be the risk of clinically important brain injuries and injuries to the cervical spine and the consequent need for imaging. Due attention should also be paid to co-existing injuries and to other concerns the clinician may have (for example, safeguarding concerns including non-accidental injury, possible non-traumatic aetiology such as seizure). Early imaging, rather than admission and observation for neurological deterioration, will reduce the time to detection for life-threatening complications and is associated with better outcomes.[34,171] (2003)

These recommendations are based on level V evidence and are considered to be grade D recommendations.

7.3 What is the best clinical decision rule for selecting adults, infants and children with head injury for CT head scan? (2014)

In order to improve the efficiency of decision making in the management of head injury, clinical decision rules can be applied – this is especially appropriate when deciding whether a CT head scan is necessary. A clinical decision rule is derived from original research and is defined as a decision making tool that incorporates three or more variables from the history, examination or simple tests. Full details of the clinical decision rules reviewed by the GDG are provided in the review protocol in Appendix D.

7.3.1 Clinical evidence

A Health Technology Assessment (HTA) report[202] reviewing minor head injury was identified that included 19 studies in adults and 14 studies in children and/or infants. This includes all diagnostic cohort studies (prospective or retrospective) with a minimum of 20 patients. All studies, apart from the exceptions listed below, of adults and children (of any age) with mild head injury (defined as patients with a blunt head injury and GCS of 13-15 at presentation) were included.

Pandor et al 2011[202] stated that the index test was the application of a clinical decision rule. The target conditions were stated as the need for neurological intervention (defined as any intracranial injury seen on CT or MR imaging head scan that required neurosurgery) and any intracranial injury (defined as any intracranial abnormality detected on CT or MR imaging head scan due to trauma). Inclusion criteria for reference standards were CT head scan, CT head scan or follow-up (for those with no CT head scan), or MR imaging. A summary of the included HTA report is given in Appendix G, which contains tables reproduced from the report, detailing individual papers and clinical decision rules for adults, children and infants.

Four additional diagnostic cohort studies were identified by the GDG that were published after the cut-off date for the HTA report.[28,84,200,218]

Evidence from these are summarised in the clinical GRADE evidence profile below (Table 8 to Table 10). See also the study selection flow chart in Appendix E, study evidence tables in Appendix H, forest plots in Appendix J and exclusion list in Appendix K.

No studies deriving or validating clinical decision rules for use in patients with moderate or severe head injury were identified from the literature search, which was run from 2006. The GDG noted that this lack of evidence is due to consensus in the field and evidence that points to the fact that all patients with moderate or severe head injury should have a CT head scan.

7.3.1.1 Adults

The GDG decided to include validated clinical decision rules only for adults and therefore studies deriving new adult clinical decision rules were excluded. This was decided as the GDG only wanted to recommend clinical decision rules that had been well tested in relevant populations, and there were several clinical decision rules that met this standard.

7.3.1.2 Children and infants

Due to a relative paucity of externally validated clinical decision rules in the paediatric population, the GDG decided to include derivation studies of sufficient quality. Abstracts were included for validation studies of paediatric clinical decision rules where full publications were not available as the GDG

considered this an area lacking in evidence. Fuller et al 2011[92] provides validation of the PECARN rule in children and infants in the UK and Osmond et al 2012[198] provides validation of the CATCH rule.

One paediatric study (Klemetti et al., 2009[149]) included within the HTA report was excluded from this review as the GDG felt it did not meet the inclusion criteria for this question. This was because the population was children admitted to hospital rather than seen in the emergency department. It was noted[57] that the University of California Davis rule reported in Palchak et al 2003[201] was a pilot study to inform the derivation of the Paediatric Emergency Care Applied Research Network clinical decision rule (PECARN) therefore this has been labelled as 'pilot PECARN' in the clinical evidence profile and evidence statements.

The GDG felt that a reference standard of follow-up for one month for children who did not have a CT head scan was unnecessarily long. Therefore our co-optee (paediatric intensivist) was contacted who advised that two weeks follow-up as a reference standard is appropriate in this situation rather than one month as per the HTA protocol. The co-optee noted that chronic subdural haematomas (the reason for a prolonged follow-up time) are uncommon in children presenting to the emergency department with head injury. The GDG agreed an amendment to the protocol which indicated that two weeks follow-up is acceptable for children.

Update 2014

Table 8: Clinical evidence profile: diagnostic accuracy of decision rules for adults

Outcome	No of studies	Design	N	Limitations	Inconsistency	Indirectness	Imprecision	TP	FP	FN	TN	Sensitivity % (j)	Specificity % (j)	PPV %	NPV %	Quality
Intracranial Injury																
CCHR high and medium risk[28,128,219,244,250,257,258]	7	Diagnostic cohort	18734	Serious limitations (a, b)	Serious inconsistency (c)	No serious indirectness	Serious imprecision (i)	1464	9039	68	8163	80 - 100	39 - 65	6 - 30	95 - 100	Very low
CCHR high and medium risk adapted to cohort[244]	1	Diagnostic cohort	3181	No serious limitations	No serious inconsistency	No serious indirectness	No serious imprecision	265	1731	47	1138	85	40	13	96	High
NOC[28,117,128,218,219,244,250,257]	8	Diagnostic cohort	15376	Serious limitations (a, d, e)	No serious inconsistency	No serious indirectness	Serious imprecision (i)	1162	10701	50	3660	86 - 100	4 - 33	4 - 17	97 - 100	Low
NOC adapted to cohort[244]	1	Diagnostic cohort	3181	No serious limitations	No serious inconsistency	No serious indirectness	No serious imprecision	310	2777	2	92	99	3	10	98	High
NCWFNS[81,128,245]	3	Diagnostic cohort	12238	Serious limitations (e)	No serious inconsistency	No serious indirectness	No serious imprecision	918	7673	19	3628	98	3 - 46	8 - 12	94 - 100	Moderate
NICE lenient[81,245,250]	3	Diagnostic cohort	19091	Serious limitations (e)	Serious inconsistency (c)	No serious indirectness	No serious imprecision	1289	8891	96	8815	82 - 99	31 - 70	9 - 18	96 - 100	Low
Scandinavian lenient[128,245,250]	3	Diagnostic cohort	12237	Serious limitations (e)	No serious inconsistency	No serious indirectness	No serious imprecision	871	6158	55	5153	84 - 96	21 - 60	11 - 15	97 - 99	Moderate
CCHR high risk[219,250]	2	Diagnostic cohort	8195	Serious limitations (a, e)	Serious inconsistency (c)	No serious indirectness	Serious imprecision (i)	520	3690	21	3964	50 - 97	51 - 77	9 - 12	97 - 99	Very low
Arienta	2	Diagnostic	11018	Serious	Serious	No serious	No serious	168	1340	10	9500	88 - 100	54 -	10 -	98 -	Low

Outcome	No of studies	Design	N	Limitations	Inconsistency	Indirectness	Imprecision	TP	FP	FN	TN	Sensitivity % (j)	Specificity % (j)	PPV %	NPV %	Quality
1997[8,128]		cohort		limitations (f)	inconsistency (c)	indirectness	imprecision						91	13	100	
Madden 1995[162]	1 (g)	Diagnostic cohort	810	Serious limitations (h)	No serious inconsistency	No serious indirectness	No serious imprecision	130	536	5	139	95 - 97	21	19 - 20	96 - 97	Moderate
Ono 2007[197]	1 (g)	Diagnostic cohort	1232	Serious limitations (h)	No serious inconsistency	No serious indirectness	No serious imprecision	63	806	0	363	100	30 - 35	7 - 11	100	Moderate
SIGN 2000 CT urgently[128,246]	2	Diagnostic cohort	4283	No serious limitations	Serious inconsistency (c)	No serious indirectness	No serious imprecision	363	3059	32	829	65 - 99	2 - 74	10 - 17	96	Moderate
NEXUS II[174,218,250]	3	Diagnostic cohort	7233	Serious limitations (e)	Serious inconsistency (c)	No serious indirectness	No serious imprecision	903	4876	68	1386	89 - 100	0 - 46	9 - 29	0 - 99	Low
EFNS CT recommended and mandatory[128,245]	2	Diagnostic cohort	5003	No serious limitations	No serious inconsistency	No serious indirectness	No serious imprecision	1113	3605	3	282	96 - 100	0 - 28	10	0 - 99	High
Miller criteria[124,170]	2	Diagnostic cohort	2407	No serious limitations	No serious inconsistency	No serious indirectness	Serious imprecision (i)	108	823	65	1411	51 - 65	63 - 69	11 - 20	90 - 96	Moderate
Neurosurgery																
CCHR high risk[28,219,250,257,258]	5	Diagnostic cohort	15605	Serious limitations (a, b, e)	No serious inconsistency	No serious indirectness	Serious imprecision (i)	227	6638	1	8739	99 - 100	48 - 77	2 - 16	93 - 100	Low
NOC[28,219,244,250,257]	5	Diagnostic cohort	12906	Serious limitations (a, b, e)	No serious inconsistency	No serious indirectness	Serious imprecision (i)	146	9627	7	3126	82 - 100	4 - 31	0 - 2	99 - 100	Low
NOC adapted to	1	Diagnostic cohort	3181	No serious limitations	No serious inconsistency	No serious indirectness	No serious imprecision	17	3070	0	94	100	3	1	100	High

Outcome	No of studies	Design	N	Limitations	Inconsistency	Indirectness	Imprecision	TP	FP	FN	TN	Sensitivity % (j)	Specificity % (j)	PPV %	NPV %	Quality
cohort[244]																
CCHR high and medium risk[219,244,250]	3	Diagnostic cohort	10223	Serious limitations (a, e)	No serious inconsistency	No serious indirectness	Serious imprecision (i)	115	5710	1	4397	99 - 100	37 - 48	1 - 2	99 - 100	Low
CCHR and medium risk adapted to cohort[244]	1	Diagnostic cohort	3181	No serious limitations	No serious inconsistency	No serious indirectness	No serious imprecision	17	3070	0	94	100	37	1	100	High
NCWFNS high and medium risk[81,245]	2	Diagnostic cohort	11136	Serious limitations (e)	No serious inconsistency	No serious indirectness	Serious imprecision (i)	123	7510	2	3501	94 - 99	3 - 44	0 - 2	99 - 100	Low
NICE lenient criteria[81,245, 250]	3	Diagnostic cohort	19091	Serious limitations (e)	No serious inconsistency	No serious indirectness	Serious imprecision (i)	224	9984	9	8874	94 - 98	29 - 67	1 - 4	100	Low
Scandinavian lenient criteria[245,250]	2	Diagnostic cohort	11136	Serious limitations (e)	No serious inconsistency	No serious indirectness	Serious imprecision (i)	123	6458	2	4553	94 - 99	20 - 50	1 - 3	100	Low
Miller criteria[124,170]	2	Diagnostic cohort	2407	No serious limitations	No serious inconsistency	No serious indirectness	Serious imprecision (i)	7	924	2	1474	50 - 100	61 - 66	1 - 2	99 - 100	Moderate

(a) Rosengren et al., 2004 is a retrospective study.
(b) Unclear reference standard Stiell 2001 and 2005. CT ordered at discretion of treating physician, follow-up by telephone interview at unspecified time point.Stiell et al., 2005 reports basis selection using a convenience sample rather than consecutive or randomised.
(c) Inconsistency across the studies - heterogeneity of the sensitivity and specificity point estimates, as demonstrated on the ROC curve.
(d) Unclear reference standard Stiell 2005. CT ordered at discretion of treating physician, follow-up by telephone interview at unspecified time point.Patients selected by a using a convenience sample rather than consecutive or randomised patients.
(e) Stein et al., 2009 and Fabbri et al 2005 had an inadequate reference standard. Observation was for up to 48 hours.52.5% of patients received a CT.
(f) Unclear reference standard Arienta et al., 1997. CT ordered at discretion of treating physician (7.7%) or follow-up telephone call. Further details not reported.
(g) Study reports both derivation and validation in different patients. Data are reported for both cohorts of patients.
(h) Method of patient selection is not reported. Unclear if patients were selected consecutively or randomly, therefore there is potential patient selection bias.
(i) The wide range of confidence intervals around the point estimate of the sensitivity in the study increases the uncertainty of the actual diagnostic accuracy.
(j) Relates to a sensitivity or specificity for a single study or a range of sensitivities or specificities when more than 1 study.

Table 9: Clinical evidence profile: diagnostic accuracy of decision rules for children

Outcome	No of studies	Design	n	Limitations	Inconsistency	Indirectness	Imprecision	TP	FP	FN	TN	Sensitivity % (i)	Specificity % (i)	PPV %	NPV %	Quality
Intracranial Injury																
NEXUS II[196]	1	Diagnostic cohort	1666	No serious limitations	No serious inconsistency	No serious indirectness	No serious imprecision	136	1298	2	230	99	15	9	99	High
CHALICE[74]	1	Diagnostic cohort	22579	Serious limitations (b, c)	No serious inconsistency	No serious indirectness	No serious imprecision	164	2853	4	19558	98	87	5	100	Moderate
Pilot PECARN [201,262]	2	Diagnostic cohort	3709	Serious limitations (a)	No serious inconsistency	No serious indirectness	No serious imprecision	230	1987	13	1479	91 - 100	43	13 - 86	98 - 100	Moderate
PECARN >2 years; <18 years[151,92]	2 (d)	Diagnostic cohort	42109	Serious limitations (b)	No serious inconsistency	No serious indirectness	No serious imprecision	503	15506	21	26079	95 - 97	58 -75	2 - 8	100	Moderate
Atabaki 2008[12]	1	Diagnostic cohort	1000	Serious limitations (e)	No serious inconsistency	No serious indirectness	No serious imprecision	62	478	3	457	95	49	11	99	Moderate
CATCH rule[199,200]	1 (d)	Diagnostic cohort	7647	No serious limitations	No serious inconsistency	No serious indirectness	No serious imprecision	323	3653	6	3665	98	50	7 - 8	99 - 100	HIgh
CATCH rule[198]	1	Diagnostic cohort	4060	Serious limitations (i)	No serious inconsistency	No serious indirectness	No serious imprecision	193	1331	4	2520	98	65	13	99	Moderate
Da Dalt 2006[55]	1	Diagnostic cohort	3798	Serious limitations (f)	No serious inconsistency	No serious indirectness	No serious imprecision	22	478	0	3298	100	87	4	100	Moderate
Dietrich 1993[67]	1	Diagnostic cohort	156	No serious limitations	No serious inconsistency	No serious indirectness	No serious imprecision	16	150	0	0	100	0	10	0	High
Guzel 2009[104]	1	Diagnostic cohort	337	No serious limitations	No serious inconsistency	No serious indirectness	No serious imprecision	46	154	21	116	69	43	23	85	High

Outcome	No of studies	Design	n	Limitations	Inconsistency	Indirectness	Imprecision	TP	FP	FN	TN	Sensitivity % (i)	Specificity % (i)	PPV %	NPV %	Quality
NOC[118]	1	Diagnostic cohort	175	No serious limitations	No serious inconsistency	No serious indirectness	No serious imprecision	14	120	0	41	100	25	10	100	High
Quayle 1997[214]	1	Diagnostic cohort	321	No serious limitations	No serious inconsistency	No serious indirectness	Serious imprecision (g)	12	43	15	251	44	85	22	94	Moderate
RCS guidelines[74]	1	Diagnostic cohort	22772	Serious limitations (b, c)	No serious inconsistency	No serious indirectness	No serious imprecision	242	1219	39	21272	86	95	17	99	Moderate
Neurosurgery																
Atabaki 2008[12]	1	Diagnostic cohort	1000	Serious limitations (e)	No serious inconsistency	No serious indirectness	Serious imprecision (g)	6	534	0	460	100	46	1	100	Low
CATCH rule[199,200]	1 (d)	Diagnostic cohort	7646	No serious limitations	No serious inconsistency	No serious indirectness	No serious imprecision	50	2255	0	5341	100	70	2	100	High
CATCH rule[198]	1	Diagnostic cohort	4060	Serious limitations (i)	No serious inconsistency	No serious indirectness	No serious imprecision	20	538	3	3487	87	87	4	100	Moderate
CHALICE[74]	1	Diagnostic cohort	22772	Serious limitations (b)	No serious inconsistency	No serious indirectness	No serious imprecision	134	3076	3	19559	98	86	4	100	Moderate
NOC[118]	1	Diagnostic cohort	175	No serious limitations	No serious inconsistency	No serious indirectness	Serious imprecision (g)	6	128	0	41	100	24	4	100	Moderate
Pilot PECARN [201]	1	Diagnostic cohort	2043	Serious limitations (a)	No serious inconsistency	No serious indirectness	No serious imprecision	29	719	0	1295	100	64	4	100	Moderate
PECARN >2 years, <18 years[151]	1	Diagnostic cohort	6411	Serious limitations (b)	No serious inconsistency	No serious indirectness	Serious imprecision (g)	11	2600	0	3800	100	59	0.4	100	Low

(a) Unclear reference standard - length of follow-up not specified. CT or performance of intervention (62.2%).
(b) Method of patient selection is not reported. Unclear if patients were selected consecutively or randomly, therefore there is potential patient selection bias.

(c) Unclear reference standard - length of follow-up not specified. All patients treated according to RCS guidelines. This recommends admission for those at high risk and CT scan for those at highest risk (3%). Follow-up: all patients who were documented as having had a skull radiograph, admission to hospital, CT scan or neurosurgery were followed up.
(d) Study reports both derivation and validation in different patients.
(e) Patients selected using a convenience sample rather than included consecutively or randomly, therefore there is potential patient selection bias.
(f) Inadequate reference standard. CT scan obtained at discretion of treating physician (2%). All children discharged immediately from ER or after short observation received a follow-up. Telephone interview approximately 10 days later. Hospital records were checked for readmissions for 1 month after conclusion of study.
(g) The wide range of confidence intervals around the point estimate of the sensitivity in the study increases the uncertainty of the actual diagnostic accuracy.
(h) Study is an abstract only.
(i) Relates to a sensitivity or specificity for a single study or a range of sensitivities or specificities when more than 1 study.

Table 10: Clinical evidence profile: diagnostic accuracy of decision rules for infants

Outcome	No of studies	Design	n	Limitations	Inconsistency	Indirectness	Imprecision	TP	FP	FN	TN	Sensitivity % (h)	Specificity % (h)	PPV %	NPV %	Quality
Intracranial Injury																
Pilot PECARN [201,262]	2	Diagnostic cohort	402	Serious limitations[(c)]	No serious inconsistency	No serious indirectness	Serious imprecision [(d)]	22	298	0	82	100	11 - 34	4 - 11	100	Low
PECARN [151,92]	2 [(a)]	Diagnostic cohort	154 35	Serious limitations[(b)]	No serious inconsistency	No serious indirectness	No serious imprecision	11 4	666 6	1	8654	99 - 100	54 - 63	2 - 63	100	Moderate
Buchanich 2007[38]	1	Diagnostic cohort	97	Serious limitations[(e)]	No serious inconsistency	No serious indirectness	No serious imprecision	22	45	0	30	100	40	33	100	Moderate
Dietrich 1993[67]	1	Diagnostic cohort	19	No serious limitations	No serious inconsistency	No serious indirectness	Serious imprecision [(d)]	1	15	0	3	100	17	6	100	Moderate
Greenes and Schutzman 1999[99]	1	Diagnostic cohort	608	Serious limitations[(f)]	No serious inconsistency	No serious indirectness	Serious imprecision [(d)]	16	161	14	417	53	72	9	97	Low
Greenes and Schutzman 2001[100]	1	Diagnostic cohort	172	Serious limitations[(f)]	No serious inconsistency	No serious indirectness	No serious imprecision	13	96	0	63	100	40	12	100	Moderate
NEXUS II[84,196]	2	Diagnostic cohort	274 1	Serious limitations[(g)]	No serious inconsistency	No serious indirectness	No serious imprecision	41	127 3	2	1425	89-100	5 - 59	2 - 9	99 - 100	Moderate
Fabbri 2011[84]	1	Diagnostic	239	Serious	No serious	No serious	No serious	18	566	0	1807	100	76	3	100	Moderate

Outcome	No of studies	Design	n	Limitations	Inconsistency	Indirectness	Imprecision	TP	FP	FN	TN	Sensitivity % (h)	Specificity % (h)	PPV %	NPV %	Quality
		cohort	1	limitations[(g)]	inconsistency	indirectness	imprecision									
Neurosurgery																
PECARN >2 years; <18 years[151]	1 [(a)]	Diagnostic cohort	2216	Serious limitations[(b)]	No serious inconsistency	No serious indirectness	Serious imprecision [(d)]	5	1035	0	1176	100	53	0.5	100	Low

(a) Study reports both derivation and validation in different patients.
(b) Method of patient selection is not reported. Unclear if patients were selected consecutively or randomly, therefore there is potential patient selection bias.
(c) Unclear reference standard - length of follow-up not specified. CT or performance of intervention (62.2%).
(d) The wide range of confidence intervals around the point estimate of the sensitivity in the study increases the uncertainty of the actual diagnostic accuracy.
(e) Unclear reference standard - length of follow-up not specified. CT scan (97%). Follow-up questionnaire/telephone interview.
(f) Unclear reference standard. CT scan (31%), follow-up calls, review of medical records.
(g) Inadequate reference standard. CT scan within 7 days (52.8%), or re-evaluation within 7 days.
(h) Relates to a sensitivity or specificity for a single study or a range of sensitivities or specificities when more than 1 study.

7.3.2 Economic evidence

Published literature

One study was included with the relevant comparison.[126,202] This is summarised in the economic evidence profile below (Table 11). See also the study selection flow chart in Appendix F and study evidence tables in Appendix I.

The three economic studies [253] [116] [238] and the de novo economic costing which were included in the 2003 guideline and 2007 update were selectively excluded in the 2014 update, due to the availability of more applicable evidence with fewer methodological limitations. Four further studies[41,191,247,249] identified in the 2014 update search were excluded. These excluded studies are summarised in Appendix L, with reasons for exclusion given.

Update 2014

Table 11: Economic evidence profile

Strategies compared for adults (aged 40 and 75 years): CT all (theoretical) *versus* "abnormal arrival" GCS *versus* CCHR (high risk) *versus* CCHR (high or medium risk) *versus* NCWFNS *versus* NOC *versus* NEXUS II *versus* NICE *versus* Scandinavian

Strategies compared for children (aged 1 and 10 years): CT all (theoretical option) *versus* CHALICE *versus* PECARN *versus* Pilot PECARN (UCD) *versus* rule of Atabaki et al 2008

Study	Applicability	Limitations	Other comments	Total cost (mean per patient)[(c)]	Total QALYs (mean per patient)	Cost effectiveness	Uncertainty
Pandor 2011[126,202] (UK)	Directly applicable [(a)]	Potentially serious limitations [(b)]	Life-time cost-utility analysis. Treatment effects evaluated at 5 and 7 years after surgery Base-case analysis: decision rules evaluated for 1, 10, 40 and 75 years old Effectiveness: based on Whitnall et al	**Adults aged 40 years:** Discharge all: £3305 Abnormal arrival GCS: £2991. CT all: £2955. NCWFNS: £2911. Scandinavian: £2905. NEXUS II: £2908. NICE: £2923. CCHR (high risk): £2918. NOC: £2922. CCHR (high or medium risk): £2909. **Adults aged 75 years:** Discharge all: £1716 Abnormal arrival GCS: £1543 CT all:£1567 NCWFNS: £1523 NICE: £1535 NEXUS II: £1520	**Adults aged 40 years:** Discharge all: 18.6633 Abnormal arrival GCS: 18.6839 CT all: 18.6868 NCWFNS: 18.6878 Scandinavian: 18.6880 NEXUS II: 18.6880 NICE: 18.6881 CCHR (high risk): 18.6882 NOC: 18.6884 CCHR (high or medium risk): 18.6888 **Adults aged 75 years:** Discharge all: 7.8277 Abnormal arrival GCS: 7.8363 CT all: 7.8368 NCWFNS:7.8376 NICE: 7.8376 NEXUS II: 7.8377	**Adults aged 40 years:** The following strategies were dominated by the Scandinavian rule: Discharge all; Abnormal arrival GCS; CT all; NCWFNS. The following strategies were dominated by the CCHR rule: NICE, CCHR (high risk); NOC. The NEXUS II strategy was extendedly dominated. CCHR (high or medium risk) versus Scandinavian: £3879 per QALY gained (pa). **Adults aged 75 years:** The following strategies were dominated by the Scandinavian rule: Discharge all; Abnormal arrival GCS; CT all; NCWFNS; NICE; NEXUS II; The following	Prevalence estimates of neurosurgical and non-neurosurgical lesions in Stein et al used in a DSA - the CHALICE rule remained dominant for children, but the NEXUS II rule was dominant for adults. PSA showed that the optimal strategy for children (aged 1 and aged 10 years) remains

Study	Applicability	Limitations	Other comments	Total cost (mean per patient)[(c)]	Total QALYs (mean per patient)	Cost effectiveness	Uncertainty
			Cost year: 2008	Scandinavian: £1517 NOC: £1534 CCHR (high risk): £1521 CCHR (high or medium risk): £1521 **Child aged 10 years:** CHALICE: £3567 PECARN: £3611 UCD: £3608 Atabaki et all: £3621 CT all: £3666 Discharge all: £4115 **Child aged 1 year:** CHALICE: £3648 PECARN: £3699 UCD: £3700 Atabaki et all: £3713 CT all: £3771 Discharge all: £4206	Scandinavian: 7.8377 NOC: 7.8378 CCHR (high risk): 7.8378 CCHR (high or medium risk): 7.8381 Incremental (2-1): (CI NR; p = NR) **Children aged 10 years:** CHALICE: 22.4156 PECARN: 22.4119 UCD: 22.4112 Atabaki et all: 22.4108 CT all: 22.4072 Discharge all: 22.3847 **Children aged 1 year:** CHALICE: 22.9857 PECARN: 22.9787 UCD: 22.9760 Atabaki et all: 22.9764 CT all: 22.9663 Discharge all: 22.9549	strategies were dominated by the CCHR rule: NOC; CCHR (high risk). CCHR (high or medium risk) versus Scandinavian: £10,397 per QALY gained (pa) **Children aged 10 years:** - **When CHALICE is included as decision rule, then** CHALICE is the dominant strategy - **When CHALICE is excluded from the possible decision rules**, then the strategies "CT all", "Discharge all" and "Atabaki et al" are all dominated by the UCD rule; the ICER for PECARN versus UCD is £3,929. **Children aged 1 year:** - **When CHALICE is included as decision rule, then** CHALICE is the dominant strategy - **When CHALICE is excluded from the possible decision rules**, then the strategies "CT all", "Discharge all" and "Atabaki et al" are all dominated by the UCD rule; the ICER for PECARN versus UCD is £14,000.	the CHALICE rule (d). For adults, the CCHR (high or medium risk) was found to dominate all other strategies, both for 40 and 75 years old.

(a) Study set in the UK. NHS and PSS perspective adopted. Outcomes and costs discounted at a rate of 3.5%.

(b) Estimating the benefit of treating neurosurgical and non-neurosurgical lesions relied upon observational data with small numbers; the model assumed that hospital admission and treatment provided no benefit for patients with a non-neurosurgical lesion that did not deteriorate or those with a normal CT scan, as no clear evidence was found of these benefits. Limitations of the primary data used in the model were especially important for the children analyses, as very little validation of clinical decision rules has been conducted in this area.

(c) For patients with and without intracranial lesion.

(d) When CHALICE was excluded from the possible decision rules for children, in consideration of the fact that it is not yet been validated, it was not possible to assess the impact of uncertainty over the findings of the cost-effectiveness analysis, as the report did not address this issue.

Update 2014

Cost-effectiveness modelling (2003, 2007)

A simple cost analysis was presented in the 2003 guideline and updated in the 2007 guideline comparing four strategies: the pre-2003 UK system (based on skull X-ray for patients who had experienced loss of consciousness or amnesia); the Canadian CT Head 5-variable rule; the Canadian CT Head 7-variable rule and the US system (CT for all patients). The cost per patient for each strategy was calculated on the basis of the expected usage of skull X-ray, CT head scan and 24 hour observation. No evidence was available to quantify differences in health outcomes for each strategy, or other cost components. Average unit costs were updated for the 2007 guideline using the NHS Reference Costs 2005-06. This cost analysis has not been updated in the current guideline update, due to the availability of recent, directly applicable evidence derived from a cost-utility analysis based on a decision model.[126,202]

7.3.3 Evidence statements

Clinical - adults

Seven studies with 18734 adults showed that CCHR high and medium risk criteria has a sensitivity of 80 - 100% and a specificity of 39 - 65% for diagnosing intracranial injury. (VERY LOW QUALITY)

Seven studies with 15376 adults showed that NOC criteria has a sensitivity of 86 - 100% and a specificity of 4 - 33% for diagnosing intracranial injury. (LOW QUALITY)

Three studies with 12238 adults showed that NCWFNS criteria has a sensitivity of 98% and a specificity of 3 - 46% for diagnosing intracranial injury. (MODERATE QUALITY)

Three studies with 19091 adults showed that NICE lenient criteria has a sensitivity of 82 - 99% and a specificity of 31 - 70% for diagnosing intracranial injury. (LOW QUALITY)

Three studies with 12237 adults showed that Scandinavian lenient criteria has a sensitivity of 84 - 96% and a specificity of 21 - 60% for diagnosing intracranial injury. (MODERATE QUALITY)

Two studies with 8195 adults showed that CCHR high risk criteria has a sensitivity of 50 - 97% and a specificity of 51 - 77% for diagnosing intracranial injury. (VERY LOW QUALITY)

Two studies with 11018 adults showed that Arienta 1997 criteria has a sensitivity of 88 - 100% and a specificity of 54 - 91% for diagnosing intracranial injury. (LOW QUALITY)

One study with 810 adults showed that Madden 1995 criteria has a sensitivity of 95 - 97% and a specificity of 21% for diagnosing intracranial injury. (MODERATE QUALITY)

One study with 1232 adults showed that Ono 2007 criteria has a sensitivity of 100% and a specificity of 30 - 35% for diagnosing intracranial injury. (MODERATE QUALITY)

Two studies with 4283 adults showed that SIGN 2000 CT urgently criteria has a sensitivity of 65 - 99% and a specificity of 2 - 74% for diagnosing intracranial injury. (MODERATE QUALITY)

Three studies with 7233 adults showed that NEXUS II criteria has a sensitivity of 89 - 100% and a specificity of 0 - 46% for diagnosing intracranial injury. (LOW QUALITY)

Two studies with 5003 adults showed that EFNS CT recommended and mandatory criteria has a sensitivity of 96 - 100% and a specificity of 0 - 28% for diagnosing intracranial injury. (HIGH QUALITY)

Two studies with 2407 adults showed that Miller criteria has a sensitivity of 51 - 65% and a specificity of 63 - 69% for diagnosing intracranial injury. (MODERATE QUALITY)

Five studies with 15603 adults showed that CCHR high risk criteria has a sensitivity of 99 - 100% and a specificity of 48 - 77% for diagnosing need for neurosurgery. (LOW QUALITY)

Five studies with 12906 adults showed that NOC criteria has a sensitivity of 82 - 100% and a specificity of 4 - 31% for diagnosing need for neurosurgery. (LOW QUALITY)

Two studies with 11136 adults showed that NCWFNS risk criteria has a sensitivity of 94 - 99% and a specificity of 99 - 100% for diagnosing need for neurosurgery. (LOW QUALITY)

Three studies with 19091 adults showed that NICE lenient criteria has a sensitivity of 94 - 98% and a specificity of 29 - 67% for diagnosing need for neurosurgery. (LOW QUALITY)

Two studies with 11136 adults showed that Scandinavian lenient criteria has a sensitivity of 94 - 99% and a specificity of 20 - 50% for diagnosing need for neurosurgery. (LOW QUALITY)

Two studies with 2407 adults showed that Miller criteria has a sensitivity of 50 - 100% and a specificity of 61 - 66% for diagnosing need for neurosurgery. (MODERATE QUALITY)

Clinical - children

Two studies with 3709 children showed that the pilot PECARN rule has a sensitivity of 91 - 100% and a specificity of 43% for diagnosing intracranial injury. (MODERATE QUALITY)

One study with 1666 children showed that NEXUS II criteria has a sensitivity of 99% and a specificity of 15% for diagnosing intracranial injury. (HIGH QUALITY)

One study with 22579 children showed that the CHALICE criteria has a sensitivity of 98% and a specificity of 87% for diagnosing intracranial injury. (MODERATE QUALITY)

Two studies with 42109 children showed that PECARN criteria has a sensitivity of 95 - 97% and a specificity of 58 - 75% for diagnosing intracranial injury. (MODERATE QUALITY)

One study with 1000 children showed that Atabaki criteria has a sensitivity of 95% and a specificity of 49% for diagnosing intracranial injury. (MODERATE QUALITY)

One study with 7647 children showed that the CATCH rule has a sensitivity of 98% and a specificity of 50% for diagnosing intracranial injury. (HIGH QUALITY)

One study with 3798 children showed that Da Dalt 2006 criteria has a sensitivity of 100% and a specificity of 87% for diagnosing intracranial injury. (MODERATE QUALITY)

One study with 156 children showed that Dietrich 1993 criteria has a sensitivity of 100% and a specificity of 0% for diagnosing intracranial injury. (HIGH QUALITY)

One study with 337 children showed that the Guzel 2009 criteria has a sensitivity of 69% and a specificity of 43% for diagnosing intracranial injury. (HIGH QUALITY)

One study with 175 children showed that the NOC criteria has a sensitivity of 100% and a specificity of 25% for diagnosing intracranial injury in patients presenting with a head injury. (HIGH QUALITY)

One study with 321 children showed that the Quayle 1997 criteria has a sensitivity of 44% and a specificity of 85% for diagnosing intracranial injury. (MODERATE QUALITY)

One study with 22772 children showed that the RCS guidelines has a sensitivity of 86% and a specificity of 95% for diagnosing intracranial injury. (MODERATE QUALITY)

One study with 1000 children showed that the Atabaki 2008 criteria has a sensitivity of 100% and a specificity of 46% for diagnosing need for neurosurgery. (LOW QUALITY)

One study with 7646 children showed that the CATCH rule has a sensitivity of 100% and a specificity of 70% for diagnosing need for neurosurgery. (HIGH QUALITY)

One study with 22772 children showed that the CHALICE criteria has a sensitivity of 98% and a specificity of 86% for diagnosing need for neurosurgery. (MODERATE QUALITY)

One study with 175 children showed that the NOC criteria has a sensitivity of 100% and a specificity of 24% for diagnosing need for neurosurgery. (MODERATE QUALITY)

One study with 2043 children showed that the pilot PECARN rule has a sensitivity of 100% and a specificity of 64% for diagnosing need for neurosurgery. (MODERATE QUALITY)

One study with 6411 children showed that the PECARN criteria has a sensitivity of 100% and a specificity of 59% for diagnosing need for neurosurgery. (LOW QUALITY)

Clinical - infants

Two studies with 15435 infants showed that the PECARN criteria has a sensitivity of 99 - 100% and a specificity of 54 - 63% for diagnosing intracranial injury. (MODERATE QUALITY)

One study with 402 infants showed that the pilot PECARN rule criteria has a sensitivity of 100% and a specificity of 11 - 34% for diagnosing intracranial injury. (LOW QUALITY)

One study with 97 infants showed that the Buchanich 2007 criteria has a sensitivity of 100% and a specificity of 40% for diagnosing intracranial injury. (MODERATE QUALITY)

One study with 19 infants showed that the Dietrich 1993 criteria has a sensitivity of 100% and a specificity of 17% for diagnosing intracranial injury. (MODERATE QUALITY)

One study with 608 infants showed that the Greenes and Schutzman 1999 criteria has a sensitivity of 53% and a specificity of 72% for diagnosing intracranial injury. (LOW QUALITY)

One study with 172 infants showed that the Greenes and Schutzman 2001 criteria has a sensitivity of 100% and a specificity of 40% for diagnosing intracranial injury. (MODERATE QUALITY)

Two studies with 2741 infants showed that the NEXUS II criteria has a sensitivity of 89 - 100% and a specificity of 5 - 59% for diagnosing intracranial injury. (MODERATE QUALITY)

One study with 2391 infants showed that the Fabbri 2011 criteria has a sensitivity of 100% and a specificity of 76% for diagnosing intracranial injury. (MODERATE QUALITY)

One study with 2216 infants showed that the PECARN criteria has a sensitivity of 100% and a specificity of 53% for diagnosing need for neurosurgery. (LOW QUALITY)

Economic

One cost-utility analysis found that:

- In adults aged 40 years, CCHR (high or medium risk) was cost effective versus the Scandinavian rule (£3879 per QALY gained). All other strategies (discharge all, abnormal arrival GCS, CT all, NCWFNS, NICE, NEXUS II, NOC, CCHR - high risk) were subject to dominance (more costly and less effective than one or combination of two other strategies).
- In adults aged 70 years, CCHR (high or medium risk) was cost effective versus the Scandinavian rule (£3879 per QALY gained). All other strategies (discharge all, abnormal arrival GCS, CT all, NCWFNS, NICE, NEXUS II, NOC, CCHR - high risk) were subject to dominance (more costly and less effective than one or combination of two strategies).

- In children aged 10 years, CHALICE was the dominant rule (less costly and more effective) when compared to the decision rules given by PECARN, pilot PECARN, Atabaki et al., or giving CT to all or discharging all.
- In children aged 1 year, CHALICE was the dominant rule (less costly and more effective) when compared to the decision rules given by PECARN, pilot PECARN, Atabaki et al., or giving CT to all or discharging all.

This analysis was assessed as partially applicable with potentially serious limitations.

7.4 Recommendations and link to evidence (2014)

See section 7.7.

7.5 Research recommendation (2014)

See section 7.8.

7.6 What is the best clinical decision rule for selecting adults, infants and children with head injury for CT head scan who have no history of amnesia or loss of consciousness who are on anticoagulant or antiplatelet therapy? (2014)

The specific populations looked at are: (i) adults classed as medium risk (no high risk factors as identified by Canadian CT head rule), no loss of consciousness or amnesia, but taking anticoagulants or antiplatelets, therefore patients would not receive a CT head scan due to any other risk factor within the pathway and (ii) children and infants with suspected head injury with no history of loss of consciousness or amnesia who are on anticoagulant or antiplatelet therapy in whom there are no risk factors to warrant a CT head scan.

For full details see review protocol in Appendix D.

A search was conducted for clinical decision rules for people with suspected head injury using anticoagulation or antiplatelet treatments.

7.6.1 Clinical evidence

7.6.1.1 Anticoagulation therapy

No clinical decision rules were identified in this specific group. However, the technical team revisited the validation studies assessing clinical decision rules, some of which provided data relating to patients with coagulopathy as a risk factor, including some data relating to the populations of interest. One study was reported in 2 papers and is included in the review.[81,83,85] Evidence from this study is summarised in the clinical GRADE evidence profile below (Table 12). See also the study selection flow chart in Appendix B, study evidence tables in Appendix E and exclusion list in Appendix G.

Fabbri et al, 2005[81] reported data relating to coagulopathic patients scanned according to two guidelines: the NICE 2003 version of the head injury guideline[181] and the Neurotraumatology Committee of the World Federation of Neurosurgical Societies (NCWFNS) proposal.[233] The study compared the diagnostic accuracy of the 2 guidelines. It also reported the incidence of intracranial lesions in a univariate and multivariate analysis using the predictor variables that indicated need for a CT head scan in each guideline. Patients were followed up for 7 days after trauma; later events were

not considered in the analysis. All patients were scanned according to the NCWFNS proposal,[233] which included the recommendation that any patient using anticoagulation therapy should be scanned. This contradicted the strategy in both NICE 2003 and 2007, which stated that adult coagulopathic patients (including those on anticoagulants) would only be scanned if loss of consciousness or amnesia were present. The data available in Fabbri et al, 2005[81] allows calculation of the number of coagulopathic patients without loss of consciousness or amnesia who had intracranial lesions, and estimation of the odds ratio for this as an independent risk factor.

Fabbri et al also published another paper[82] using the same cohort of patients. The incidence of intracranial lesions in all patients who would not have been scanned according to the NICE 2003 guideline was assessed, including coagulopathic patients without loss of consciousness. The numbers differ slightly from the numbers available in Fabbri 2005. This could be because (i) other risk factors in the NICE 2003 guideline are not included as part of the NCWFNS proposal and (ii) the risk factors necessitating a CT head scan denoted in Fabbri 2005 as NICE 2003 recommendations are different to those actually recommended in the NICE 2003 guideline. This is discussed further in the quality of evidence of the link to evidence section below.

The authors were contacted and Fabbri provided additional information about the 2005 study. Specifically, the definition of coagulopathy was clarified. In the context of this study it refers to patients using warfarin with an international normalised ratio (INR) of greater than 2.

No studies were identified which derived or validated clinical decision rules for this question in children or infants. One prospective cohort study[154] was identified which reported the incidence of intracranial haemorrhage following blunt head trauma in children with bleeding disorders, but did not provide information specific to the review question. The GDG therefore felt that it was appropriate to extrapolate the evidence presented by Fabbri et al to the whole population of patients with head injury including children and infants.

Table 12: Clinical evidence profile: intracranial lesions in coagulopathy patients

Quality assessment							No of patients		Effect			
No of studies	Design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other	Coagulo-pathy	No coagulo-pathy	Relative (95% CI)	Absolute	Quality	Importance
Univariate analysis of coagulopathy versus non-coagulopathy in patients who would not have been scanned by NICE 2003 guideline, but were scanned according to NCWFNS proposal (follow-up 7 days)[(g)83]												
1[83]	Observational	Serious risk of bias[(a,b,c)]	No serious inconsistency	No serious indirectness	No serious imprecision	None	16/66 (24.2%)	24/435 (5.5%)	OR 5.48 (2.73 to 11.0)	-	Low	CRITICAL
Univariate analysis of coagulopathy versus non-coagulopathy in patients without loss of consciousness or amnesia (follow-up 7 days) (g)[81]												
1[81]	Observational	Serious risk of bias[(a,b)]	No serious inconsistency	No serious indirectness	No serious imprecision	None	25/83 (30.1%)	517/7872 (6.6%)	OR 6.1 (3.8 to 9.9)	-	Low	CRITICAL
Univariate analysis of coagulopathy versus non-coagulopathy. (follow-up 7 days) (g)[81]												
1[81]	Observational	Serious risk of bias[(a,b)]	No serious inconsistency	Serious indirectness[(f)]	No serious imprecision	None	67/265 (25.3%)	474/7690 (6.2%)	OR 5.1 (3.8 to 6.9)	-	Very low	CRITICAL
Multivariate analysis[(d)] of coagulopathy versus non-coagulopathy. (follow-up 7 days) (g)[81]												
1[81]	Observational	Serious risk of bias[(a)]	No serious inconsistency	Serious indirectness[(f)]	No serious imprecision	None	67/265 (25.3%)	474/7690 (6.2%)	Adjusted OR 8.4 (5.5 to 12.6)	-	Very low	CRITICAL
Univariate analysis of coagulopathy versus non-coagulopathy in patients with loss of consciousness or amnesia. (follow-up 7 days) [(g)81]												
1[81]	Observational	Serious risk of bias[(a,b)]	No serious inconsistency	Serious indirectness[(f)]	No serious imprecision	None	42/182 (23.1%)	500/7773 (6.4%)	OR 4.4 (3.1 to 6.2)	-	Very low	CRITICAL
Multivariate analysis[(e)] of coagulopathy versus no coagulopathy in patients with loss of consciousness or amnesia. (follow-up 7 days) (g)[81]												
1[81]	Observational	Serious risk of bias[(a)]	No serious inconsistency	Serious indirectness[(f)]	No serious imprecision	None	42/182 (23.1%)	500/7773 (6.4%)	Adjusted OR 4.8 (2.6 to 8.6)	-	Very low	CRITICAL

(a) Post-hoc analysis of prospectively collected data relating to a cohort of 7955 mild head injury patients. Some patients were excluded from the eligible 9464 patients because of unclear history of trauma as the primary event (n=559), refusal of diagnostic and management procedures (n=235).Some of these patients may have been anticoagulated patients without loss of consciousness or amnesia.

(b) Univariate analysis.

(c) Also reports a further 1235/7955 patients excluded from the analysis for a variety of reasons (numbers not reported). Some of these patients may have been anticoagulated patients without loss of consciousness or amnesia.

(d) Multivariate stepwise logistic regression analysis. Variables included in analysis are risk factors used in the NCWFNS as indicators for a CT scan.

(e) Multivariate stepwise logistic regression analysis. Variables included in analysis are risk factors used in the NICE guideline (2003 version) as indicators for a CT scan.

(f) The population is not directly applicable. The effect size is reported to illustrate that all patients using warfarin have a large increased risk of developing intracranial lesions regardless of whether they have loss of consciousness or amnesia.

(g) Patients were followed for 7 days after trauma; later events were not considered in the paper's analysis. The GDG agreed this was a suitable follow-up period for this question. All patients using warfarin were scanned according to the NCWFNS proposal.

7.6.1.2 Antiplatelet therapy

One study did look at this patient group, and primarily included patients who were on aspirin and indobufen.[85] Patients who were on ticlopidine may have been included (there is ambiguity on this point in the manuscript), but patients on clopidogrel were excluded from the analysis. Given these factors, the GDG considered the evidence to be of limited relevance.

7.6.2 Economic evidence

Published literature

No relevant economic evaluations comparing clinical decision rules for CT head scan for patients on anticoagulant or antiplatelet drugs were identified. No studies were selectively excluded.

Unit costs

In the absence of recent UK cost-effectiveness analysis, relevant unit costs provided below were used in consideration of cost effectiveness.

Table 13: Unit costs of the health resources which are likely to be involved in the diagnosis and treatment of HI patients on anticoagulants.

Description	Cost (£)	Interquartile range (£)	Source
Emergency Department visit	82[(a)]	60-101	National Schedule of Reference costs 2010-11 (NHS PCTs and Trusts combined).[59,63]
CT scan (one area, one contrast)[(b)]	95	73-106	National Schedule of Reference costs 2010-11 (NHS PCTs and Trusts combined). [59,63]
CT scan (two areas, no contrast)[(b)]	112	90-124	National Schedule of Reference costs 2010-11 (NHS PCTs and Trusts combined). [59,63]
Admission with no deterioration or neurosurgery: head injury without intracranial injury without comorbidities or complications	899	429-1,221	National Schedule of Reference costs 2010-11 (NHS PCTs and Trusts combined). [59,63]
Neurosurgical intervention after deterioration: Intracranial Procedures for Trauma with Diagnosis of Head Injury / Skull Fracture with comorbidities or complications	5741	4778.34 - 6409	National Schedule of Reference costs 2010-11 (NHS PCTs and Trusts combined). [59,63]
Neurosurgical intervention before deterioration: Intracranial Procedures for Trauma with Diagnosis of Head Injury / Skull Fracture without comorbidities or complications	5017	4061-5621	National Schedule of Reference costs 2010-11 (NHS PCTs and Trusts combined). [59,63]
Intensive care costs	1,792	1,504-2,140	National Schedule of Reference costs 2010-11 (NHS PCTs and Trusts combined). [59,63]
Rehabilitation - cost per place per	92	NR	PSSRU 2011. [53,54]

Description	Cost (£)	Interquartile range (£)	Source
day for young adults with brain injury			
Nursing home	1,005	NR	PSSRU 2011 (Local authority residential care for older people).[53,54]

(a) NHS reference costs for "No investigation with no significant treatment" and for Accident and Emergency Services: Not Leading to Admitted were selected because other NHS reference costs for emergency services included some form of investigation (in many cases, the cost of CT scanning), and including this costs would have amounted to double counting.

(b) At time of development, diagnostic imaging was considered as an unbundled cost which would be additional to an admission to hospital.

7.6.3 Evidence statements

Clinical

- One study with 501 patients aged 10 years or more with suspected head injury and no loss of consciousness or amnesia who would not have been scanned by any criteria in the NICE 2003 version of the guideline showed warfarin use (INR >2) compared with non-use to be a significant univariate predictor of intracranial lesions (odds ratio 5.4 (2.7 to 11)) for a non user risk of 5.5%. (LOW QUALITY)
- One study with 7955 patients aged 10 years or more with suspected head injury (INR >2) and no loss of consciousness or amnesia showed warfarin use compared with non-use to be a significant univariate predictor of intracranial lesions (odds ratio 6.1 (3.8 to 9.9)) for a non-user risk of 6.6%. (LOW QUALITY)
- One study with 7955 patients aged 10 years or more with suspected head injury showed warfarin use (INR >2) compared with non-use to be a significant univariate predictor of intracranial lesions (odds ratio 5.1 (3.8 to 6.9) for a non-user risk of 6.2%. (VERY LOW QUALITY)
- One study with 7955 patients aged 10 years or more with suspected head injury showed warfarin use (INR >2) compared with non-use to be a significant multivariate predictor of intracranial lesions (odds ratio 8.4 (5.5 to 12.6) for a non-user risk of 6.2%. (VERY LOW QUALITY)
- One study with 7955 patients aged 10 years or more with suspected head injury and loss of consciousness or amnesia showed warfarin use (INR >2) compared with non-use to be a significant univariate predictor of intracranial lesions (odds ratio 4.4 (3.1 to 6.2)) for a non-user risk of 6.4%. (VERY LOW QUALITY)
- One study with 7955 patients aged 10 years or more with suspected head injury and loss of consciousness or amnesia showed warfarin use (INR >2) compared with non-use to be a significant multivariate predictor of intracranial lesions (odds ratio 4.8 (2.6 to 8.6)) for a non-user risk of 6.4%. (VERY LOW QUALITY)

Economic

- No relevant economic evaluations were identified.

7.7 Recommendations and link to evidence (2014)

7.7.1 Adults

Recommendations	**26. For adults who have sustained a head injury and have any of the following risk factors, perform a CT head scan within 1 hour of the risk factor being identified:** • **GCS less than 13 on initial assessment in the emergency department.** • **GCS less than 15 at 2 hours after the injury on assessment in the emergency department.** • **Suspected open or depressed skull fracture.** • **Any sign of basal skull fracture (haemotympanum, 'panda' eyes, cerebrospinal fluid leakage from the ear or nose, Battle's sign).** • **Post-traumatic seizure.** • **Focal neurological deficit.** • **More than 1 episode of vomiting.** **A provisional written radiology report should be made available within 1 hour of the scan being performed. [new 2014]** **27. For adults with any of the following risk factors who have experienced some loss of consciousness or amnesia since the injury, perform a CT head scan within 8 hours of the head injury:** • **Age 65 years or older.** • **Any history of bleeding or clotting disorders.** • **Dangerous mechanism of injury (a pedestrian or cyclist struck by a motor vehicle, an occupant ejected from a motor vehicle or a fall from a height of greater than 1 metre or 5 stairs).** • **More than 30 minutes' retrograde amnesia of events immediately before the head injury.** **A provisional written radiology report should be made available within 1 hour of the scan being performed. [new 2014]**
Relative values of different outcomes	Diagnostic accuracy for intracranial injury and the need for neurosurgery were the outcomes prioritised for this review. Sensitivity was considered the most important outcome by the GDG for this review question as a clinical decision rule should select all patients with suspected intracranial injury for CT head scan. The consequences of missing a patient with intracranial injury would have serious implications, including death. The GDG also noted that the reference standard for this protocol included 1 month follow-up phone calls for those who did not have a CT head scan. The GDG noted that subdural haematomas may occur later than this (for example, 2 - 3 months), but they felt a 1 month follow-up in the studies was adequate to capture an acceptable measure of diagnostic accuracy. Studies that had less than 1 month follow-up were included, but downgraded under limitations noting that there was an inadequate reference standard.
Trade off between clinical benefits and	The GDG noted that in adults there is only one study that has directly validated the recommendation in the 2007 version of this guideline (Stein et al 2009[250]). This study

harms	reported the 2007 version of the NICE head injury guideline (CG56) to have the lowest specificity and the Scandinavian rule[130] the highest. The study is a "notes extraction of data study" (retrospective review of a patient database). Therefore, the GDG considered that there is not sufficiently high quality evidence (in the whole population of the focus of this guideline) to warrant a change in the current recommendation in CG56 for the adult clinical decision rule for CT head scanning. However, a prospective validation study comparing diagnostic accuracy of the recommendations from this NICE guideline update with other clinical decision rules (including the Scandinavian rule) is an important area for future research. The GDG were reassured that the clinical decision rule used and adapted for the recommendation in the 2007 version of this guideline (and currently used in the NHS) performed well. They felt that a significant increase in specificity in comparison to that achieved in current practice would be necessary to warrant implementation of an alternative clinical decision rule in the NHS. Additionally, the GDG also noted evidence of increased risk of developing a haematoma in all patients using warfarin, not just those with loss of consciousness or amnesia and have modified this recommendation to ensure that all these patients are scanned (see recommendation 28). It is anticipated that this would probably increase the specificity of the NICE guideline in detecting intracranial haematomas.
Economic considerations	One cost-utility analysis[202] found that the Canadian CT Head Rule for high or medium risk is the cost-effective strategy for adults aged 40 and 75 years when compared to the Scandinavian rule. The remaining strategies (discharge all; CT scan abnormal arrival GCS; CT all; NCWFNS; NICE, CCHR (high risk); NOC, NEXUS II) were all dominated or extendedly dominated. In a probabilistic sensitivity analysis (PSA), the Canadian CT Head Rule (high or medium risk) was found to dominate all of the other strategies, for both age groups. The GDG expressed concern that the total costs of the decision rules when applied to medium risk patients may have been underestimated due to the additional costs associated with admission whilst waiting for a CT head scan. The GDG felt this was important to note as the increase in numbers of CT head scans that occurred as a result of the implementation of CG4 was mainly in the medium risk group. Medium risk patients, who may be triaged as clinically non-urgent on arrival to the emergency department, and who require a CT head scan within 8 hours of request (in the 2007 guideline) are often admitted to await a CT head scan. While a proportion of these medium risk patients do need to be admitted for observation (for example, because of intoxication, or in older patients, for medical and social reasons), it is possible that some of them will be admitted only as a way to meet the Clinical Quality Indicator of total time in the emergency department rather than for specific clinical need. Further, if such practice leads to delayed diagnosis of intracranial bleeding, the increased costs of associated complications should also be considered. The GDG noted that these considerations were not incorporated in the HTA report, and therefore the total and incremental costs for medium risk patients may have been underestimated. However, a univariate sensitivity analysis that explored the range of the 95% confidence interval of each parameter, found that for all ages the conclusions remained robust. Thus, even if the authors of the HTA report have underestimated the costs of the different clinical decision rules for medium risk patients, results do not change when costs are allowed to vary.
Quality of evidence	The clinical evidence identified was included in an HTA report. The quality of this evidence ranged from very low to high, with the majority of evidence in adults being of moderate quality. Risk of bias was identified in the studies, mainly due to unclear/inadequate reference standards, retrospective study design or failure to report the method of patient selection. The GDG considered the evidence and felt that

	the most applicable study within the report was Stein et al., 2009[250] as it directly validated the NICE 2007 guideline compared to clinical decision rules. This study is a secondary analysis (retrospective review of a patient database) of a prospectively collected mild head injury database of adolescents and adults.[81] The study shows similar sensitivities and specificities across the range of clinical decision rules tested. Any benefits from reduction in unnecessary CT head scans reflected in the specificity are uncertain due to the retrospective methodology and inadequate reference standard (52.5% received a CT, follow-up of up to 6 hours for medium risk and 24 to 48 hours for high risk patients according to NCWFS guidelines). The GDG therefore considered that there was not sufficiently high quality evidence to change the current recommendation for selection of adult patients for CT head scans. No evidence was identified for moderate or severe head injury. This reinforced the GDG decision to leave the existing recommendation unchanged as it was felt inappropriate to extrapolate the reviewed evidence beyond its application in mild head injury. The health economic evidence was considered to have potentially serious limitations due to the data used to populate the model. The model primarily used data from a mild head injury population and also there was a lack of data on subgroups of patients of interest (for example, patients on anticoagulants). Concerns regarding the underestimation of costs for medium risk patients were addressed through a univariate sensitivity analysis which proved conclusions were robust.
Other considerations	The GDG discussed the recommendations regarding selection of patients for imaging and recommendations regarding the urgency of imaging overlap in the 2007 version of this guideline, and that having separate recommendations resulted in unhelpful duplication. The recommendations on urgency for imaging in the 2007 version of this guideline are based on the high and medium risk criteria of the Canadian CT head rule. The GDG have therefore combined the selection of patients for imaging and urgency of imaging, but split these into 2 recommendations based on risk factors for imaging within 1 and 8 hours. The first recommendation listed above now has 'performed within 1 hour of meeting the risk factor' which is taken from the urgency of imaging recommendation. Therefore, 'amnesia for events more than 30 minutes before impact' has been removed and moved into the second recommendation as this is a 'within 8 hour' medium risk Canadian CT head rule criterion. The urgency of imaging recommendation has not been prioritised for update and therefore the content of the bullet points within the 2007 version of this recommendation has not been altered, but have only been moved within the selection for imaging recommendations for additional clarity. The rationale in 2007 was that selection for head imaging is based upon the Canadian CT-head rules, therefore it is possible to distinguish between those patients at high risk for need for neurosurgical intervention (the five point rules) and those at high risk for clinically important brain injuries (the seven point rules). The former set of patients will need CT imaging to be performed urgently (that is, within one hour). The GDG agreed that effective and appropriate intervention in practice should not be delayed while awaiting any radiology report. The GDG intention in defining the time frame in this recommendation has been to reflect the likely urgency in clarifying appropriate management in these clinical circumstances. These updated recommendations have had 'requested immediately' deleted and 'assessed to meet' added. The GDG felt that 'requested immediately' is unnecessary detail as current UK practice has moved on from a situation where imaging is not requested immediately if a risk factor for imaging within 1 hour is present. The GDG considered that the emphasis should now be on results of imaging being reported by radiology departments to the emergency department in a timely manner. They have therefore added 'a provisional written radiology report should be made available within 1 hour of the CT head scan taking place'.

	The GDG also acknowledged that some units in the UK have radiographers reporting on imaging. The GDG felt that the key issue is that any reporting professional should be appropriately trained and possess the skills and competence to perform this role in line with their own professional competency standards and that implementation of reporting standards and delivery should be guided by local governance frameworks. They have reflected this issue in the wording of their recommendation by indicating that a provision 'radiology' report should be made available within the time frame specified. The GDG were cautious of changing current recommendations based on the limited new evidence identified. They felt that a significant increase in specificity in diagnostic accuracy of a clinical decision rule would be necessary to warrant such substantial change in practice that would result from implementation of a new clinical decision rule. The GDG felt that the existing recommendations should remain unchanged for these reasons. It is important to consider this recommendation alongside those regarding anticoagulants (see recommendation 28 below). The GDG prioritised this recommendation as a key priority for implementation as: it has a high impact on outcomes that are important to patients; has a high impact on reducing variation in care and outcomes; leads to a more efficient use of NHS resources; and means patients reach critical points in the care pathway more quickly.

Recommendations	**28. For patients (adults and children) who have sustained a head injury with no other indications for a CT head scan and who are having warfarin treatment, perform a CT head scan within 8 hours of the injury. A provisional written radiology report should be made available within 1 hour of the scan being performed. [new 2014]**
Relative values of different outcomes	Diagnostic accuracy of clinical decision rules in predicting intracranial lesions and need for definitive neurosurgical intervention were the outcomes prioritised for this question. No studies reporting these were available. However, data were available reporting the incidence of intracranial lesions in the patient group of interest from a study validating the NICE 2003 guideline. The GDG considered this directly applicable evidence. No other outcomes were reported. The GDG considered a follow-up period of 7 days was appropriate to capture the relevant outcomes in these studies as most intracranial haemorrhages would have occurred before this time in patients using anticoagulation therapies The GDG took into consideration the odds ratio for coagulopathy and coagulopathy with loss of consciousness or amnesia as predictors for intracranial lesions.
Trade off between clinical benefits and harms	A validation study of the 2003 version of this guideline reported that a significant number of people using warfarin therapy who would not have been scanned were at significantly increased risk of intracranial lesions.[81,82] Although recommending that patients using warfarin should have a CT head scan may mean that there is additional radiation exposure for these patients, the benefits of diagnosing and appropriately treating an intracranial bleed outweigh the risks attributable to ionising radiation from a CT head scan for this population. Multivariate analysis showed a significant increased risk of developing an intracranial lesion. The absolute risk for patients without the predictors is also similar between the analyses. The multivariate analysis of the NICE 2003 guideline and the NCWFNS showed that the NWFNS approach to coagulopathy had higher diagnostic accuracy because the adjusted odds ratio was higher.[81] Tests for subgroup differences showed I squared at 56%. The GDG concluded it was justified to scan all patients taking warfarin as well as those with loss of consciousness or amnesia. The recommendation regarding CT head scan due to some loss of consciousness or amnesia and coagulopathy has therefore been amended (see recommendation above) and a separate recommendation written for patients using warfarin. No studies were identified addressing this question in children and infants. However, given the significant increase in risk of intracranial haemorrhage in adult patients on warfarin, the GDG felt that the evidence identified should be extended to children and infants on warfarin. They felt that the risks of intracranial haemorrhage in this population were likely to exceed the risk to these patients from ionising radiation.
Economic considerations	There was no economic evidence to inform this question. It is thought that there is great variation as to how patients on anticoagulation that do not show any signs or symptoms of clinically important traumatic brain injury are currently managed in emergency departments of the UK NHS. In some instances, these patients are admitted and observed for 6 hours post injury and are discharged if all the criteria below are met: 1. They can be observed by a responsible adult 2. They are asymptomatic at 6 hours post injury (no headache or nausea/vomiting) 3. Their INR is less than3.0

	Other clinicians would, however, admit these patients for observation for 24 hours and would stop anti-coagulation or antiplatelet drugs and repeat CT head scans. The clinical trade off between the incremental benefit given by these different strategies (discharge all according to the NICE 2007 head injury guideline (CG56) or admit and observe in hospital, and/or CT all HI patients on anticoagulation, and/or repeat CT at a later time) was weighed against the differential in resource use of the different strategies by considering the unit costs of each stage of the pathway using 2010-2011 costs. The GDG noted that patients with head injury using anticoagulants who have not experienced loss of consciousness (LOC) or amnesia do not routinely receive a CT head scan under current guidelines. However, the impact of their medication on clotting times may delay the time it takes to develop an intracranial bleed and thus impact on the time at which this can be diagnosed by CT head scan. The timing of the CT head scan in relation to the likelihood of delayed bleeding, will influence the (cost) effectiveness of a given strategy. For this reason the likelihood of false negatives at different time points that the CT scan can be performed, and the health and cost implications of a false negative, was also considered. However, without a review of the evidence regarding timing of CT in this group of patients, the recommended urgency of CT should remain the same as in the previous guideline. The cost effectiveness of providing CT head scans for all anticoagulated patients with head injury will therefore be influenced by the proportion of patients whose intracranial bleed would have been initially undetected leading to delayed treatment, as well as the proportion of those patients in whom delayed treatment would have had long term negative implications for health and health resource use (therefore need for rehabilitation). Should CT head scans be required for all patients on anticoagulants, then the additional cost per additional patient scanned would amount to approximately £95 (that is the cost of a CT scan for 1 area, 1 contrast; source: NHS reference costs, 2011), the potential cost of admission if the CT head scan is not undertaken within the 4 hour emergency target, and the cost of timely neurosurgical intervention. This cost would be offset by reducing the number of false negative cases that involve higher costs linked to revisits to the emergency department, neurosurgical intervention after deterioration and long term rehabilitation costs due to less favourable neurological outcomes. To note, the CT head scan costs approximately the same as 1 place, for 1 day, on a rehabilitation programme. On balance the GDG came to a consensus that CT head scan for all patients on anticoagulation was likely to be a cost effective intervention due to the substantial adverse health consequences and costs associated with an undetected intracranial bleed.
Quality of evidence	The included study provides directly applicable evidence for the review question asked. No clinical decision rules were identified but data analysing the risk of intracranial lesions in patients with head injury using warfarin were identified. This came from a large dataset that sought to prospectively measure outcomes according to the NICE 2003 version of this guideline. The data are directly relevant as the study attempts to investigate patients that would be missed by the NICE 2003 head injury guideline. However, the data come from one cohort of patients and are reported in 2 papers. There is a discrepancy in the numbers reported between the 2 papers. [81,83] Despite this, all the odds ratios are high and confidence intervals narrow, suggesting that all patients with head injury using warfarin are at significantly increased risk of developing an intracranial haemorrhage. The lowest risk estimate was reported in patients with a loss of consciousness or amnesia, a group already recommended for scanning by the previous versions of the NICE head injury guideline.

	Despite the low rating for the quality of evidence with this evidence GDG are confident that there is an increased risk of bleeding in this group. However, the exact estimate of increased risk is unclear. The effect sizes could be large and the population relates directly to the group addressed in our question. The GDG felt that even the lower confidence intervals are evidence to suggest that important lesions would be missed if this group of patients did not undergo CT head scan. Therefore they believed the true effect is likely to be close to the estimate of effect, but there is a possibility that it is substantially different. The GDG noted that the included evidence (Fabbri et al) was available during the previous update of this guideline, but a specific question around anticoagulants was not included. For this update, we have included anticoagulation as a specific area within the scope and have also requested additional information (clarifying the definition of anticoagulant within the paper) from the authors to enable us to include this paper within the clinical review and make a recommendation underpinned by this evidence. The GDG discussed the discrepancy in the data from the 2 papers by Fabbri, which may be due to different criteria used clinical for decision rules (different methods in describing data). This could be because some coagulopathic patients without loss of consciousness may have been scanned according to the NICE 2003 head injury guideline because of the presence of other risk factors not included as part of the NCWFNS proposal (for example, age over 65 is a risk factor in the NICE guideline but in the NCWFNS proposal). It could also be in part because the factors requiring a CT head scan listed for the NICE recommendations in Fabbri 2005 are different to those actually recommended in the NICE 2003 guideline: Fabbri 2005 states NICE CT head scan GCS 14 at least 2 hours after surgery or GCS less than 14 at any point, the NICE 2003 guideline recommends a CT head scan if GCS equal to 13 or 14 at 2 hours after the injury or GCS less than 13 at any point. This suggests that more people would be scanned according to Fabbri than the actual NICE guideline recommended. This might make the reported sensitivity higher and the specificity lower in Fabbri than actually is the case in the NICE guideline. However, the proportion of patients this might apply to is unknown. If it is small it might not have a significant impact on the outcomes. Despite this discrepancy the increased level of risk associated with people using anticoagulants without loss of consciousness in both papers is high (Table 12). There are also very little data relating to the incidence of intracranial haemorrhage in children taking anticoagulants or antiplatelets. In 1 prospective cohort study[155] of 43,904 children (less than 18 years old) with non-trivial blunt head trauma, only 15 were taking anticoagulation therapy. Two patients in the whole study population were diagnosed with an intracranial haemorrhage, of which one was taking warfarin. The population of children taking anticoagulants can therefore be assumed to be very small, and there are no clinical decision rules or other study types which directly answer this review question in this population. However, the GDG considered that the data identified in adult studies was sufficiently compelling to extend this recommendation to children.
Other considerations	The GDG felt that the recommendation should reflect the included evidence and that the Fabbri paper gave evidence for patients taking warfarin with an INR>2. The GDG discussed the implications of recommending CT head scan in patients taking warfarin only if their INR>2, but felt that mandatory testing of INR levels in the emergency department may unnecessarily delay a CT head scan. There was also concern noted about the standardised testing of INR levels. The GDG considered it more appropriate to omit INR testing from the recommendation. The group also discussed timing of imaging and whether it should be delayed for those on anticoagulants to be able to detect a slow bleed. The GDG noted that

	although bleeds may be slow to develop fully they should be detectable on a CT head scan at an early stage. Fabbri reported a median time from injury to CT scan of 234 (175 to 335) minutes for patients diagnosed with an intracranial lesion at the first scan. The GDG agreed that a CT head scan would be able to pick up a clinically detectable haemorrhage at less than 8 hours but the data provided no evidence for scanning at 1 hour where there were no other indications under the 2007 guideline. The GDG therefore felt that it was safe to recommend 'within 8 hours' and that imaging prior to 8 hours was reasonable. The GDG agreed that effective and appropriate intervention in practice should not be delayed while awaiting any radiology report. The GDG intention in defining the time frame in this recommendation has been to reflect the likely urgency in clarifying appropriate management in these clinical circumstances. The GDG also acknowledged that some units in the UK have radiographers reporting on imaging. The GDG felt that the key issue is that any reporting professional should be appropriately trained and possess the skills and competence to perform this role in line with their own professional competency standards and that implementation of reporting standards and delivery should be guided by local governance frameworks. They have reflected this issue in the wording of their recommendation by indicating that a provision 'radiology' report should be made available within the time frame specified. The GDG considered evidence on clopidogrel, but excluded all identified evidence from the clinical review as it did not meet our protocol (indirect population, included patients on warfarin or clopidogrel, not all patients were scanned and/or unknown if they had initial LOC or amnesia that is, whether they would have been scanned under 2007 NICE recommendations). The GDG decided to make a research recommendation (see recommendation 7.8.3) for clopidogrel due to uncertainty in this area and the absence of directly applicable evidence. This should also include aspirin and other haemostatic agents. The GDG are aware of the ongoing AHEAD study (http://www.shef.ac.uk/scharr/sections/hsr/emris/ahead), funded by the National Institute for Health Research (NIHR) Research for Patient Benefit programme which will report after the publication of this guideline. This study is a prospective multi-site study exploring the clinical outcomes and management of anticoagulated patients (prescribed Warfarin) who suffer head injury The GDG noted other agents that may act in a similar way to anticoagulants and antiplatelets, for example selective serotonin reuptake inhibitors; however these were not prioritised for review. The GDG were also aware of national guidance on warfarin reversal (Guidance on warfarin reversal is available from the British Committee for Standards in Haematology guidance published in 2011 (http://www.bcshguidelines.com/documents/warfarin_4th_ed.pdf). The GDG prioritised the warfarin recommendation as a key priority for implementation as it has a high impact on outcomes that are important to patients, has a high impact on reducing variation in care and outcomes, leads to a more efficient use of NHS resources and means patients reach critical points in the care pathway more quickly.

7.7.2 Children and infants

Recommendations	**29. For children who have sustained a head injury and have any of the following risk factors, perform a CT head scan within 1 hour of the risk factor being identified:** • **Suspicion of non-accidental injury.** • **Post-traumatic seizure but no history of epilepsy.** • **On initial emergency department assessment, GCS less than 14, or for children under 1 year GCS (paediatric) less than 15.** • **At 2 hours after the injury, GCS less than 15.** • **Suspected open or depressed skull fracture or tense fontanelle.** • **Any sign of basal skull fracture (haemotympanum, 'panda' eyes, cerebrospinal fluid leakage from the ear or nose, Battle's sign).** • **Focal neurological deficit.** • **For children under 1 year, presence of bruise, swelling or laceration of more than 5 cm on the head.** **A provisional written radiology report should be made available within 1 hour of the scan being performed. [new 2014]** **30. For children who have sustained a head injury and have more than one of the following risk factors (and none of those in recommendation 29), perform a CT head scan within 1 hour of the risk factors being identified:** • **Loss of consciousness lasting more than 5 minutes (witnessed).** • **Abnormal drowsiness.** • **Three or more discrete episodes of vomiting.** • **Dangerous mechanism of injury (high-speed road traffic accident either as pedestrian, cyclist or vehicle occupant, fall from a height of greater than 3 metres, high-speed injury from a projectile or other object).** • **Amnesia (antegrade or retrograde) lasting more than 5 minutes.**[j] **A provisional written radiology report should be made available within 1 hour of the scan being performed. [new 2014]** **31. Children who have sustained a head injury and have only 1 of the risk factors in recommendation 30 (and none of those in recommendation 29) should be observed for a minimum of 4 hours after the head injury. If during observation any of the risk factors below are identified, perform a CT head scan within 1 hour.** • **GCS less than 15.** • **Further vomiting.** • **A further episode of abnormal drowsiness.** **A provisional written radiology report should be made available within 1**

[j] Assessment of amnesia will not be possible in preverbal children and is unlikely to be possible in children aged under 5 years.

	hour of the scan being performed. If none of these risk factors occur during observation, use clinical judgement to determine whether a longer period of observation is needed. [new 2014]
Relative values of different outcomes	Diagnostic accuracy in predicting intracranial injury and need for neurosurgery were the outcomes prioritised for this review. Sensitivity was considered the most important outcome by the GDG for this review question as a clinical decision rule should select all patients with intracranial injury for CT head scan. The consequence of missing a patient with intracranial injury would have serious implications, including death and long term neurological sequelae.
Trade off between clinical benefits and harms	The GDG noted that the NICE 2007 head injury guideline (CG56) is based on the Children's Head Injury Algorithm for the Prediction of Important Clinical Events (CHALICE) clinical decision rule. During this update, additional clinical decision rules including the Canadian Assessment of Tomography for Childhood Head Injury (CATCH) and the Prediction Rule for identification of children at very low risk of Clinically-important Traumatic Brain Injury (referred to herein as PECARN) were identified. The CATCH and PECARN clinical decision rules have undergone internal (but not external) validation and neither has been validated in our UK population. The GDG noted that the CHALICE clinical decision rule has not undergone validation in any population, but there have been a small number of studies assessing its performance retrospectively. Overall, the GDG felt that the evidence was not strong enough to recommend a change from current practice to another clinical decision rule at this time. The GDG would want to see a large increase in specificity to warrant such a substantial change in practice to implement a new decision rule. The GDG agreed that unnecessary CT head scans should be avoided as children are more sensitive to the damaging effects of ionising radiation. However, concerns regarding the risks of ionising radiation should not prevent CT head scans being performed in cases where the threshold of clinical suspicion of clinically important traumatic brain injury has been breached. The GDG discussed aspects of the 2007 head injury guideline (CG56) that are contentious in clinical practice, most notably some of the risk factors which mandate immediate CT head scan. The GDG recognised that the practice of observation for a period of time prior to performing a CT head scan in children is common, and that a significant number of emergency departments use a modified version of the 2007 NICE guideline in this regard. Taking this into account, the GDG reached consensus based on their knowledge and expertise to define which patients should undergo immediate CT head scan, and which may undergo active observation during which time they receive an immediate CT head scan if they deteriorate. The GDG also realised that this is an area in which clinical judgment of the individual clinician is important.
Economic considerations	One cost-utility analysis (Pandor et al. 2011) found the CHALICE rule to be the dominant strategy for children aged 1 and 10 years. This finding was confirmed in a Probabilistic Sensitivity Analysis (PSA). When the CHALICE rule was excluded from the possible clinical decision rules, the PECARN rule was cost effective compared to the pilot PECARN rule, using mean costs and QALYs from the PSA. To note, the study found very little difference in QALY gain between the decision rules employed. In light of this evidence, the GDG considered the use of the CHALICE clinical decision rule is likely to represent a cost effective strategy for the NHS in the younger population.
Quality of evidence	The clinical evidence identified included an HTA report. The quality of this evidence ranged from moderate to high in children and low to moderate in infants. Risk of bias was identified in the studies, mainly due to unclear or inadequate reference standards, or the study design being retrospective or not reporting the method of

	patient selection. The GDG felt that it was appropriate to include conference abstracts and additional studies validating PECARN and CATCH were included. No validated clinical decision rules were identified in regards to observation of head injured children and this recommendation was therefore made using GDG consensus based on clinical experience and expertise and to be consistent with recommendations on observation elsewhere in the guideline. The health economic evidence was considered to be directly applicable, but had potential limitations in that evidence on the CHALICE clinical decision rule for infants and children was not based on a validation study. The GDG considered that on taking all of the above into account, CHALICE should remain the basis for the current update, despite it being unvalidated.
Other considerations	The GDG considered that as practice is different in children with the frequent use of active observation, the recommendations for urgency should be simplified. The GDG agreed that once the decision is made to perform a CT head scan in children, this should be done within 1 hour of the risk factor being identified. The only patients in the paediatric population that the GDG felt may have a scan "within 8 hours" are those on anticoagulants (see Recommendation 28. As with the recommendations for adults, this updated recommendation has had 'requested immediately' deleted and 'assessed to meet' added in. The GDG felt that 'requested immediately' is unnecessary detail and that current UK practise has moved on from a situation where imaging is not requested immediately if a risk factor for CT head scan within 1 hour is met. The group considered that the emphasis should now be on radiology to enable results of imaging to be reported back to the emergency department in a timely manner and not just on conducting imaging and therefore have added in 'a provisional written radiology report should be made available within 1 hour of the CT taking place'. The GDG agreed that effective and appropriate intervention in practice should not be delayed while awaiting any radiology report. The GDG intention in defining the time frame in this recommendation has been to reflect the likely urgency in clarifying appropriate management in these clinical circumstances. The GDG also acknowledged that some units in the UK have radiographers reporting on imaging. The GDG felt that the key issue is that any reporting professional should be appropriately trained and possess the skills and competence to perform this role in line with their own professional competency standards and that implementation of reporting standards and delivery should be guided by local governance frameworks. They have reflected this issue in the wording of their recommendation by indicating that a provision 'radiology' report should be made available within the time frame specified. It is important to consider the recommendations for CT head scan in children and infants alongside those regarding anticoagulants (see recommendation 28). The HTA report[202] included for this review stated in their protocol that a 1 month follow-up for the reference standard was adequate. The GDG felt that this may be unnecessarily long and queried this with a paediatric intensivist, who was co-opted to the group, who was contacted and advised that 2 weeks follow-up was appropriate as a reference standard for children. This was because chronic subdural haematomas (the reason for a prolonged follow-up time in adults) are uncommon in accidental brain trauma in children presenting at the emergency department with head injury. The GDG agreed with this interpretation. The GDG noted that CHALICE presents the dangerous mechanism of injury risk factor as three independent variables, whereas this has now been combined (as listed in the 2007 version of this guideline). It is noted that in current practice clinicians may not perform CT head scan just for high speed road traffic accidents, may only perform CT head scan due to high speed projectiles or objects if another factor was

	present, and may have a lower threshold for performing a CT head scan after a high fall. However it is recognised that clinical judgement is used in conjunction to applying these recommendations. The GDG prioritised these recommendations as key priorities for implementation as they have a high impact on outcomes that are important to patients, have a high impact on reducing variation in care and outcomes, lead to a more efficient use of NHS resources and mean patients reach critical points in the care pathway more quickly.

7.8 Research recommendations (2014)

7.8.1 Adults

Research question:

2. **What is the clinical and cost effectiveness of the NICE guideline recommendation on CT head scanning in this update versus other clinical decision rules (including the Scandinavian and NCWFNS) for selection of patients for CT head scan?**

Why this is important:

The current NICE guideline for selection of patients for CT head scan is based on the Canadian CT Head Rules. The evidence identified since the NICE 2007 recommendations is limited and of low quality. There is a need for this NICE 2014 guideline to be validated in a broader population of head injured patients, including moderate and severely head injured patients as evidence was only identified in those with mild head injury. The NICE guideline, Scandinavian and NCWFNS clinical decision rules should be compared in a prospective validation study. The GDG were reassured that the NICE 2007 guideline performed well in the identified studies since the 2007 guideline update. To warrant recommendation of a different clinical decision rule and a consequent substantial change in practice, a large increase in specificity and cost effectiveness needs to be demonstrated. This can only demonstrated through such a prospective comparative validation study performed in our population.

7.8.2 Children and infants

Research question:

3. **What is the clinical and cost effectiveness of the 2014 NICE guideline recommendation on CT head scanning versus clinical decision rules including CHALICE, CATCH and PECARN for selection of children and infants for head CT scan?**

Why this is important:

The current NICE guideline for determining which patients need a CT head scan is based on the CHALICE clinical decision rule. CHALICE was derived in the UK but has yet to be validated, and limited evidence has been identified since the NICE clinical guideline was published in 2007. There is a need for a prospective validation and direct comparison of the 2014 NICE guideline and CHALICE, CATCH and PECARN clinical decision rules in a UK setting to determine diagnostic accuracy (sensitivity, specificity, and predictive values for intracranial injury and the need for neurosurgery) and cost effectiveness within the relevant population to which the NICE guideline is applied.

The study should be a prospective study with economic evaluation and should capture subgroups by age, separating out infants (under 2 years), children and young people (under 16 years) and

adolescents (16 to 18 years). The results of such a study will confirm whether current practice is optimal and, if not, which would be the ideal clinical decision rule to implement in a UK population. To warrant recommendation of a different clinical decision rule and a consequent substantial change in practice, significant improvement in diagnostic accuracy must be demonstrated. This can only be done through such a prospective comparative validation study performed in our population.

Update 2014

7.8.3 Anticoagulants and antiplatelets

Research question:

4. **In patients with head injury does the use of antiplatelet and anticoagulant drugs increase the risk of intracranial haemorrhage over and above factors included in the current recommendations for CT head scans?**

Why this is important:

Antiplatelet and anticoagulant drugs are widely and increasingly prescribed, and many patients presenting with a head injury to the emergency department are taking these drugs. While the majority of these drugs are prescribed in older patients they are also used in younger people. This guideline provides recommendations on performing CT head scans in patients on warfarin. However, limited evidence has been identified for patients using other antiplatelet or anticoagulant drugs within studies deriving or validating clinical decision rules for determining which patients need CT head scans. There is a particular paucity of evidence in determining whether they are at increased risk of intracranial haemorrhage.

A study with appropriate economic evaluation is needed to quantify the risk of taking these drugs over and above the risk factors included in an existing clinical decision rule. Antiplatelet and anticoagulant drugs should be studied as a predictor of intracranial injury and analysed within a multivariate analysis with other predictors (including the risk factors used in this guideline to determine when a CT head scan is needed). Univariable analyses of risk of intracranial injury in groups of head injury patients who are taking these agents and those who are not, and who have no other indications for CT head scan under current guidance would also be useful. The GDG felt that, where possible, each drug should be considered separately, particularly aspirin and clopidogrel, and that the reference standard should include CT head scan and a follow-up period of sufficient duration to capture delayed bleeding, for example, at 7 days and 1 month. Analysis would benefit from subgroup results by age (children, adults and patients over 65 years). The GDG suggested reporting similar data used in the AHEAD study (www.shef.ac.uk/scharr/sections/hsr/emergency/ahead).

7.9 What is the diagnostic accuracy of biomarkers (S100B, NSE, GFAP) in the emergency department for selecting adults with head injury for CT head scan? (2014)

The diagnosis of traumatic brain injury (TBI) is essentially a clinical one.[168,226] However, this approach, while providing the best current solution, can be imprecise. This may be particularly the case in mild TBI, where conventional imaging may be normal, and cognitive abnormalities may be due to confounders (for example pre-existing dementia, hypoxia or hypotension from associated injuries, alcohol or recreational drugs). In addition, the clinical picture of mild TBI may be difficult to differentiate from other conditions (such as post-traumatic stress disorder) which result in overlapping phenotypes (and possibly even imaging findings).[226] Perhaps more importantly, there is an increasing recognition that even mild TBI can result in prolonged cognitive and behavioural deficits,[21,42,68,120,153,242,271] and the ability to identify patients at risk of these sequelae would aid clinical management, allow selection of patients for novel therapeutic interventions, and refine resource allocation. The availability of novel objective methods of detecting TBI provide an attractive means of better defining the presence of TBI in these contexts, with improvements in epidemiological precision. The techniques that have been explored in this regard include advanced neuroimaging with MR imaging, electroencephalographic (EEG) based diagnosis, and circulating biomarkers. Of these, MR imaging is expensive and logistically challenging, conventional EEG not appropriate for the emergency setting and processed summary EEG variables remain poorly validated. Circulating biomarkers are a potential logistically appealing and clinically relevant option.

For full details see review protocol in Appendix D.

S100B, NSE and GFAP were prioritised for inclusion within this question as they were considered to cover the majority of biomarkers currently being studied within this field. The GDG are aware of a range of other diagnostic biomarkers, which may be reviewed within future updates of this guidance, but the stage of research is considered to be too early for consideration within this guideline. The GDG considered it important to look for evidence in both adult and child populations.

7.9.1 Clinical evidence

Fifteen prospective cohort studies were included in the review.[22-24,29,40,43,44,77,91,173,175,177,203,210,290] Thirteen studies investigated the diagnostic accuracy of S100B for detecting intracranial injury.[22-24,29,40,43,44,77,173,175,177,210,290] This included two studies conducted in children[29,43] and one study that investigated NSE as well as S100B.[177] Two studies report the diagnostic accuracy of NSE for detecting intracranial injury[91,177] one of which, Fridriksson et al., 2000, is a paediatric study.[91] One study was identified that details the diagnostic accuracy of GFAP for detecting intracranial injury.[203] The GDG considered that CT or negative follow up 1 month for adults, 2 weeks for children) was an appropriate reference standard.

Diagnostic meta-analysis was not performed for this review as the quality of evidence was low and there are many variations within the index test, such as the time taken from injury to blood sampling , time from blood sampling to laboratory measurement, technical specifications of equipment used to measure the levels of biomarkers within blood, and the reference cut-off for normal levels of individual biomarkers.

One HTA report[202] was identified that systematically reviewed the ability to use biomarkers to predict intracranial injury or the need for neurosurgery in adults and children with mild head injury. A new review has been conducted for this guideline rather than reporting the finding of the HTA review, as the HTA protocol did not match our protocol for this review question. It did not include moderate and severe TBI, included additional biomarkers which were not prioritised by the GDG, and included the use of biomarkers in settings other than the emergency department. Evidence from these studies

are summarised in the clinical GRADE evidence profile below (Table 12). See also the study selection flow chart in Appendix H, forest plots in Appendix J, study evidence tables in Appendix E and exclusion list in Appendix K.

Update 2014

Table 14: Clinical evidence profile: diagnostic accuracy of S100B

Outcome	No of studies	Design	n	Limitations	Inconsistency	Indirectness	Imprecision	TP	FP	FN	TN	Sensitivity % (e)	Specificity % (e)	PPV %	NPV %	Quality
ICI in adults[22-24,40,44,77,173,175,177,210,290]	11	Diagnostic	4264	Serious limitations[(a)]	Serious inconsistency [(b)]	No serious indirectness	Serious imprecision [(c)]	374	2929	8	1097	83 - 100	20 - 57	9 - 54	89 - 100	Very low quality
ICI in children[40, 43]	2	Diagnostic	174	Serious limitations[(d)]	No serious inconsistency	No serious indirectness	No serious imprecision	59	70	0	45	100	33 - 42	45 - 46	100	Moderate quality

(a) In 3 studies, patients selected rather than included consecutively or randomly, therefore there is patient selection bias.
(b) Inconsistency in the index test across the studies (measured S100B in serum or plasma, several different reference cut-off points used, different technical equipment used in laboratories and different mean times from trauma to sampling and from sampling to measurement in the laboratory) has led to heterogeneity of the sensitivity and specificity point estimates, as demonstrated on the ROC curve.
(c) The wide range of confidence intervals around the sensitivity and specificities in the studies increases the uncertainty of the actual diagnostic accuracy.
(d) Patients selected rather than included consecutively or randomly, therefore there is patient selection bias.
(e) Relates to a sensitivity or specificity for a single study or a range of sensitivities or specificities when more than 1 study.

Table 15: Clinical evidence profile: diagnostic accuracy of NSE

Outcome	No of studies	Design	n	Limitations	Inconsistency	Indirectness	Imprecision	TP	FP	FN	TN	Sensitivity % (b)	Specificity % (b)	PPV %	NPV %	Quality
ICI in adults[177]	1	Diagnostic	139	No serious limitation	No serious inconsistency	No serious indirectness	No serious imprecision	32	100	0	7	100	7	24	100	High quality
ICI in children[91]	1	Diagnostic	49	Serious limitations[(a)]	No serious inconsistency	No serious indirectness	No serious imprecision	17	13	5	14	77	52	57	74	Moderate quality

(a) Method of patient selection is not reported, therefore there is a potential patient selection bias.
(b) Relates to a sensitivity or specificity for a single study or a range of sensitivities or specificities when more than 1 study.

Table 16: Clinical evidence profile: diagnostic accuracy of GFAP

Outcome	No of studies	Design	n	Limitations	Inconsistency	Indirectness	Imprecision	TP	FP	FN	TN	Sensitivity % (b)	Specificity %(b)	PPV %	NPV %	Quality
ICI in adults[203]	1	Diagnostic	117	Very serious limitations[(a)]	No serious inconsistency	No serious indirectness	No serious imprecision	31	70	1	15	97	18	31	94	Low quality
Need for neurosurgery[203]	1	Diagnostic	117	Very serious limitations[(a)]	No serious inconsistency	No serious indirectness	No serious imprecision	14	60	0	43	100	42	19	100	Low quality

(a) Potential patient selection bias through a convenience sample rather than consecutive randomised patient selection. The study also added an additional 9 patients from the control group into the analysis who received a CT scan based on clinician judgement.

(b) Relates to a sensitivity or specificity for a single study or a range of sensitivities or specificities when more than 1 study.

7.9.2 Economic evidence

Published literature

No relevant economic evaluations comparing clinical decision rules for CT head scan for patients on anticoagulant or antiplatelet drugs were included. One study[225] was excluded due to limited applicability. This is summarised in Appendix L, with reasons for exclusion given.

Unit costs

In the absence of recent UK cost-effectiveness analysis, the cost of using biomarkers in the UK NHS using NHS reference costs 2012[59,64] to aid consideration of cost effectiveness.

The HRG code used in the calculation was "VB08Z", with the currency description of "category 2 investigation with category 1 treatment". This encaptures the investigation code 20 of "Serology", and investigation code 21 of "Observation/electrocardiogram, pulse oximetry/head injury/trends", The NHS reference cost corresponding to "VB08Z" for the following settings was incorporated in the calculation: Accident and Emergency services (both for leading to admitted and not leading to admitted); Accident and Emergency services: Minor Injury Service (both for leading to admitted and not leading to admitted); Accident and Emergency services: Walk In Centres (both for leading to admitted and not leading to admitted); Non 24 hr Accident and Emergency/Casualty Department (both for leading to admitted and not leading to admitted).

The weighted average of the NHS reference costs using the level of activity and the national average unit cost for all of the above settings, and have found the following cost figure for diagnostic biomarkers: £131.34. [59,64]

7.9.3 Evidence statements

Clinical

- Eleven studies with 4264 adults showed that S100B has a sensitivity of 83 – 100% and a specificity of 20 – 57% for diagnosing intracranial injury in people presenting to the emergency department with head injury. (VERY LOW QUALITY)
- Two studies with 174 children showed that S100B has a sensitivity of 85 - 100% and a specificity of 33 - 42% for diagnosing intracranial injury in people presenting to the emergency department with head injury. (MODERATE QUALITY)
- One study with 139 adults showed that NSE has a sensitivity of 100% and a specificity of 7% for diagnosing intracranial injury in people presenting to the emergency department with head injury. (HIGH QUALITY)
- One study with 49 children showed that NSE has a sensitivity of 77% and a specificity of 52% for diagnosing intracranial injury in people presenting to the emergency department with head injury. (MODERATE QUALITY)
- One study with 108 adults showed that GFAP has a sensitivity of 97% and a specificity of 18% for diagnosing intracranial injury in people presenting to the emergency department with head injury. (LOW QUALITY)
- One study with 108 adults showed that GFAP has a sensitivity of 100% and a specificity of 42% for diagnosing need for neurosurgery in people presenting to the emergency department with head injury. (LOW QUALITY)

Economic

- No relevant economic evaluations were identified.

Recommendations	No recommendation made
Relative values of different outcomes	The GDG prioritised diagnostic accuracy in predicting intracranial injury for this review. Sensitivity was considered the most important outcome by the GDG for this review question as an investigation should select all patients with intracranial injury for CT head scan.
Trade off between clinical benefits and harms	After consideration of the evidence the GDG felt that it was not appropriate to make a recommendation, as the data for many of these biomarkers is limited. One exception is S100B, which was the subject of a recent systematic review,[169] and has been studied in nearly 1000 patients in over 25 studies. Many of these studies were based in the ICU and involved patients with moderate or severe head injury, thus limiting relevance and applicability to the issue of initial patient management in the full spectrum of TBI, which is the focus of these guidelines. The review concluded that S100B measurements could have a significant role in predicting prognosis in moderate and severe TBI, and potentially excluding significant intracranial injury in mild TBI. However, like the authors of the review, the GDG felt that further evidence was needed before firm recommendations could be made on the use of this biomarker, further information was needed on the confounds produced by extracranial injury, optimal sampling time point, sample processing protocols, assay techniques, and clear thresholds for outcome prediction. The GDG considered that the low numbers of false negatives was potentially promising, but concluded that there was insufficient evidence on the use of S100B in particular, and circulating biomarkers in general, to enable firm recommendations to be made concerning their use as part of a clinical decision rule or as a standalone means of triage or prognosis. Any recommendation for use of such markers may need to be specific to the severity of TBI and the aim of the analysis: for example, early (≤ 3 hour) S100B levels may provide indication of the presence of significant brain injury, but later S100B elevation in moderate or severe TBI may provide evidence of secondary neuronal injury, and require multiple assays and determination of peak levels as a prognostic marker. The GDG noted some significant obstacles to using biomarkers in some contexts. For example, one recommended cut off for interpreting S100B assays is three hours post-injury. If this proves to be the case, the challenge will be to ensure that the test is readily available, provides a quick result and is interpretable by staff in the emergency department. It is also important to understand that the normal levels of circulating biomarkers alter as the nervous system matures and therefore diagnostic cut off concentrations will vary between children and adults. Before significant NHS resources are targeted in this area, it is important to confirm that biomarkers are sufficiently accurate indicators of significant brain injury and intracranial bleeding to allow use in routine clinical practice. The GDG made a research recommendation to explore this area further (see section 7.10). The GDG noted that they would welcome research into near patient testing of biomarkers for TBI given the limited time window for testing with these biomarkers (3 hours). An important patient consideration was the avoidance of radiation burden should a biomarker rule out an unnecessary CT head scan, however they noted the low specificity within the current evidence base. Also important to patients are issues such as discomfort or inconvenience. Economic consideration may include the cost of an overnight admission for observation or CT head scan within 4 hours.
Economic considerations	No economic evidence was identified for inclusion for biomarkers.

	The main costs to the NHS associated with the use of biomarkers consist of the cost of the test, healthcare professionals' time and education (for example, in setting and calibrating the necessary assay kits), as well as laboratory overhead costs. Additional costs in the use of biomarkers are linked with the risks of delaying the necessary intervention (neurosurgery) if the biomarker produces a false negative result. In addition, the clinical review has found variation in the time required for a biomarker assay to produce a test result (from 2 to 6 hours), which in turn involves risks for those patients who require early intervention in the form of surgery. Furthermore, the GDG has suggested that currently under 10% of emergency departments routinely use diagnostic biomarkers in the UK NHS to screen head injury patients. With an estimated cost of £131.34 for each of these tests, the widespread use of biomarkers in the NHS could thus pose considerable implementation costs. Overall, cost effectiveness remains unclear and further research is warranted.
Quality of evidence	The GDG acknowledged the limited quality and number of studies for S100B, NSE and GFAP in children and adults. It is noted that a number of factors vary within the index test of the included studies, such as the time taken from injury to blood sampling , time from blood sampling to laboratory measurement, technical specifications of equipment used to measure the levels of biomarkers within blood, and the reference cut-off for normal levels of individual biomarkers. No studies were identified that assessed biomarkers as part of a clinical decision rule.
Other considerations	The GDG noted that UCHL-1 was an additional biomarker where evidence is published, however this is not included within the scope of this guideline and therefore not prioritised for review. The GDG also acknowledge the published literature on prognostic biomarkers, the most recent of which is a systematic review on the use of S100B for prognostication in acute TBI,[169] however a review question was not prioritised in this area.

7.10 Research recommendations (2014)

Research question:

5. In adults with medium risk indications for brain injury under current NICE CT head injury guidance, what is the clinical and cost effectiveness of using the diagnostic circulating biomarker S100B to rule out significant intracranial injury?

Why this is important:

Circulating biomarkers, if validated, could provide a convenient and clinically applicable aid to the diagnosis of mild traumatic brain injury (TBI) – a 'troponin for the brain'. If such biomarkers were sufficiently sensitive as well as specific for injury type (separating patients with traumatic axonal injury (TAI) from those with contusions), panels of biomarkers might not only help to determine which patients need neuroimaging but also allow us to devise rational, cost-effective pathways for neuroimaging – perhaps reserving primary use of advanced MR imaging for patients who have TAI as these lesions are undetectable on CT head scans.[289] In addition, the availability of quantifiable biomarkers, scaled with the severity of injury, could help clinicians monitor the progression of brain injury in patients with more severe TBI, help stratify patients for trials and therapies, and provide significant prognostic information across all severities of TBI.

There is low-quality clinical effectiveness data for using the biomarker S100B to rule out significant intracranial injury in patients in the emergency department. Current evidence suggests that there is variation in the use of biomarker tests, including in the timing of testing, the concentration of biomarker used as a diagnostic cut-off, protocols used for sample transport and storage, and the equipment used for biomarker assays in laboratories. A diagnostic study (using randomised or consecutively selected patients) is needed to investigate the role of S100B in patients with selected head injury patterns.

The GDG also recognised the potential utility use of near-patient testing for biomarker tests to reduce the time from injury and blood sampling to test results. In addition, the GDG would welcome an additional outcome of 3-month follow-up of functional outcome/post-concussion symptoms alongside this study with appropriate economic evaluation. This research would provide UK-based evidence as to the potential benefit of biomarkers and any associated reduction in CT head scans and hospital admissions.

Update 2014

7.11 Investigation of clinically important brain injuries (2003)

A systematic review of clinical decision rules for the selection of patients who have sustained a head injury for CT imaging of the head was carried out according to the methods outlined in Chapter Two. Six level one studies[75,117,159,170,216,252] were identified. It was agreed that the review would focus on this evidence, but also give due cognisance to the findings of a level one systematic review examining the prognostic value of a diagnosis of 'skull fracture'[123] and a level two study that reported on the first part of a project likely to produce level one evidence.[258]

The studies may be divided into contextual information and actual decision rules. Four studies provide level one evidence on the following important contextual issues. First, skull X-ray is of limited value in assisting the diagnosis of ICH as the sensitivity of a positive finding is only 38%.[123] While it is true that a finding of skull fracture on radiography significantly elevates the risk of ICH one cannot rule out ICH on the basis of a negative radiograph (sensitivity was 0.38, see section 1.5).

Second, patients with a negative CT scan and no other body system injuries or persistent neurological findings can be safely discharged.[159] The negative predictive power quoted in this study was 99.7%.

Third, a strategy of either 100% CT imaging or high quality in-patient observation for patients who have sustained a minor/mild head injury will be 100% sensitive.[75,252] The task is therefore to derive a more sophisticated clinical decision rule for patient selection that will improve specificity without impairing sensitivity.

7.12 What is the best initial diagnostic technique to determine which patients have sustained damage to the head and require further assessment of the head? (2007)

7.12.1 Introduction and rationale for the clinical question

In the 2003 guideline the GDG recommended CT imaging for the head as the primary investigation of choice for the detection of acute clinically important brain injuries (see recommendations 32 and 33). In this update a review was carried out to ascertain whether CT is still in 2007 the most accurate tool for use in the initial diagnosis of head injury. This review also investigates whether there are other imaging tools that have been compared to CT and are accurate in identifying head injury. The outcome measures for including studies for this review were sensitivity and specificity of the imaging technique with or without mortality, disability, neurological outcome, hospital duration, and cost.

7.12.2 Clinical evidence

In the earlier version of the head injury guideline no evidence was found that addressed this question. However in this update one study was retrieved[109] in children and no evidence was retrieved for adults. This included study[109] examined the diagnostic value of physical examination (including neurological exam) for positive CT scan findings in 98 children (2-16 years) children with closed head injury. This prospective diagnostic study (level II evidence) evaluated physical examination using CT as the reference standard. This study was based in San Diego, USA. Halley et al concludes that physical examination cannot identify all cases of brain injury that are demonstrated on CT imaging. Physical examination was demonstrated in this study as having poor sensitivity of 0.69 (CI: 0.42-0.87) and specificity of 0.4 (CI: 0.30-0.51) for identifying patients with brain injury but this presupposes that CT is 100% accurate.

7.12.3 Economics evidence from 2007 update

See and economic Chapter 13.

7.12.4 Summary of evidence from 2007 update

The evidence is a relatively weak, as the Halley et al[109] study included a limited sample size with 9 out of the 98 subjects not being contactable.

A decision model[253] estimated that CT scanning all patients was both more effective and cost saving than with X-raying all patients. It also showed that selective CT scanning could be just as effective as routine CT with lower cost. However, the setting was the USA where costs are quite different to the NHS and the estimates of effectiveness were derived from case series.

7.12.5 Rationale behind recommendation

Generally speaking, CT is more sensitive than X-ray at detecting clinically important lesions, although evidence specific to head trauma was not retrieved. CT is likely to be cost effective but only if a) the extra lesions found by CT pose a significant health risk, b) identification leads to earlier/better treatment and c) early/modified treatment improves survival. For these variables there is no high quality evidence. However, a decision model[253] based on case series evidence estimated that CT scanning all patients would both more effective and cost saving than with X-raying all patients in a US context.

The GDG felt based on their expertise that CT is the most appropriate tool for diagnosing life-threatening conditions resulting from head injury. The GDG also felt that a recommendation was required to emphasizes that X-ray is not a suitable substitute for CT. However, it was necessary to acknowledge that plain X-rays are useful adjuvant to CT in managing children with suspected non-accidental injury and therefore a new recommendation was developed (see update 2007 recommendation).

7.12.6 Recommendations

32. The current primary investigation of choice for the detection of acute clinically important brain injuries is CT imaging of the head. [2003]

33. For safety, logistic and resource reasons, do not perform magnetic resonance imaging (MRI) scanning as the primary investigation for clinically important brain injury in patients who have sustained a head injury, although it is recognised that additional information of importance to the patient's prognosis can sometimes be detected using MRI. [2003][143]

34. Ensure that there is appropriate equipment for maintaining and monitoring the patient within the MRI environment and that all staff involved are aware of the dangers and necessary precautions for working near an MRI scanner. [2003]

MRI safety, availability and speed may improve in the future to the point where it becomes a realistic primary investigation option for head injury.

These recommendations are based on level five evidence and are considered to be grade D recommendations.

7.12.6.1 Update 2007 recommendations

35. Do not use plain X-rays of the skull to diagnose significant brain injury without prior discussion with a neuroscience unit. However, they are useful as part of the skeletal survey in children presenting with suspected non-accidental injury. [2007]

36. If CT imaging is unavailable because of equipment failure, patients with GCS 15 may be admitted for observation. Arrangements should be in place for urgent transfer to a centre with CT scanning available should there be a clinical deterioration that indicates immediate CT scanning is necessary. [2007]

7.13 What are the effects on patient outcomes of providing an immediate CT versus observation? (2007)

7.13.1 Introduction and rationale for the clinical sub question

A question that arises from identifying CT as the best initial imaging technique to determine which patients have sustained damage to the head and require care is whether providing an immediate CT yields better patient outcomes compared with observation. A review of the clinical evidence was deemed necessary as a sub question as a part of the previous clinical question (see 6.3).

7.13.2 Clinical evidence

One study (level 1++ evidence) was identified[4] for this review. This recent large, randomised controlled trial[4] investigated CT compared with admission to hospital for observation. This study included hospital patients aged ≥6 years of age with mild head injury within the past 24hrs who attended emergency departments. The main findings from this trial were that at 3 months, 21.4% (275/1316) of patients in the CT group had not recovered completely compared with 24.2% (300/1286) admitted for observation. The difference was found to be not significant in favour of CT (95%CI: -6.1%-0.6%). The worst outcomes like mortality and severe loss of function were similar between the groups. None of the patients with normal findings on immediate CT had complications later.

7.13.3 Economics evidence from 2007 update

See economic section Chapter 13.

7.13.4 Summary of evidence from 2007 update

The Af Geijerstam study[4] showed that the use of CT in the management of patients with mild head injury leads to similar clinical outcomes compared with observation in hospital.

The associated economic evaluation[191] showed that for these mild head injured patients CT scanning and then discharge after a negative scan was cost saving compared with admission with no loss of health outcome.

7.14 Piloting the new rules (2003)

The process of implementing these guidelines is beyond the GDG but it is recommended that the clinical decision rules advocated in this chapter be piloted and their usage and impact on health outcomes analysed at a small number of representative hospitals before being broadly adopted. The GDG 2003 were aware that both the head and cervical spine imaging rules advocated were derived from a Canadian sample, where the proportion of head injury episodes involving assaults and the influence of alcohol is apparently much lower, and the proportion involving road traffic accidents much higher, than in the UK. It is unclear how this could impact on CT ordering rates following adoption of the rules in a UK context.

7.15 Non-accidental injury in children (2003)

These guidelines are not intended to cover the acute management of non-accidental injury, but it is important that health professionals are aware that the head injury examination is an important opportunity to identify this problem. There is evidence that a distinct pattern of brain injuries is associated with non-accidental injury in children. This results from the different mechanisms of injury in accidental versus non-accidental head injury.

Work on the derivation of clinical decision rules to predict non-accidental injury based on imaging patterns has recently been begun.[282] However, the decision rules in this area will require substantial validation before they can inform clinical practice. Future versions of this guideline should determine the status of research in this area.

7.16 Safeguarding and initial investigations

Recommendations	**37. A clinician with training in safeguarding should be involved in the initial assessment of any patient with a head injury presenting to the emergency department. If there are any concerns identified, document these and follow local safeguarding procedures appropriate to the patient's age. [2003, amended 2014]**
Relative values of different outcomes	Not subject to formal evidence review.
Trade off between clinical benefits and harms	Attendance at hospital is an important opportunity to assess the risk of maltreatment of individuals, both children and vulnerable adults. This is accompanied by a legal requirement for staff to take the appropriate action.
Economic considerations	This recommendation was reached by consensus. Whilst there are costs to staff time to undertake the appropriate action, safeguarding is a mandatory activity.
Quality of evidence	Not subject to formal evidence review.
Other considerations	The 2003 NICE head injury guideline made a recommendation regarding the appropriate management of non-accidental injury in children which was amended in the 2007 update. Since 2003, legislation has been introduced which clearly identifies the appropriate action that staff should take if they suspect there are concerns regarding maltreatment. The language associated with such practice has also moved on since 2003 with the term 'safeguarding' becoming a recognised and well-understood concept within health and social care practice that is subject to formal regulation by organisations such as the Care Quality Commission. The term 'safeguarding' describes a range of activities that organisations should have in place to protect people. Similarly, the use of the term non-accidental injury has for the most part been replaced by the use of the term 'child maltreatment'. The NICE clinical guideline 89; 'When to suspect child maltreatment' (http://www.nice.org.uk/CG89) defines maltreatment as including neglect, physical, sexual and emotional abuse, and fabricated or induced illness. That guidance used the definitions of child maltreatment as set out in the document 'Working together to safeguard children' and has made a number of recommendations on physical features, clinical presentations, neglect, functioning and parent –child interaction that should be followed within NHS practice in England and Wales. It is now recognised that those most in need of protection are: • children • young people • vulnerable adults whose circumstances make them vulnerable. The 2007 NICE head injury guideline made minor edits to the original 2003 recommendation. However the GDG for this guideline update felt it important to amend this recommendation because of its equalities responsibilities – in this case to reflect the needs of vulnerable adults as a population not considered previously by this guideline. The GDG therefore drafted a new recommendation based on consensus but with due consideration of the legal responsibilities in this area. They noted that safeguarding adults involves the timely implementation of systems, processes and practices to enable people to live a life that is free from abuse and neglect. They felt that vulnerable adults for the purposes of this guideline would include the elderly and frail, living on their own in the community, or without much

	family support in care homes. They also noted that people with physical or learning disabilities and people with mental health needs are at increased risk of suffering harm both in institutions and in the community. They also felt that the intoxicated, through alcohol or drug use may be considered vulnerable. They did not wish to specify 'vulnerable' in the recommendation as this could only definitively be decided following a full assessment by someone with the relevant safeguarding expertise. The GDG were aware of the Department of Health document, Safeguarding Adults: The Role of Health Services (2011). A suite of guidance documents aimed at the role of managers and boards, healthcare practitioners, and commissioners that should inform practice is available at: www.dh.gov.uk/en/Publicationsandstatistics/Publications/PublicationsPolicyAndGuidance/DH_124882. For children and young people, the GDG noted that safeguarding legislation and government guidance means that staff have a responsibility to: protect children from maltreatment; prevent impairment of children's health or development; ensure that children are growing up in circumstances consistent with the provision of safe and effective care and take action to enable all children and young people to have the best outcome. They further noted that all NHS bodies have a duty under section 11 of the Children Act 2004 to ensure that their functions are discharged with regard to the need to safeguard and promote the welfare of children. (Children Act 2004:www.uk-legislation.hmso.gov.uk/acts/acts2004/ukpga_20040031_en_1) The GDG considered that all staff responsible for the assessment and care of patients with head injury in the emergency department would receive safeguarding training at a level in line with local recommendations. All staff in the emergency department should be aware of the local processes required to express and act on safeguarding concerns, and there should be a clear pathway within emergency departments which outlines how to contact key allied professionals including social care services, and in the case of children, paediatricians with expertise in child safeguarding. The GDG have prioritised this recommendation as a key priority for implementation as it has a high impact on outcomes that are important to patients, a high impact on reducing variation in care and outcomes, lead to a more efficient use of NHS resources, promotes equalities and means patients reach critical points in the care pathway more quickly.

8 Assessment in the emergency department: imaging of the cervical spine

8.1 Introduction (2014)

Patients with head injury may sustain bony and/or soft tissue injuries to the cervical spine. When imaging is required, the first line test will either be a series of cervical spine X-rays or a Computerised Tomography (CT) scan. Depending on the clinical situation, Magnetic Resonance (MR) imaging may also be required to assess for soft tissue injury to the ligamentous structures, intervertebral discs and spinal cord. This section includes the use of the abbreviation MR, previously referred to in earlier guideline iterations as MRI.

The 2007 version of the NICE guideline employed a modified version of the Canadian Cervical Spine Rule, suggesting that plain X- rays should be the initial mode of imaging of the cervical spine unless the patient was undergoing CT head scan, in which case the initial mode of cervical spine imaging should also be CT.

Following acquisition of initial cervical spine imaging, the GDG note that there will be four groups of patients:

1. Patients who are fully alert and orientated (GCS 15), with no focal neurological deficit, no discomfort on moving their necks AND whose **initial mode of cervical spine imaging is negative**. Patients in this group do not require further imaging.
2. Patients who are fully alert and orientated (GCS 15), with no focal neurological deficit, minimal discomfort on moving their neck, but whose **initial mode of cervical spine imaging has positive findings.** In this group the questions that remain are (i) do those with a positive CT now need an MR scan and (ii) do those with positive plain X-rays need a CT or MR scan?
3. Patients whose conscious level is reduced (GCS <15), or who have a focal neurological deficit, or who have severe neck pain, whose **initial mode of imaging is negative or equivocal.** In this group, the questions to be answered are (i) do those with a negative CT scan now need an MR scan and (ii) do those with negative plain X-rays now need a CT or MR scan?
4. Patients whose conscious level is reduced (GCS <15), or who have a focal neurological deficit, or who have severe neck pain, whose **initial mode of cervical spine imaging has positive findings.** In this group the questions that remain are (i) do those with a positive CT scan now need an MR scan and (ii) do those with positive plain X-rays now need a CT or MR scan?

Current practice for groups 2 - 4 would be in most situations to investigate with further imaging, although the second line of imaging and its timing undoubtedly varies. There is an understandable reluctance to CT the cervical spine of injured children due to the risks to the thyroid gland from radiation exposure.

The GDG have prioritised review questions to optimise the selection of patients for cervical spine imaging in two clinical scenarios. The first is how to select patients who require initial imaging (using CT cervical spine scan or plain X-rays) on presentation to emergency departments. The second relates to how to select those who have undergone initial imaging but require further imaging of the cervical spine using MR or CT (after initial CT cervical spine scan or plain X-rays) due to continued clinical suspicion of injury with negative or indeterminate initial imaging. The review questions are detailed below in section 8.5 - 8.7.

8.2 Investigation of cervical spine injuries (2007)

Patients who have sustained head injury may have co-incidental cervical spine injury. These patients require clinical and radiographic clearance of the cervical spine before removal of an immobilisation device. The major consequence of a missed bony or ligamentous injury is damage to the cervical cord.

8.2.1 Imaging options (2003)

There are four options for imaging of the cervical spine. It is recognised that technological advances in imaging modalities may make the following discussion obsolete in the future.

- X-rays:
  - cross table lateral
  - 3 film series (with swimmer's view for cervico-thoracic junction if required)
  - 5 film series including 'trauma obliques'.
- Lateral flexion/extension series – immediate and/or delayed.
- CT (localised or whole cervical spine including cervico- thoracic junction).
- Magnetic Resonance Imaging.

8.2.1.1 X-rays

When adequate visualisation of the entire cervical spine is achieved a negative predictive value for a three-view series has been quoted as between 93-98%.[5,20,164] Sensitivity however varies from 62% to 84% in these high risk populations. It is estimated that in a high risk population one in six cervical spine injuries would be missed relying on an adequate three-view plain film series alone.[107] If fractures that are clinically important are used as the gold standard then sensitivity is approximately 94%[261] and overall specificity 96% in a low risk group.[25]

There is evidence that five-view cervical spine X-ray does not improve predictive value compared to three-view X-ray with CT as the gold standard.[90] The use of a lateral view alone will miss a significant proportion of injuries detected by a three-view series.[47]

Patients who have sustained major trauma are more difficult to evaluate with X-ray and specificity decreases to between 79% and 89%, mainly due to inadequate or incomplete studies. The most common reason for this is poor visualisation of the cervico-thoracic junction.

8.2.1.2 Lateral flexion/extension views

In alert symptomatic patients, lateral flexion/extension views can be safely performed over the pain-free range. Studies have shown significant false positive and false negative rates.[158] Ten per cent of 'normals' may have 'abnormal' flexion/extension views.[137]

There is controversy over the safety of using fluoroscopically guided passive flexion and extension to assess patients who are not fully conscious.

8.2.1.3 CT imaging of the cervical spine

CT imaging of the cervical spine may be localised (for example, cranio-cervical or cervico-thoracic to clarify a clinical or plain X-ray where there is suspicion), or cover the whole cervical spine.

Several studies report 100% sensitivity for detection of injuries in areas poorly visualised or suspicious on plain X-rays. These studies are flawed however in that they have not used an

alternative gold standard.[107] If a CT head scan has been requested the cost of cervical CT is reduced and can be accomplished quickly without additional patient transfer.

8.2.1.4 Magnetic Resonance Imaging (MRI) of the cervical spine

There is evidence that MRI detects a higher proportion of soft tissue abnormalities when performed within 48 hours of injury than plain X-rays and CT[18] but the clinical significance of these injuries is unclear. MRI is less effective than CT in the detection of bony injury.[148] It has also been demonstrated that MRI can miss ligamentous injuries if delayed.[79] Injuries of the mid-cervical spine, especially subluxation and lateral fractures are associated with vertebral artery injury which may be detected by MRI.[284]

8.2.1.5 Occipital condyle injuries

Occipital condylar fractures are uncommon injuries associated with high energy blunt trauma to the head and/or upper cervical spine. They are difficult to diagnose clinically but should be suspected in patients showing signs of lower cranial nerve palsy after injury. Demonstration on X-ray series is extremely difficult and radiological diagnosis requires good quality CT.

8.3 What is the best diagnostic imaging technique to determine which patients have sustained damage to the cervical spine and require further assessment of cervical spine? (2007)

8.3.1 Introduction and rationale for the clinical question

Given the potentially devastating consequences of a missed cervical spine injury, timely and accurate diagnosis is essential for optimal management. This review is required to identify which of the currently available tools is best to identify clinically important cervical spine injury.

The population group were patients with head injury and suspected cervical spine injury. The intervention/imaging options were:

- Computed Tomography Scan (CT)
- Magnetic Resonance Imaging (MRI)
- X-rays: cross table lateral, 3 film series, 5 film series, lateral flexion; extension series or swimmer views
- Observation alone
- Physical examination.

The outcome measures for included studies for this review were sensitivity and specificity of the imaging technique.

8.3.2 Clinical evidence

We included one meta-analysis[125] which compared plain X-rays with CT. This meta-analysis included seven diagnostic cohort studies. The studies varied in the number of views (3 and 5) and some were retrospective and others prospective. Another prospective diagnostic cohort study[194] was also retrieved comparing 3 view X-ray with CT. The final prospective diagnostic cohort study[36] comparing helical CT and X-rays (single cross-table lateral). All 3 studies were graded as diagnostic studies level II evidence. All these studies included patients over 16 years of age. We found no studies in children and infants.

A meta-analysis[125] was retrieved which included seven diagnostic cohort studies .This study comprised of 3834 patients with blunt trauma events requiring imaging. The reference standard was either CT or all imaging scans and clinical follow-up. CT scans had a higher sensitivity of 98% (95% CI, 96-99) compared to X-rays which were 52% (95% CI, 47-56). The test for heterogeneity for the sensitivity of CT was 0.99 and for X-rays was 0.07. As there was a high variation in the sensitivities for X-rays we reviewed the seven studies[13,20,66,101,192,229,283] individually. The patient populations varied between the studies. Three studies[20,66,229] selected only the most severely injured patients (altered mental status or those requiring admission to the intensive care unit). One study[283] selected only high risk blunt trauma patients. Another study's[101] inclusion criteria was for blunt trauma patients with physical findings of posterior midline neck tenderness, altered mental status or neurological deficit. The final two studies[13,192] reviewed patients that had suffered a cervical spine fracture or patients that had both CT and X-ray imaging for suspected cervical spine fracture. The later study[13] reported a prevalence of cervical spine injury of 76% (19 of 25 included patients). The sensitivities in these seven studies ranged from 39 to 76%. The studies varied in number of X-ray views (3 and 5) and three were retrospective and four prospective. The meta-analysis[125] evidence supports the use of cervical spine CT as initial screening test in high risk patients.

A prospective cohort study[194] was retrieved. This was a small study (N=34) that selected high risk blunt trauma patients in a US trauma centre. The study used X-rays to identify fractures of the cervical spine and CT scans were used as the reference standard. The sensitivity of X-rays (3 view) was 93.3% and the specificity was 95.0%.

The final prospective cohort study[36] comprised of 442 unconscious intubated blunt trauma patients in the UK. The reference standard was MRI and/or clinical outcome. The interventions tested were helical CT (n=381) and X-rays (single cross-table lateral) (n=421). Only 421 patients had cross table lateral film as 21 patients went straight to CT for reasons of clinical priority. 381 patients had a CT scan that was followed up by MRI or clinical outcome. Cervical spine injuries were found in 14% of the patients. CT scans were more sensitive than X-rays (98.1% vs 72.1% respectively). X-rays had a lower specificity (94.2%) than CT scans (98.8%). Only 200 of the X-rays were adequate.

8.3.3 Economics Evidence from 2007 update

See Economics section in chapter 13.4.

8.3.4 Summary of evidence from 2007 update

The meta-analsyis[125] found that CT had a higher sensitivity than X-rays. Nygren[194] found that X-rays had a sensitivity of 93.3% in high risk blunt trauma patients (CT was used as the reference standard). Brohi et al[36] found that CT scans had a higher sensitivity than X-rays in a group of unconscious intubated blunt trauma patients.

The economic evidence[2,6,103,163] suggests that CT scanning of the cervical spine is cost effective in higher risk groups who are already undergoing head CT. However, the costs and health consequences associated with the increased radiation exposure were not taken into account, and the settings of these studies were outside the UK NHS.

8.3.5 Rationale behind recommendation

There is no evidence at present to suggest that CT screening is required for everyone regardless of head injury severity; the economic evidence suggests that it would not be cost-effective for head injury patients with a low risk of spinal damage.

The new evidence[36,125,194] indicates that in severely head injured patients, CT is the best initial diagnostic tool for assessment of the cervical spine. The GDG suggested a change in wording of the

recommendation to add that patients with head injury (GCS ≤ 13) and intubated patients should have CT scans of the cervical spine rather than X-rays.

If CT detects more unstable fractures then potentially it will lead to health gain and cost savings by averting paralysis. The cost-effectiveness evidence[2,6,26,103,163] suggests that CT scanning of the cervical spine is cost effective in higher risk groups but not in all head injured patients. These studies were conducted from a US perspective and therefore are not directly applicable to the UK NHS. Logically, as long as CT is picking up more unstable fractures, cervical spine CT will be cost effective for those NHS patients at the very highest risk; the threshold at which it becomes not cost effective is, however, difficult to determine.

The rationale for this amendment to the previous recommendation is that in this group of head injured patients (GCS ≤ 13) X-rays are not able to detect all cervical spine injuries. The update evidence is level two evidence. The recommendation is based on the evidence retrieved along with GDG consensus. GDG agreed that this change to the recommendation could also be applied for children as there is no evidence at present to suggest otherwise.

8.4 Recommendations (2003)

38. Be aware that, as a minimum, CT should cover any areas of concern or uncertainty on X-ray or clinical grounds. [2003]

39. Ensure that facilities are available for multiplanar reformatting and interactive viewing of CT cervical spine scans. [2003, amended 2014]

40. MR imaging is indicated if there are neurological signs and symptoms referable to the cervical spine. If there is suspicion of vascular injury (for example, vertebral malalignment, a fracture involving the foramina transversaria or lateral processes, or a posterior circulation syndrome), CT or MRI angiography of the neck vessels may be performed to evaluate for this.[2003, amended 2014]

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41. Be aware that MRI may add important information about soft tissue injuries associated with bony injuries demonstrated by X-ray and/or CT. [2003]

42. MRI has a role in the assessment of ligamentous and disc injuries suggested by X-ray, CT or clinical findings. [2003]

43. In CT, routinely review on 'bone windows' the occipital condyle region for patients who have sustained a head injury. Reconstruction of standard head images onto a high-resolution bony algorithm is readily achieved with modern CT scanners. [2003]

44. In patients who have sustained high-energy trauma or are showing signs of lower cranial nerve palsy, pay particular attention to the region of the foramen magnum. If necessary, perform additional high-resolution imaging for coronal and sagittal reformatting while the patient is on the scanner table. [2003]

These recommendations are based on level III evidence and are considered to be grade B recommendations.

8.5 Review question: What is the best clinical decision rule for selecting adults, infants and children with head injury for initial imaging with plain X-rays or CT scan for cervical spine injury? (2014)

The head-injured patient may also have sustained concomitant injury to the cervical spine. Some head injured patients who require a CT head scan will also need cervical spine imaging. The purpose of this review is to inform the optimal diagnostic pathways for these patients using the best evidence available.

The NICE review paper for update indicated that new evidence was available in response to a research recommendation made in the 2007 guideline.

For full details see review protocol in Appendix D.

8.5.1 Clinical evidence

8.5.1.1 Adults

Nine studies were identified in adults investigating the diagnostic accuracy of cervical spine injury clinical decision rules. Five papers[14,121,122,256,259] were included in the 2007 version of this guideline, with an additional three papers[46,73,102] identified for this update. Clinical decision rules identified are the Canadian C-spine rule, derived by Stiell et al., 2001[259] and the NEXUS criteria, derived by Hoffman et al., 1992.[122] All studies included are derived for adults (either ≥16 or ≥18), with the exception of Hoffman et al., 1992[122] and Hoffman et al., 2000,[121] which includes patients of all ages. One additional paper was also included which detailed a sub group analysis of the NEXUS study[121] describing patients aged 65 and over.[272]

Some papers describe their inclusion criteria as patients presenting to the emergency department (ED) with blunt trauma,[14,102,122] rather than the specific population for this question which is those presenting with a head injury.

Both the Canadian C-spine rule and NEXUS criteria derivation studies assessed the decision rules against a reference standard of plain X-rays (with some additional CT or MR scanning requested at the discretion of the treating physician, and telephone follow-up for those who did not undergo imaging). It is noted that Duane et al., 2011[73] tested the Canadian C-spine rule using a reference standard of patients having a complete cervical spine CT and Griffith et al., 2011[102] tested the NEXUS criteria using a reference standard of cervical spine CT (retrospective review of notes).

Bandiera et al 2003 is a sub-study of the Canadian C-spine derivation study[259] (phase 1), with the aim of comparing the clinical decision rule with physician judgement. It is also noted that Bandiera et al 2003 included all patients, whereas the inclusion criteria for the Canadian C-spine rule, and those studies validating the clinical decision rule,[14,46,256,259] state 'alert, stable adult patients with GCS 15'.

Details of the included clinical decision rules are in Table 17.

Evidence from the included studies are summarised in the clinical evidence profile in Table 18.

See also the study selection flow chart in Appendix E, forest plots in Appendix J, study evidence tables in Appendix H and exclusion list in Appendix K.

8.5.1.2 Children and infants

Two studies were identified for this question, one of which was previously included in the guideline, Viccellio et al., 2001;[276] a subgroup of patients <18 years old in a NEXUS validation study.[121] Pieretti et al., 2009[208] derived and validated the PEDSPINE rule in children aged 3 years or younger, using two

different cohorts of patients within one study. The included papers in children and infants describe patients presenting at the emergency department with blunt trauma, rather than the specific population for this question which is those presenting with a head injury.

Two diagnostic case control studies were also identified but were excluded; Leonard et al., 2011[156] and Ehrlich et al., 2009[78]. Leonard et al., 2011 derives the PECARN C-spine rule in children aged ≤10 and Ehrlich et al., 2009 tests the Canadian C-spine rule and NEXUS criteria in patients aged <16 years old. Diagnostic case control study designs were considered to have very high limitations and were not prioritised for review within our protocol.

Details of the included rules are in Table 17.

Evidence from these included studies are summarised in the clinical evidence profile in Table 19.

See also the study selection flow chart in Appendix E, forest plots in Appendix J, study evidence tables in Appendix J and exclusion list in Appendix K.

Table 17: Summary of clinical decision rules identified – imaging for suspected cervical spine injury

Decision rule	Criteria	Study testing rule
Canadian C-spine rule (for patients with trauma who are alert and in a stable condition and in whom cervical spine injury is a concern)	Any high-risk factor that mandates X-ray? Age >65 years or dangerous mechanism of injury or paraesthesia in extremities. Yes - X-ray. No - Any low-risk factor that allows safe assessment of range of motion? Simple rear-end motor vehicle collision, or sitting position in the emergency department or ambulatory at any time or delayed (not immediate) onset of neck pain or absence of midline cervical-spine tenderness No - X-ray. Yes - Able to rotate neck actively. 45˚ left and right Unable - X-ray. Yes - no X-ray.	Derivation: Stiell 2001 Validation: Stiell 2003 Duane 2011 Coffey 2011 Bandiera 2003
NEXUS low risk criteria	Cervical spine X-ray is indicated for patients with trauma unless they meet all of the following criteria: No posterior midline cervical-spine tenderness No evidence of intoxication A normal level of alertness No focal neurologic deficit, and No painful distracting injury. (Pilot NEXUS criteria does not have focal neurological deficit in the criteria and excludes patients with whiplash.)	Derivation: Hoffman1992 Validation: Hoffman 2000 Touger2002 Stiell 2003 Griffith 2011 Viccellio 2001
PEDSPINE (patients aged under 3 years)	Independent predictors of cervical spine injury: GCS <14 Motor vehicle crash GCSEYE = 1 Age >2 years.	Derivation and validation: Pieretti 2009

Assessment in the emergency department: imaging of the cervical spine

Table 18: Clinical evidence profile: diagnostic accuracy of decision rules for adults

Outcome	No of studies	Design	N	Limitations	Inconsistency	Indirectness	Imprecision	TP	FP	FN	TN	Sensitivity % (h)	Specificity % (h)	PPV %	NPV %	Quality
Cervical spine injury																
Canadian C-spine (X-ray, CT or follow-up as reference standard)[14,46,73,256,258]	4	Diagnostic cohort	24047	Serious limitations (a)	No serious inconsistency	No serious indirectness	Serious imprecision (b)	384	13318	1	10344	99 - 100	43 - 45	18 - 60	100	Low quality
Canadian C-spine (CT as reference standard)[73]	1	Diagnostic cohort	3201	Serious limitations (a)	No serious inconsistency	Serious indirectness (c)	No serious imprecision	192	2991	0	18	100	1	6	100	Low quality
NEXUS pilot - all ages [122]	1	Diagnostic cohort	974	No serious limitations	No serious inconsistency	Serious indirectness (d)	No serious imprecision	27	-	0	-	100	52.2	-	100	Moderate quality
NEXUS - all ages[121]	1	Diagnostic cohort	34069	No serious limitations	No serious inconsistency	Serious indirectness (d)	No serious imprecision	576	29184	2	4307	100	13	19	100	Moderate quality
Subgroup NEXUS - <65 years[272]	1	Diagnostic cohort	30443	Serious limitations (e)	No serious inconsistency	Serious indirectness (d)	No serious imprecision	Missed cases = 6				100	13	100	2	Low quality
Subgroup NEXUS - ≥65 years[272]	1	Diagnostic cohort	2943	Serious limitations (e)	No serious inconsistency	Serious indirectness (d)	No serious imprecision	Missed cases = 2				100	15	5	100	Low quality
NEXUS[256]	1	Diagnostic cohort	7438	No serious limitations	No serious inconsistency	No serious indirectness	No serious imprecision	147	4599	15	2677	91	37	31	99	High quality
NEXUS (CT or follow-up as	1	Diagnostic cohort	1565	Serious limitations (f)	No serious inconsistency	Serious indirectness (g)	No serious imprecision	37	1160	4	364	90	24	30	99	Low quality

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Outcome	No of studies	Design	N	Limitations	Inconsistency	Indirectness	Imprecision	TP	FP	FN	TN	Sensitivity % (h)	Specificity % (h)	PPV %	NPV %	Quality
reference standard)[102]																

(a) Patient selection unclear - not reported in 3 of 4 studies, therefore there is potential patient selection bias.
(b) The wide range of confidence intervals around the point estimate of the sensitivity in the study increases the uncertainty of the actual diagnostic accuracy.
(c) Indirect population, study is in all adults (>16 years) who suffered blunt trauma resulting in a trauma team activation.
(d) Indirect population, study is in all patients with blunt trauma who underwent radiography of the cervical spine in a participating emergency department.
(e) Study does not report suffient data to calculate diagnostic 2 x 2 table.
(f) Retrospective review of database, therefore there is a potential patient selection bias.
(g) Indirect population, study is in patients older than 18 years and have search terms 'trauma, rule out fracture, motor vehicle accident or assault'.
(h) Relates to a sensitivity or specificity for a single study or a range of sensitivities or specificities when more than 1 study.

Table 19: Clinical evidence profile: diagnostic accuracy of decision rules for children and infants

Outcome	No of studies	Design	N	Limitations	Inconsistency	Indirectness	Imprecision	TP	FP	FN	TN	Sensitivity % (e)	Specificity % (e)	PPV %	NPV %	Quality
Cervical spine injury																
NEXUS[276]	1	Diagnostic cohort	3065	No serious limitations	No serious inconsistency	Serious indirectness (a)	No serious imprecision	30	2432	0	603	100	20	12	100	Moderate
PEDSPINE[208]	1	Diagnostic cohort(d)	12533	Serious limitations (b)	No serious inconsistency	Serious indirectness (c)	No serious imprecision	78	3748	5	8702	93 - 94	70	19 - 22	100	Low

(a) Indirect population, study is in blunt trauma patients who received cervical spine X-rays rather than those with head injury.
(b) Retrospective review of database, therefore there is potential patient selection bias.
(c) Indirect population, study is in all trauma patients rather than those with head injury.
(d) Sample split into 2 cohorts, the first to derive clinical predictors for a protocol and the second (n = 4179) to validate the protocol.
(e) Relates to a sensitivity or specificity for a single study or a range of sensitivities or specificities when more than 1 study.

8.5.2 Economic evidence

Published literature

No relevant economic evaluations comparing the Canadian C-Spine rule and the NEXUS clinical decision rules for selecting patients with head injury and suspected cervical spine injury for initial imaging with an X-ray or CT scan were identified. There were no excluded studies.

New cost-effectiveness analysis

The NCGC economic model sought to identify the cost effective clinical decision rule and diagnostic imaging technique (plain X-ray or CT scan) for the initial investigation of suspected Cervical Spine Injury (CSI) in patients with head injury. The analysis compared seven clearance strategies which allowed for differential applications of diagnostic imaging*: CT on all; X-ray on all, CT according to NEXUS, CT according to Canadian C-Spine, X-ray according to NEXUS, CT according to Canadian C-spine, and No Imaging.* The accuracy of clinical decision rules and diagnostic imaging techniques were derived from published literature examined in the clinical review.[46,73, 256, 102,110] A number of model inputs (prevalence of CSI, clinical judgements for further imaging and treatment, and the proportion of indeterminate results from diagnostic imaging) were estimated by the GDG due to scarcity of published information. The measured outcome was the number of false negatives avoided. A detailed description of the model is presented in Appendix M.

Table 20: Economic evidence profile: Diagnostic Clearance Strategies

Study	Applicability	Limitations	Other comments	Total cost	Total effects (number of false negatives identified)	Total Net Benefit [Rank][(a)]	Uncertainty
NCGC Model (Appendix M) (UK) Intervention: 1) *No imaging* 2) *CT on all* 3) *X-ray on all* 4) *CT according to NEXUS* 5) *CT according to Canadian C-spine* 6) *X-ray according to NEXUS* 7) *X-ray according to Canadian C-spine*	Directly Applicable [(b)]	Potentially Serious Limitations[(c)]	Cost-Effectiveness Analysis assessed diagnostic imaging strategies for patients with head injury and suspected cervical spine injury.	1) 1,245 2) £328,753 3) £558,012 4) £335,403 5) £294,566 6) £310,960 7) £301,101	1) 5.0 2) 1.4 3) 2.8 4) 2.8 5) 1.4 6) 2.8 7) 1.7	1) -10,001,245 [7] 2) -£3,162,212[2] 3) -£6,138,116 [6] 4) -£5,915,507 [4] 5) -£3,128,025 [1] 6)-£5,968,870 [5] 7) -£3,620,306 [3]	CT according to Canadian C-Spine remained dominant in the base case PSA (i.e. in 93% of iterations) and in the DSA when prevalence of CSI in head injury patients varied (0.5%-5%), when initial imaging assumptions for the allocation of diagnostic imaging for patients who are not recommended diagnostic imaging according to decision rules were estimated by the GDG, and in scenarios where the clinical decision was not to further image negative and indeterminate results and only further image only indeterminate results. Assuming that 'No Imaging' is not a plausible strategy in practice, CT according to Canadian C-spine was optimal when false negative litigation costs were varied between (£0-£1,000,000) and in the hypothetical scenario where QALYs were attached to TP/FP/TN/FN outcomes. Strategy 2 (CT on all) was optimal when the clinical decision was to further image both negative and indeterminate results.

Abbreviations: CSI = Cervical Spinal Injury; TP/*FP/TN/FN = True Positive, False Positive, True Negative and False Negative; DSA = Deterministic Sensitivity Analysis; PSA = Probabilistic Sensitivity Analysis;*

(a) Net benefit = Number of FNs multiplied by the cost of a FN (a litigation cost of £200,000) minus total cost of strategy. Because the cost penalty of a false negative was greater than the total cost of strategy, the net Benefit figure is negative. Net Benefit Results were ranked from 1 to 7 across all strategies with Rank 1 representing the largest Net Benefit and Rank 7 as the least Net Benefit.

(b) The analysis was developed using a UK healthcare perspective; interventions and associated resource use were relevant to the UK NHS. Costs were calculated using NHS reference costs 2011-2012. Although the primary analysis deviated from the reference case by not using the QALY as a primary outcome due to lack of lifetime horizon, a sensitivity analysis was conducted to explore the impact of a marginal QALY gain for each true positive.

(c) Due to the lack of available data, prevalence of CSI, clinical judgement for treatment and further imaging decisions and indeterminate result probabilities for adults were estimated by the GDG. These estimates were not applicable to the paediatric population. The diagnostic mark-up and treatment time horizon may not have been sufficient to assess long term cost and health consequences. The CEA was optimistic in assuming that all patients experienced no deterioration after treatment or no treatment. Also, the base case analysis only considered the false negative outcome and did not consider potential health consequences from diagnostic imaging associated radiation for false positive diagnoses.

Update 2014

In the NCGC economic model, the cost of a strategy was attributed to diagnostic, observation and treatment costs .*CT according to Canadian C-spine* had the lowest total costs after the baseline comparator *No Imaging*. Effectiveness was measured as the number of false negatives avoided compared to *No Imaging*. *CT according to Canadian C-spine* was most effective, avoiding a total of 4 additional False Negatives per 1000 patients as compared to *No Imaging*. The analysis showed *CT according to Canadian C-spine* dominant over all other strategies; it was both less expensive and more effective than all other comparators. Appendix M contains further details. This baseline result was robust against deterministic and probabilistic sensitivity analyses (in 93% of simulations the conclusion remained unchanged). In particular, *CT according to Canadian C-spine* remained optimal when the prevalence of CSI within the population sustaining head injury varied between 0.5%-5%.

The conclusion regarding the optimal initial decision rule employed is in part dependent on the clinical rules that follow initial negative and indeterminate results. When the clinical decision was to only further image patients with initial indeterminate findings or not to further image patients with either initial negative and indeterminate diagnostic results, the Canadian rule remained optimal. However, when the clinical decision was to further image everyone, regardless of the certainty the clinician had in the findings, the optimal initial strategy would be to CT everyone.

Assuming that *No Imaging* was a theoretical strategy which is not applicable in practice, the *CT according to Canadian C-spine* was optimal when the false negative litigation costs varied form £0 - £1,000,000. The conclusions also remained robust when minimal QALY gain was associated with false positive findings.

8.5.3 Evidence statements

Clinical - adults

Four diagnostic cohorts with 24047 adults showed that the Canadian C-spine rule with radiography, CT or follow-up as a reference standard has a sensitivity of 99 - 100% and a specificity of 43 - 45% for diagnosing cervical spine injury. (LOW QUALITY)

One diagnostic cohort with 3201 adults showed that the Canadian C-spine rule, with cervical spine CT as a reference standard, has a sensitivity of 100% and a specificity of 1% for diagnosing cervical spine injury. (LOW QUALITY)

One diagnostic cohort with 974 patients of all ages showed that the pilot NEXUS criteria has a sensitivity of 100% and a specificity of 52% for diagnosing cervical spine injury. (MODERATE QUALITY)

One diagnostic cohort with 34069 patients of all ages showed that the NEXUS criteria has a sensitivity of 100% and a specificity of 13% for diagnosing cervical spine injury. (MODERATE QUALITY)

Subgroup analysis in patients < 65 years olds in 1 diagnostic cohort with 30443 patients showed that the NEXUS criteria has a sensitivity of 100% and a specificity of 13% for diagnosing cervical spine injury. (LOW QUALITY)

Subgroup analysis in patients $\geq$ 65 years olds in 1 diagnostic cohort with 2943 patients showed that the NEXUS criteria has a sensitivity of 100% and a specificity of 15% for diagnosing cervical spine injury. (LOW QUALITY)

One diagnostic cohort with 7438 adults showed that the NEXUS criteria has a sensitivity of 91% and a specificity of 37% for diagnosing cervical spine injury. (HIGH QUALITY)

One diagnostic cohort with 1565 adults showed that the NEXUS criteria with CT as a reference standard has a sensitivity of 90% and a specificity of 24% for diagnosing cervical spine injury. (LOW QUALITY)

Clinical - children and infants

One diagnostic cohort with 3065 children showed that the NEXUS criteria have a sensitivity of 100% and a specificity of 20% for diagnosing cervical spine injury. (MODERATE QUALITY)

One diagnostic cohort[k] with 12533 infants showed that the PEDSPINE rule have a sensitivity of 93 - 94% and a specificity of 70% for diagnosing cervical spine injury. (LOW QUALITY)

Economic

No relevant published economic evaluations comparing clinical decision rules for patient selection for cervical spine imaging were identified. There were no excluded studies.

For patients with head injury and suspected cervical spine injury, initial CT according to the Canadian C-spine decision rule is dominant (more effective and less costly) when compared to blanket strategies (No diagnostic imaging or diagnostic imaging (CT/X-ray) on all) and strategies using the NEXUS decision rule (CT/X-ray according to NEXUS). This conclusion was based on evidence that had direct applicability and potentially serious limitations.

8.6 Review question: What is the best clinical decision rule for selecting adults, infants and children with head injury, who have received a negative or indeterminate X-ray of the cervical spine, for further imaging with CT or MR imaging for cervical spine injury? (2014)

Although CT scans are increasingly being used as the initial imaging modality for investigation of suspected cervical spine injury (as it has a better diagnostic accuracy of detecting bony and soft tissue injuries than plain X-ray), there is still a cohort of patients whose initial cervical spine investigation is plain X-ray. Within this cohort a proportion will have negative or indeterminate findings on plain X-ray, yet clinical suspicion of cervical spine injury persists. Due to the consequences of missing a clinically significant cervical spine injury it is important to determine the presence or absence of injury in this group of patients. It was felt that clinical practice was variable as regards further imaging in this cohort of patients and hence this question was prioritised for review. Whilst CT scans perform well in diagnosing bony injury, MR is superior in identifying injuries to the spinal cord and ligaments. The question therefore aimed to determine the optimal strategy to select patients for CT or MR scan in order to detect all injuries in this group of patients.

For full details see review protocol in Appendix D.

8.6.1 Clinical evidence

Please note, this question also covers those scans that are ‘indeterminate’, that is the initial cervical spine X-ray is neither positive nor negative for injury. The search remains the same for this broader question and the sift was conducted to also pick up these terms.

8.6.1.1 Adults

No studies were identified looking at the diagnostic accuracy of clinical decision rules for the selection for patients for further imaging after receiving an X-ray which was negative or indeterminate.

[k] Sample split into 2 cohorts, the first to derive clinical predictors for a protocol and the second (n = 4179) to validate the protocol.

8.6.1.2 Children and infants

No evidence identified.

8.6.2 Economic evidence

Published literature

No relevant economic evaluations comparing clinical decision rules for determining which people with head injury should have further imaging after a negative X-ray were identified. There were no excluded studies.

New cost-effectiveness analysis

No studies were identified looking at the diagnostic accuracy of clinical decision rules for the selection for patients for further imaging after receiving an X-ray scan which was negative.

The NCGC model undertook a sensitivity analysis which informs this question: three clinical scenarios of further testing were explored, (i.e. to undertake further imaging on everyone, to undertake further imaging on indeterminate cases only, or to not undertake any further screening on negative or indeterminate cases). For patients where the initial X-ray results were negative or indeterminate, the patient could be further imaged with a CT or MRI according to clinical judgement, which took into account the clarity and certainty of the X-ray findings. Alternatively patients could be discharged or observed if further screening was not chosen as a strategy.

The CT according to Canadian C-spine strategy was optimal in the base case analysis and forms the basis of who should get CT and X-ray in the first instance. This only remained the optimal initial strategy when the clinical decision was to not further image or was to further image only indeterminate CT and X-ray initial imaging results. Therefore, this suggests that further imaging patients with negative (therefore normal) initial X-ray results is not an optimal strategy given the first strategy employed. A more detailed description of the model and its results can be found in Section 8.5.2, above and a complete description is presented in Appendix M.

8.6.3 Evidence statements

Clinical

No evidence identified.

Economic

No relevant published economic evaluations comparing decision rules for cervical spine imaging after initial imaging results were identified.

8.7 Review question: What is the best clinical decision rule for selecting adults, infants and children with head injury, who have received a negative or indeterminate CT cervical spine scan, for further imaging with MR scan for cervical spine injury? (2014)

CT scans are increasingly being used as the initial modality of imaging in cases of suspected cervical spine injury. This is because they display better diagnostic accuracy in detecting bony injuries compared to plain X-rays and MR scans. However, MR scans display superior diagnostic accuracy in identifying injuries to the spinal cord and ligaments. Whilst CT cervical spine scans are useful in combination with clinical examination in excluding significant cervical spine injury in the majority of cases, there is a cohort of patients who have a normal or indeterminate CT cervical spine scan but clinical suspicion of injury persists. Due to the consequences of missing injuries to the spinal cord and ligaments, it is important to attempt to confirm the presence or absence of injury in this group of patients. This question was prioritised for review as guidance is required for this scenario due to the importance of detection of injury and the likelihood of variation in clinical practice. The objective of this question is to identify who should receive further cervical spine imaging in the group of patients who have an initial negative or indeterminate CT cervical spine scan, but clinical suspicion of cervical spine injury persists.

For full details see review protocol in Appendix D.

8.7.1 Clinical evidence

Please note, this question also covers those scans that are 'indeterminate', that is the initial CT scan is neither positive nor negative for injury. The search remains the same for this broader question and the sift was conducted to also pick up these terms.

8.7.1.1 Adults

No studies were identified looking at the diagnostic accuracy of clinical decision rules for the selection for patients for further imaging after receiving a CT scan which was negative.

8.7.1.2 Children and infants

No evidence identified.

8.7.2 Economic evidence

Published literature

No studies were identified looking at the diagnostic accuracy of clinical decision rules for the selection for patients for further imaging after receiving a CT scan which was negative.

The NCGC model included a sensitivity analysis which informs this question. This sensitivity analysis explored three scenarios (therefore to undertake further imaging on everyone, to undertake further imaging on indeterminate cases only, or to not undertake any further screening on negative or indeterminate cases). With an initial negative or indeterminate CT result, patients could receive further imaging, specifically an MR imaging or a Flexion-Extension X-ray according to clinical judgement. Clinical judgement took into account the clarity and certainty of the initial CT finding. Otherwise, patients could be discharged or observed if further screening was not chosen as a strategy.

The CT according to Canadian C-spine strategy was optimal in the base case analysis and forms the foundation of who should get CT and X-ray in the first instance. This only remained the optimal initial strategy when the clinical decision was to not further image or was to further image only indeterminate CT and X-ray initial imaging results. Therefore, this suggests that further imaging patients with confident and clear negative (therefore normal) initial CT results is not an optimal strategy. A more detailed description of the model and its results can be found in Section 8.5.2, above and a complete report is presented in Appendix M.

8.7.3 Evidence statements

No relevant published economic evaluations comparing clinical decision rules for cervical spine imaging after initial imaging results were identified.

8.8 Recommendations and link to evidence (2014)

8.8.1 Adults

Recommendations	**45. For adults who have sustained a head injury and have any of the following risk factors, perform a CT cervical spine scan within 1 hour of the risk factor being identified:** • **GCS less than 13 on initial assessment.** • **The patient has been intubated.** • **Plain X-rays are technically inadequate (for example, the desired view is unavailable).** • **Plain X-rays are suspicious or definitely abnormal.** • **A definitive diagnosis of cervical spine injury is needed urgently (for example, before surgery).** • **The patient is having other body areas scanned for head injury or multi-region trauma.** • **The patient is alert and stable, there is clinical suspicion of cervical spine injury and any of the following apply:** **i. age 65 years or older** **ii. dangerous mechanism of injury (fall from a height of greater than 1 metre or 5 stairs; axial load to the head, for example, diving; high-speed motor vehicle collision; rollover motor accident; ejection from a motor vehicle; accident involving motorised recreational vehicles; bicycle collision)** **iii. focal peripheral neurological deficit** **iv. paraesthesia in the upper or lower limbs.** **A provisional written radiology report should be made available within 1 hour of the scan being performed. [new 2014]**
Relative values of different outcomes	The primary outcomes for this review question were sensitivity and specificity of clinical decision rules for detecting cervical spine injury. The GDG prioritised sensitivity as the most important outcome as they considered that, due to the potentially long lasting and debilitating effects (preventable morbidity) of cervical spine injury that it is important to pick up all clinically important cervical spine

	injuries.
Trade off between clinical benefits and harms	The GDG considered the trade off between selecting a clinical decision rule with a high sensitivity to select patients for imaging who do have a cervical spine injury (and therefore to minimize false negatives) and also to reduce radiation risk of imaging patients who do not have any injury. The group also considered the litigation costs of missing injuries. The group assessed the Canadian C-spine rule in detail to identify the factors associated with high, medium and low risk patients and agreed that high risk factors should be investigated using CT (age over 65, dangerous mechanism of injury and paraesthesia in extremities). The GDG also considered that if the patient is having a CT scan to investigate other injuries (head injury or multi-region trauma) then the cervical spine should be scanned. This avoids delays associated with a second separate scan, may reduce patient anxiety caused by additional imaging episodes and may reduce costs. Although the clinical review did not identify evidence regarding selection of patients for further imaging following initial investigation the GDG considered that if a plain X-ray series is technically inadequate (for example, desired view unavailable), suspicious or definitely abnormal, then a CT scan should be conducted. This was supported by the economic model. Focal peripheral neurological deficit was added to the list of high risk factors by the GDG as this suggests that there is potential neurological damage that would automatically warrant further assessment. This factor was excluded from the Canadian C-spine derivation study as it was presumed that these patients would automatically receive imaging.
Economic considerations	No published economic evidence was found to inform this question. The GDG felt an original economic analysis was necessary to assess the differential use of decision rules for diagnostic imaging. The GDG highlighted that these diagnostic procedures (X-ray, CT scan, and MR imaging) also detect brain injury and wanted the inclusion of brain injury in the economic model. Prevalence of three different types of traumatic brain injuries were found in the Pandor et al HTA (non-intracranial lesion; non neurosurgical lesion; neurosurgical lesion). However, no data indicating the proportion of patients who would experience head injury with/without brain injury and with/without cervical spine injury was identified. After careful consideration of available evidence and that further GDG estimations would be necessary, the GDG agreed that the economic analysis should exclude traumatic brain injury. Thus, the economic analysis concentrated solely on patients with head injury with/without cervical spine injury. In particular, the NCGC conducted an economic analysis to assess the main trade offs for this topic - the cost of the diagnostic imaging (X-ray, CT scan and MR imaging) and treatment versus the litigation costs of misdiagnosing patients who should have undergone an investigation to detect their spine injury (false negative patients). The GDG decided seven comparators were appropriate: blanket strategies (no imaging, CT on all and X-ray on all) and *decision* rule strategies (CT according to NEXUS, X-ray according to NEXUS, CT according to Canadian C-spine and X-ray according to Canadian C-spine). The analysis further detailed in Appendix M and explored the costs and diagnostic outcomes associated with short time frame of diagnosis and treatment. The analyses suggested that the selective use of CT using the Canadian C-Spine decision rule dominated all other strategies, meaning that CT using the Canadian C-

	spine decision rule was both less costly and avoided more false negative diagnoses than the other comparators. As the analysis was undertaken using a UK healthcare system perspective, the results are directly applicable to the UK. Limitations associated with uncertainties around assumptions and estimates of model inputs were acknowledged by the GDG and explored in deterministic and probabilistic sensitivity analyses. Despite potential variation in prevalence of CSI (0.5%-5%), initial imaging assumptions for the allocation of diagnostic imaging for patients who are not recommended diagnostic imaging according to decision rules (equal proportions undergoing alternative imaging techniques versus GDG estimated proportions undergoing alternative imaging techniques), and GDG estimated probabilities of clinical judgements for observation, treatment and further imaging, the base case conclusion remained robust. In addition, assuming that No Imaging was a theoretical strategy not plausible or ethical in practice, the CT according to Canadian C-spine was optimal when the false negative litigation costs varied from £0 - £1,000,000. In the sensitivity analysis that explored different further imaging strategies – no further imaging, further imaging for indeterminate X-ray and CT results, further imaging for everyone (indeterminate and negative X-ray and CT results), *CT according to Canadian C-spine* was not the optimal initial strategy in the scenario where everyone received further imaging. The GDG discussed that further imaging everyone was not reasonable in practice given imaging results are used alongside clinical judgement. Thus, the GDG felt confident with the base case results. The urgency of undertaking diagnostic imaging was not reviewed in this update. Thus, the recommended urgency of diagnostic imaging remains the same as the previous guideline. A systematic search for quality of life estimates in this population did not retrieve usable estimates to derive an appropriate pay off in terms of long term health outcomes for each of the possible diagnostic outputs of the model. The GDG considered the Glasgow Outcomes Score (GOS) scale used for describing health outcomes in people with head injury but found it not suitable for describing health outcomes in patients with head injury and cervical spine injury. This led to a deviation from the reference case in that an accurate incremental QALY gain from each of the strategies could not be derived and a lifetime approach was not employed. Thus, the model does not formally assess the risk of radiation associated with diagnosis imaging as the short time horizon of the analysis does not allow for a complete investigation of long term affects from radiation. Moreover, the GDG did not find an appropriate metric that fully incorporated potential health effects from the risk of radiation. The deviation from the NICE reference case was addressed in a sensitivity analysis where minimal QALY pay-offs were assigned to each outcome (1.5 QALYs per true positive, 2 QALYs per false negative, 2 QALYs per true negative, and 1 QALY per false positive) in a hypothetical scenario. Assuming that No Imaging was not appropriate in practice, the conclusion that CT using the Canadian C-spine decision rule remained optimal in the scenario of minimal QALY gain associated with each true positive and minimal QALY loss with each false negative. Acknowledging the differential risks of radiation between CT and X-ray, the risk of an inaccurate or inadequate CSI diagnosis with an X-ray, and the findings from the economic model, the GDG judged a CT scan could be optimal in situations where patients were at high risk of cervical spine injury and the Canadian C-Spine decision rule was of value.
Quality of evidence	The clinical review identified evidence for the diagnostic accuracy of the Canadian C-spine and NEXUS decision rules in selecting adult patients for initial imaging of the cervical spine (low to high quality evidence). These clinical decision rules were

	originally derived to select patients for X-ray. Griffith et al and Duane et al both use CT scans to image patients as initial imaging, but have been downgraded to low quality as they are in indirect populations (broader selection criteria used than head injury as they include all blunt trauma (trauma team activation) or other trauma criteria within retrospective databases). The recent Coffey et al. paper was felt to provide the most applicable information from that found for Canadian C-spine X-ray, CT or follow-up as reference standard as it was derivated and validated in the context of the UK, and as such should be given more weight in considerations and used in the economic model. No evidence was identified for clinical decision rules for selection of patients for further imaging (for example X-ray followed by CT or CT followed by MR imaging). This included situations wherein the initial imaging was negative but there was still clinical suspicion of injury or if the imaging was indeterminate. The economic review identified no evidence for the use of clinical decision rules for the selection of patients for diagnostic imaging. Little evidence was found to inform a number of inputs for the economic model. The diagnostic accuracy of diagnostic imaging and clinical decision rules was based on findings from the clinical review as listed above. The applicability and quality of the clinical evidence was taken into account in its selection and when interpreting model results. The prevalence of cervical spine injury, clinical judgement probabilities for observation, treatment and further imaging as well as the percentage of indeterminate results after diagnostic imaging were estimated by the GDG after extensive discussion around commonly observed characteristics of patients presenting to the emergency department and subsequent clinical management. Uncertainties around these estimates were explored in deterministic and probabilistic sensitivity analysis.
Other considerations	It was noted that the current strategy of imaging (current imaging practice in the UK) was not included in the economic model. However the GDG were reminded that the review question was focused on comparing clinical decision rules, therefore modified rules or other strategies were not included. It was also noted that there was no evidence identified that was directly based on current UK practice. The GDG felt that it was more helpful to combine the recommendations for selection of patients for imaging and urgency of imaging into one recommendation. The previous guideline recommendations on urgency of imaging have therefore been deleted (see Appendix O). Other discussion points included the fact that X-rays were often unhelpful in older people (aged over 65 years) due to difficulties in interpretation caused by degenerative changes, and that they are inadequate in some people due to body habitus (for example rugby players with broad shoulders). The GDG discussed consequences of indeterminate X-rays including the extended time patients may remain in hospital and the unnecessary anxiety that the patient and their family or carers would have should a later scan show no fracture or injury. The GDG acknowledged that some units in the UK have radiographers reporting on imaging. The GDG felt that the key issue is that any reporting professional should be appropriately trained and possess the skills and competence to perform this role in line with their own professional competency standards and that implementation of reporting standards and delivery should be guided by local governance frameworks. They have reflected this issue in the wording of their recommendation by indicating that a provision 'radiology' report should be made available within the time frame specified.

	The GDG prioritised this recommendation as a key priority for implementation as it has a high impact on outcomes that are important to patients, it has a high impact on reducing variation in care and outcomes, leads to a more efficient use of NHS resources, promotes equalities and means patients reach critical points in the care pathway more quickly.

Update 2014

• **Recommendations**	**46. For adults who have sustained a head injury and have neck pain or tenderness but no indications for a CT cervical spine scan (see recommendation 45), perform 3-view cervical spine X-rays within 1 hour if either of these risk factors are identified:** • **It is not considered safe to assess the range of movement in the neck (see recommendation 47).** • **Safe assessment of range of neck movement shows that the patient cannot actively rotate their neck to 45 degrees to the left and right.** **The X-rays should be reviewed by a clinician trained in their interpretation within 1 hour of being performed. [new 2014]** **47. Be aware that in adults and children who have sustained a head injury and in whom there is clinical suspicion of cervical spine injury, range of movement in the neck can be assessed safely before imaging ONLY if no high-risk factors (see recommendations 45, 48 and 49) and at least one of the following low-risk features apply. The patient:** • **was involved in a simple rear-end motor vehicle collision** • **is comfortable in a sitting position in the emergency department** • **has been ambulatory at any time since injury** • **has no midline cervical spine tenderness** • **presents with delayed onset of neck pain. [new 2014]**
Relative values of different outcomes	The primary outcomes for this review question were sensitivity and specificity of clinical decision rules for detecting cervical spine injury. The GDG prioritised sensitivity as the most important outcome as they considered that, due to the potentially long lasting and debilitating effects (preventable morbidity) of cervical spine injury that it is important to pick up all clinically important cervical spine injuries.
Trade off between clinical benefits and harms	The GDG considered the trade off of wanting to select a clinical decision rule with a high sensitivity to select patients for imaging who do have a cervical spine injury (and therefore to minimize false negatives) and also to reduce radiation risk of imaging patients who do not have any injury. The group also considered the litigation costs of missing injuries. The group assessed the Canadian C-spine rule in detail to identify the factors associated with high, medium and low risk patients. This recommendation indicates which patients should be selected for X-ray of the cervical spine within 1 hour of meeting certain indications (as described in the bullet points in recommendations 46 and 47). These indications correspond to the medium and low risk criteria from the Canadian C-spine rule. Medium risk factors include absence of low risk factors, not considered safe to assess the range of movement in the neck, or the patient cannot actively rotate the neck to 45 degrees to the left and right. Low risk factors to allow safe assessment of the range of movement of the neck include any of simple rear-end motor vehicle collision, comfortable in a sitting position in the emergency department, has been ambulatory at any time since the injury, delayed onset of neck pain and no midline cervical spine tenderness.
Economic considerations	No published economic evidence was identified to inform this question. The GDG felt an original economic analysis was necessary to assess the differential use of decision rules for diagnostic imaging. Thus, the NCGC conducted an economic

analysis to assess the main trade offs for this topic - the cost of the diagnostic imaging (X-ray, CT scan and MR imaging) and treatment versus the litigation costs of misdiagnosing patients who should have undergone an investigation to detect their spine injury (false negative patients).

The GDG decided seven comparators were appropriate: blanket strategies (no imaging, CT on all and X-ray on all) and decision rule strategies (CT according to NEXUS, X-ray according to NEXUS, CT according to Canadian C-spine and X-ray according to Canadian C-spine). The analysis further detailed in Appendix M and explored the costs and diagnostic outcomes associated with short time frame of diagnosis and treatment.

The analyses suggested that the selective use of CT using the Canadian C-spine decision rule dominated all other strategies, meaning that CT using the Canadian C-spine decision rule was both less costly and avoided more False Negative diagnoses than the other comparators. As the analysis was undertaken using a UK healthcare system perspective, the results are directly applicable to the UK.

Limitations associated with uncertainties around assumptions and estimates of model inputs were acknowledged by the GDG and explored in deterministic and probabilistic sensitivity analyses. Despite potential variation in prevalence of CSI (0.5%-5%), initial imaging assumptions for the allocation of diagnostic imaging for patients who are not recommended diagnostic imaging according to decision rules (equal proportions undergoing alternative imaging techniques versus GDG estimated proportions undergoing alternative imaging techniques), and GDG estimated probabilities of clinical judgements for observation, treatment and further imaging, the base case conclusion remained robust. In addition, assuming that No Imaging was a theoretical strategy not plausible or ethical in practice, the CT according to Canadian C-spine was optimal when the false negative litigation costs varied from £0 - £1,000,000.

In the sensitivity analysis that explored different further imaging strategies – no further imaging, further imaging for indeterminate X-ray and CT results, further imaging for everyone (indeterminate and negative X-ray and CT results), *CT according to Canadian C-spine* was not the optimal initial strategy in the scenario where everyone received further imaging. The GDG discussed that further imaging everyone was not reasonable in practice given imaging results are used alongside clinical judgement. Thus, the GDG felt confident with the base case results.

The urgency of undertaking diagnostic imaging was not reviewed in this update. Thus, the recommended urgency of diagnostic imaging remains the same as the previous guideline.

A systematic search for quality of life estimates in this population did not retrieve usable estimates to derive an appropriate pay off in terms of long term health outcomes for each of the possible diagnostic outputs of the model. The GDG considered the Glasgow Outcomes Score (GOS) scale used for describing health outcomes in people with head injury but found it not suitable for describing health outcomes in patients with head injury and cervical spine injury. This led to a deviation from the reference case in that an accurate incremental QALY gain from each of the strategies could not be derived and a lifetime approach was not employed. Thus, the model does not formally assess the risk of radiation associated with diagnosis imaging as the short time horizon of the analysis does not allow for a complete investigation of long term affects from radiation. Moreover, the GDG did not find an appropriate metric that fully incorporated potential health effects from the risk of radiation.

The deviation from the NICE reference case was addressed in a sensitivity analysis where minimal QALY pay-offs were assigned to each outcome (1.5 QALYs per true positive, 2 QALYs per false negative, 2 QALYs per true negative, and 1 QALY per false

	positive) in a hypothetical scenario. Assuming that No Imaging was not appropriate in practice, the conclusion that CT using the Canadian C-spine decision rule remained optimal in the scenario of minimal QALY gain associated with each true positive and minimal QALY loss with each false negative. The GDG discussed whether the economic analysis conclusions were applicable to patients for whom the Canadian C-spine decision rule gave no indication for a CT. The GDG considered that these patients would be at low or medium risk of cervical spine injury. Given the low prevalence of CSI in people with head injury, the benefit of increased accuracy in positive cervical spine injury diagnoses from a CT scan in comparison to an X-ray would be negligible in this population. The GDG felt that the higher level of radiation associated with a CT in comparison to an X-ray and the negative effects this could have on long term health outcomes was a great concern for these patients. Thus, the GDG felt that the findings from this economic analysis were not applicable in these situations. Rather, the lower cost of an X-ray and the lower level or radiation would outweigh the higher cost and higher level of radiation associated with a CT scan. Acknowledging the differential risks of radiation between CT and X-ray, the risk of an inaccurate or inadequate CSI diagnosis with an X-ray, and the findings from the economic model, the GDG judged a CT scan could be optimal in situations where patients were at high risk of cervical spine injury and the Canadian C-Spine decision rule was of value.
Quality of evidence	The clinical review identified evidence for the diagnostic accuracy of the Canadian C-spine and NEXUS decision rules for selecting patients for initial imaging of the cervical spine (low to high quality evidence). These rules were originally derived to select patients for X-ray. Griffith et al and Duane et al both use CT scans to image patients as initial imaging, but have been downgraded to low quality as they are in indirect populations (broader selection criteria used than head injury as they include all blunt trauma (trauma team activation) or other trauma criteria within retrospective databases. The recent Coffey et al. paper was felt to provide the most applicable information from that found for Canadian C-spine X-ray, CT or follow-up as reference standard as it was derivated and validated in the context of the UK, and as such should be given more weight in considerations and used in the economic model. No evidence was identified for clinical decision rules for selection of patients for further imaging (for example X- ray followed by CT or CT followed by MR). This included situations where the initial scan was negative but there was still a clinical suspicion of injury or if the imaging was indeterminate. The economic review identified no evidence for the use of clinical decision rules for the selection of patients for diagnostic imaging. Little evidence was found to inform a number of inputs for the economic model. The accuracy of diagnostic imaging and decision rules were based on findings from the clinical review as listed above. The applicability and quality of the clinical evidence was taken into account in its selection and when interpreting model results. The prevalence of cervical spine injury, clinical judgement probabilities for observation, treatment and further imaging as well as the percentage of indeterminate results after diagnostic imaging were estimated by the GDG after extensive discussion around commonly observed characteristics of patients presenting to the emergency department and subsequent clinical management. Uncertainties around these estimates were explored in deterministic and probabilistic sensitivity analysis.
Other considerations	The GDG felt that it was more helpful to combine the recommendations for selection for patients for imaging and urgency of imaging into one recommendation, therefore the previous guideline recommendations on urgency of imaging have been deleted (see Appendix O).

	The GDG considered that if the X-ray is technically inadequate (for example, desired view unavailable), suspicious or definitely abnormal that a CT scan should be performed (see recommendation 45 above). The GDG acknowledged the lack of immediate reporting within an emergency room service. The GDG therefore identified the need for clinicians to have the ability to interpret 3-view cervical spine x rays and correlate those findings in line with the specific clinical circumstances of the individual patient to guide appropriate patient care. They did not wish to specify who that clinician might be but felt that what was important was that the relevant clinician had the appropriate skills and competence to fulfil that role.

8.8.2 Children and infants

Recommendations	**48. For children who have sustained a head injury, perform a CT cervical spine scan only if any of the following apply (because of the increased risk to the thyroid gland from ionising radiation and the generally lower risk of significant spinal injury):** • **GCS less than 13 on initial assessment.** • **The patient has been intubated.** • **Focal peripheral neurological signs.** • **Paraesthesia in the upper or lower limbs.** • **A definitive diagnosis of cervical spine injury is needed urgently (for example, before surgery).** • **The patient is having other body areas scanned for head injury or multi-region trauma.** • **There is strong clinical suspicion of injury despite normal X-rays.** • **Plain X-rays are technically difficult or inadequate.** • **Plain X-rays identify a significant bony injury.** **The scan should be performed within 1 hour of the risk factor being identified. A provisional written radiology report should be made available within 1 hour of the scan being performed. [new 2014]**
Relative values of different outcomes	The primary outcomes for this review question were sensitivity and specificity of cervical spine injury clinical decision rules. The GDG prioritised sensitivity as the most important outcome as they considered that, due to the potentially long lasting and debilitating effects (preventable morbidity) of cervical spine injury that it is important to pick up all clinically important cervical spine injuries. The GDG also considered the radiation burden in children, which poses greater risks in comparison to adults.
Trade off between clinical benefits and harms	The GDG considered the trade off between selecting a clinical decision rule with a high sensitivity to optimise selection of patients for imaging who do have a cervical spine injury (and therefore to minimize false negatives) and reducing radiation risk from imaging patients who do not have any injury. The group also considered the litigation costs of missing injuries. The GDG recognised that for some children CT cervical spine scan should be the initial mode of radiological investigation, but that this should only be for those at

	highest risk of cervical spine injury. In this group of patients the GDG considered that any increase in radiation burden would be outweighed by the benefit of detecting cervical spine injury. Due to the limited volume and quality of evidence for this question in children, the GDG made its recommendation through extrapolation of the evidence identified in adults and GDG consensus based on expertise and knowledge in this area. This recommendation therefore lists several risk factors for performing CT cervical spine scan as the initial investigation in children, some of which are new to this guideline update. In addition, the 2007 guideline differentiated between children aged 10 years and over, and those under 10 years (with those 10 years and over investigated as in adults). In this guideline update recommendations apply to all children under the age of 16 years in line with clinical practice. In making their recommendations the GDG considered the Canadian C-spine rule and clinically important practice points. The high risk factor of paraesthesia in the upper or lower limbs was selected from this clinical decision rule as the consequence of this outweighs the risk of radiation. The GDG considered that if the patient is having a CT scan due to investigation of other injuries and there is suspicion of cervical spine injury (head injury or multi-region trauma) then the cervical spine should be scanned. This avoids delays associated with a second separate scan, may reduce patient anxiety caused by additional imaging episodes and may reduce costs. The GDG considered that if a plain X-ray series is technically inadequate (for example, desired view unavailable), suspicious or definitely abnormal then a CT cervical spine scan should be conducted. Focal peripheral neurological deficit was included in the list of risk factors as this suggests potential neurological damage that automatically warrants further assessment. This factor was excluded from the derivation of the Canadian C-spine rule as it was presumed that these patients would automatically receive imaging. For children, it was not possible to replicate the economic model conducted in adults due to a paucity of evidence in areas such as the frequency of cervical spine injury, outcomes and practice.
Economic considerations	No published economic evidence was identified to inform this question in children. The GDG felt that the original economic analysis conducted by the NCGC to assess the main trade offs for this topic in an adult population could not be directly extrapolated to the paediatric population. The main trade offs considered in the economic analysis for the adult population were the cost of the diagnostic imaging (X-ray, CT cervical spine scan and MR imaging) and treatment versus the litigation costs of misdiagnosing patients who should have undergone an investigation to detect their spine injury (false negative patients). Due to the paucity of the evidence identified in the paediatric population it was not possible to determine the appropriateness of model inputs for this population. In particular, it was not possible to determine the prevalence of cervical spine injury and the clinical judgements for further imaging and treatment used in the analysis for adults. Whilst cervical spine injury is rare in children when compared with adults, the GDG considered that the population identified in this recommendation represent the patients at highest risk of cervical spine injury. The GDG discussed that failing to accurately diagnose a cervical spine injury was the greatest concern for these patients because of potential long term health consequences. In addition, the GDG discussed the differing levels of radiation burden associated with X-ray and CT cervical spine scan and the potential contribution to a reduction in long term health outcomes. The GDG felt the likely health decrements associated with a missed cervical spine injury diagnosis was greater than those from radiation associated with CT scanning. The GDG therefore considered a strategy of selective CT scanning to be

	optimal in this population. The urgency of diagnostic imaging was not reviewed in this update and so the recommendation from the previous guideline remains. The GDG agreed that the previously recommended maximum 1 hour time period between (i) the risk factor being identified and the act of diagnostic imaging and (ii) the imaging being performed and the results being reported were necessary to facilitate timely decision making regarding further management.
Quality of evidence	The clinical review identified low to moderate quality evidence regarding the NEXUS and PEDSPINE rules in children. The population used was indirect as it was broader than just patients with head injury (included all trauma patients), and was therefore downgraded to reflect this. Due to the paucity and quality of the evidence identified the GDG were unable to make a recommendation based on either of the identified studies. Therefore the data identified in the review for adults (from the Canadian C-spine rule) were extrapolated and modified using GDG consensus on clinically acceptable practice to derive this recommendation. The economic review identified no evidence for the use of clinical decision rules for the selection of patients under the age of 16 for diagnostic imaging.
Other considerations	The GDG felt that it was more helpful to combine the recommendations for selection of patients for imaging and urgency of imaging into one recommendation, therefore the previous guideline recommendations on urgency of imaging have been deleted (see Appendix O). The GDG considered that this recommendation represented the best available evidence and was clinically acceptable for all children aged under 16 years. This is in contrast to the 2007 guideline which provided different strategies for those aged 10 years and over, and those aged under 10 years. Of note, the GDG considered that the addition of focal peripheral neurological deficit and paraesthesia in the upper or lower limbs to this high risk group reflected current practice. The GDG acknowledged that some units in the UK have radiographers reporting on imaging. The GDG felt that the key issue is that any reporting professional should be appropriately trained and possess the skills and competence to perform this role in line with their own professional competency standards and that implementation of reporting standards and delivery should be guided by local governance frameworks. They have reflected this issue in the wording of their recommendation by indicating that a provision 'radiology' report should be made available within the time frame specified. The GDG have made a research recommendation in this area due to the limited clinical evidence identified, see section 8.9.

Recommendations	**49. For children who have sustained a head injury and have neck pain or tenderness but no indications for a CT cervical spine scan (see recommendation 48), perform 3-view cervical spine X-rays before assessing range of movement in the neck if either of these risk factors are identified:** • **Dangerous mechanism of injury (that is, fall from a height of greater than 1 metre or 5 stairs; axial load to the head, for example, diving; high-speed motor vehicle collision; rollover motor accident; ejection from a motor vehicle; accident involving motorised recreational vehicles; bicycle collision).** • **Safe assessment of range of movement in the neck is not possible (see recommendation 47).** **The X-rays should be carried out within 1 hour of the risk factor being identified and reviewed by a clinician trained in their interpretation within 1 hour of being performed. [new 2014]** **50. If range of neck movement can be assessed safely (see recommendation 47) in a child who has sustained a head injury and has neck pain or tenderness but no indications for a CT cervical spine scan, perform 3-view cervical spine X-rays if the child cannot actively rotate their neck 45 degrees to the left and right. The X-rays should be carried out within 1 hour of this being identified and reviewed by a clinician trained in their interpretation within 1 hour of being performed. [new 2014]**
Relative values of different outcomes	The primary outcomes for this review question were sensitivity and specificity of clinical decision rules for cervical spine injury. The GDG prioritised sensitivity as the most important outcome as they considered that due to the potentially long lasting and debilitating effects (preventable morbidity) of cervical spine injury it is important to pick up all clinically important cervical spine injuries. The GDG also considered the radiation burden, which poses greater risk in children in comparison to adults.
Trade off between clinical benefits and harms	The GDG considered the trade off of wanting to select a clinical decision rule with a high sensitivity to select patients for imaging who do have a cervical spine injury (and therefore to minimize false negatives) and also to reduce the radiation burden of imaging patients who do not have any cervical spine injury. The group also considered the litigation costs of missing injuries. As there was limited evidence addressing this question in children the GDG made this recommendation based on extrapolation and modification of the evidence identified for adults by determining GDG consensus on clinically acceptable practice based on their knowledge and expertise in this area. For children, it was not possible to replicate the economic model conducted in adults due to a paucity of evidence in areas such as the frequency of cervical spine injury, outcomes and practice.
Economic considerations	No published economic evidence was identified to inform this question. The GDG felt that the original economic analysis conducted by the NCGC to assess the main trade offs for this topic in an adult population could not be directly extrapolated to the paediatric population. The main trade offs considered in the economic analysis for the adult population were the cost of the diagnostic imaging

	(X-ray, CT cervical spine scan and MR imaging) and treatment versus the litigation costs of misdiagnosing patients who should have undergone an investigation to detect their spine injury (false negative patients). Due to the paucity of the evidence identified in the paediatric population it was not possible to determine the appropriateness of model inputs for this population. In particular, it was not possible to determine the prevalence of cervical spine injury and the clinical judgements for further imaging and treatment used in the analysis for adults. The GDG considered that the population identified in this recommendation represents patients at medium risk of cervical spine injury. The GDG discussed that the risks of failing to accurately diagnose a cervical spine injury and of the radiation burden from X-rays or a CT cervical spine scan were both concerns for these patients because of the potential negative effect on long term health. The GDG felt that the higher level of radiation associated with a CT cervical spine scan in comparison to 3 view cervical spine X-rays and the negative effects of this radiation on long term health outcomes was the greater concern for these patients. Thus the GDG concluded that 3 view cervical spine X-rays should be selected as the initial investigation of choice in this population. The urgency of diagnostic imaging was not reviewed in this update and so the recommendation from the previous guideline remains. The GDG agreed that the previously recommended maximum 1 hour time period between (i) the risk factor being identified and the act of diagnostic imaging and (ii) the imaging being performed and the results being reported were necessary to facilitate timely decision making regarding further management.
Quality of evidence	The clinical review identified low to moderate quality evidence regarding the NEXUS and PEDSPINE rules in children. The population used was indirect as it was broader than just patients with head injury (included all trauma patients), and was therefore downgraded to reflect this. Due to the paucity and quality of the evidence identified the GDG were unable to make a recommendation based on either of the identified studies. Therefore the data identified in the review for adults (from the Canadian C-spine rule) were extrapolated and modified using GDG consensus on clinically acceptable practice to derive this recommendation. The economic review identified no evidence for the use of clinical decision rules for the selection of patients under the age of 16 for diagnostic imaging.
Other considerations	The GDG felt that it was more helpful to combine the recommendations for selection for patients for imaging and urgency of imaging into one recommendation, therefore the previous guideline recommendations on urgency of imaging have been deleted (see Appendix O). The GDG considered that this recommendation represented the best available evidence and was clinically acceptable for all children aged under 16 years. This is in contrast to the 2007 guideline which provided different strategies for those aged 10 years and over, and those aged under 10 years. The GDG acknowledged the lack of immediate reporting within an emergency room service. The GDG therefore identified the need for clinicians to have the ability to interpret 3-view cervical spine x rays and correlate those findings in line with the specific clinical circumstances of the individual patient to guide appropriate patient care. They did not wish to specify who that clinician might be but felt that what was important was that the relevant clinician had the appropriate skills and competence to fulfil that role. The GDG considered that if the X-ray is technically inadequate (for example, desired view unavailable), suspicious or definitely abnormal that a CT scan should be performed (see recommendation 49).

	The GDG have made a research recommendation in this area due to the limited clinical evidence identified.

Update 2014

51. In children who can obey commands and open their mouths, attempt an odontoid peg view. [2003, amended 2014]

8.9 Research recommendation

6. In children and infants with suspected cervical spine injury, are any existing clinical decision rules for selection of patients for cervical spine imaging clinically and cost effective in the UK NHS?

Why this is important:

Our systematic review revealed a paucity of evidence for this population and condition, and recommendations have consequently been extrapolated from adult clinical decision rules. However, this may not provide the optimal approach. Undetected cervical spine injury has potentially lifelong debilitating consequences which must be weighed against risks from ionising radiation (with children at greater risk from radiation than adults). This prognostic study should be designed to prospectively validate and compare the recommendations in this NICE 2014 guideline and existing cervical spine imaging clinical decision rules (including the Canadian C-spine rule, NEXUS criteria, and PECARN criteria) by reporting their diagnostic accuracy (sensitivity, specificity and predictive values) in the UK population. The reference standard for this study would be X-ray, CT, or negative follow up (48 hours minimum). This validation study should include a cost-effectiveness analysis, and should be designed to determine which is the optimal modality of initial imaging in this population. Sub analyses should be performed according to age and developmental stage i.e. preverbal (<2 years) and verbal (2 years and over). Only by performing such a prospective comparative validation can it be determined whether any are appropriate for implementation in our population. Should it be demonstrated that none are clinically or cost effective, it will be essential to perform a clinical decision rule derivation study to provide further evidence for this population.

8.10 Using adult rules with infants and children (2007)

The literature on cervical spine injury in infants and children has not to date produced highly sensitive and specific clinical decision rules based on level one evidence that can be used to select such patients for imaging cervical spine. There is evidence that the prevalence of intracranial complications in children and infants is much lower than in adults but to date no clearly defined rules with acceptable sensitivity and specificity have been produced.[67,108]

8.11 Good practice in emergency department assessment (2003)

The following should be practised during emergency department assessment.

52. Be aware that the priority for all emergency department patients is the stabilisation of airway, breathing and circulation (ABC) before attention to other injuries. [2003]

53. Ascribe depressed conscious level to intoxication only after a significant brain injury has been excluded. [2003]

54. All emergency department clinicians involved in the assessment of patients with a head injury should be capable of assessing the presence or absence of the risk factors for CT head and cervical spine imaging (recommendations 27 - 32 and recommendations 45 - 50). Training should be made available as required to ensure that this is the case. [2003]

55. Patients presenting to the emergency department with impaired consciousness (GCS less than 15) should be assessed immediately by a trained member of staff. [2003]

56. In patients with GCS 8 or less, ensure there is early involvement of an anaesthetist or critical care physician to provide appropriate airway management, as described in recommendations 69 and 70, and to assist with resuscitation. [2003]

57. A trained member of staff should assess all patients presenting to an emergency department with a head injury within a maximum of 15 minutes of arrival at hospital. Part of this assessment should establish whether they are high risk or low risk for clinically important brain injury and/or cervical spine injury. Use recommendations 26 - 31 and recommendations 45 - 50 on patient selection and urgency for imaging (head and neck cervical spine). [2003]

58. In patients considered to be at high risk for clinically important brain injury and/or cervical spine injury, extend assessment to full clinical examination to establish the need to request CT imaging of the head and/or imaging of the cervical spine and other body areas. Use recommendations 26 - 31 and recommendations 45 - 50 as the basis for the final decision on imaging after discussion with the radiology department. [2003, amended 2007]

59. Patients who, on initial assessment, are considered to be at low risk for clinically important brain injury and/or cervical spine injury should be re-examined within a further hour by an emergency department clinician. Part of this assessment should fully establish the need to request CT imaging of the head and/or imaging of the cervical spine. Use recommendations 26 - 31 and recommendations 45 - 50 as the basis for the final decision on imaging after discussion with the radiology department. [2003, amended 2007]

60. Manage pain effectively because it can lead to a rise in intracranial pressure. Provide reassurance, splintage of limb fractures and catheterisation of a full bladder, where needed. Treat significant pain with small doses of intravenous opioids[l] titrated against clinical response and baseline cardiorespiratory measurements. [2007]

61. Throughout the hospital episode, use a standard head injury proforma in documentation when assessing and observing patients with a head injury. This form should be of a consistent format across all clinical departments and hospitals in which a patient might be treated. Use a separate proforma for those under 16 years. Areas to allow extra documentation should be included (for example, in cases of non-accidental injury). Examples of proforma that should be used in patients with head injury are provided in appendix O of the full guideline. [2003, amended 2007]

These recommendations are based on level five evidence and are considered to be grade D recommendations.

[l] At the time of publication (August, 2013), intravenous opioids did not have a UK marketing authorisation for this indication. The prescriber should follow relevant professional guidance, taking full responsibility for the decision. Informed consent should be obtained and documented. See the General Medical Council's Good practice in prescribing and managing medicines and devices for further information.

9 Imaging practice and involvement of the neurosurgical department.

9.1 Good practice in imaging of patients with a head injury (2003)

It is assumed that general principles of good practice in imaging will be adhered to, as outlined in publications by the Royal College of Radiologists.[221] On the basis of consensus, the Guideline Development Group has made the following recommendations.

- All CT scans of the head should be reviewed by a clinician who has been deemed competent to review such images.
- All plain radiographs of the cervical spine should be reviewed by a clinician who has been deemed competent to review such images.
- Where necessary, transport or transmission of images should be used to ensure that a competent clinician review the images.
- All imaging performed on patients with head injury should have a full or interim written report for the patients' notes within an hour of the procedure having been performed.
- Imaging of any kind should not delay neurosurgical or anaesthetic referral in patients with severe head injury. (D)

These recommendations are based on level five evidence and are considered to be grade D recommendations.

9.2 Involving neurosurgical care (2003)

62. Discuss with a neurosurgeon the care of all patients with new, surgically significant abnormalities on imaging. The definition of 'surgically significant' should be developed by local neurosurgical centres and agreed with referring hospitals, along with referral procedures. [2003, amended 2014]

An example of a neurosurgical referral letter is shown in Appendix O.[231]

This recommendation is based on level five evidence and is considered to be a grade D recommendation.

Examples of abnormalities not surgically significant have been produced by a survey of neuroradiologists and emergency physicians in Canada. However, these criteria have not to date been accepted by UK neurosurgeons, and a survey carried out in 2003 by the Society of British Neurological Surgeons found substantial concern about the Canadian criteria. The UK survey was carried out specifically to complement the development of this guideline. It would be desirable if the criteria to be used in this area could be based on the opinion of UK neurosurgeons.

9.2.1 Recommendations for research (2007)

The GDG identified the following priority areas for research in the original guideline as well as in this update.

9.2.1.1 Research Question

7. Research is needed to develop consensus on criteria for lesions not currently considered to be surgically significant following imaging of a patient with head injury.

Although most neurosurgeons agree about which extradural and subdural haematomas should be removed, there is controversy about whether or not to remove traumatic intracerebral haemorrhage (TICH) and cerebral contusions (CC). A prospective randomised controlled trial (PRCT) should be set up to discover if early surgery improves the outcome in these lesions compared to initial conservative treatment.

9.2.1.2 Why this research is important

One option in the management of traumatic intracerebral haemorrhage (TICH) and cerebral contusions (CC) is to monitor the patient clinically or with intracranial pressure monitoring and other forms of brain tissue monitoring such as brain tissue oxygen (BtO2) or microdialysis. When the patient deteriorates, s/he is rushed to the operating theatre. The problem is that this approach has never been validated in a prospective randomised controlled trial (PRCT). Waiting until there is deterioration in the level of consciousness (LOC) or until there is deterioration in the monitoring parameters builds delay into the management and results in secondary brain damage occurring and becoming established prior to surgery in all such cases. The principle of early surgical evacuation of spontaneous intracerebral haemorrhage (SICH) has been investigated in the surgical trial in intracerebral haemorrhage (STICH) and reported in the Lancet (2005). The results of such a PRCT in TICH would fundamentally alter the recommendations made by NICE, in terms of which patients should be referred to neurosurgery and, more importantly, how they should be managed there. There is no level 1 evidence about what to do with these patients and the need for such a PRCT in head injured patients is urgent. This research question should immediately be put to UK Research Funding bodies.

9.3 Other reasons for discussing a patient's care with a neurosurgeon (2003)

Other criteria for discussing a patient's care with a neurosurgeon were developed by both Guideline Development Group consensus and recommendations from previous guidelines.[231]

63. Regardless of imaging, other reasons for discussing a patient's care plan with a neurosurgeon include:

- **Persisting coma (GCS 8 or less) after initial resuscitation.**
- **Unexplained confusion which persists for more than 4 hours.**
- **Deterioration in GCS score after admission (greater attention should be paid to motor response deterioration).**
- **Progressive focal neurological signs.**
- **A seizure without full recovery.**
- **Definite or suspected penetrating injury.**
- **A cerebrospinal fluid leak. [2003]**

This recommendation is based on level five evidence and is considered to be a grade D recommendation.

9.4 Criteria for neurosurgical interventions (2003)

These guidelines assume best practice will be followed once neurosurgeons have become involved with a particular patient. The exact nature and timing of the interventions is beyond the scope of the guidelines.

9.5 Transfer from secondary to tertiary care settings (2003)

The risk of a further injury to patients during transfer to tertiary care is well established.[96] In the previous guideline transfer of the patient between a general hospital and a neurosciences unit were advised to follow the principles set out by the Neuroanaesthesia Society of Great Britain and Ireland and the Association of Anaesthetists of Great Britain and Ireland.[189] The recommendations are listed below see section 9.6.5 with slight modifications to wording so that they fit the style of these guidelines. The PaCO2 targets recommended for intubated patients are based on recent literature in this area.[48,69,70] Since the original guideline there has been a study published in this area which has been reviewed in this update and recommendations have been revised accordingly see section 9.6.5.

9.6 What are the benefits for patients of receiving treatment at a neurosciences centre who have suffered a clinically important brain injury that does not require surgical intervention? (2007)

9.6.1 Introduction and rationale for the clinical question

There is no uncertainty about the management of patients with operative lesions; they must be transferred to the neurosciences unit for their operation. However, there is concern that patients who have suffered a clinically important brain injury, who are initially referred to an emergency department but do not have an operable lesion, may have a poorer outcome if they are not referred to a neurosciences centre. The dilemma for hospital staff at the DGH is whether to keep the patients at that location or to transfer them to a neurosciences unit to continue with their treatment. This question is relevant for clinicians at both types of hospitals. It is important to address whether the patient will receive better non – operative treatment if they go onto a specialist neurosciences centre than if they remained at the initial DGH.

An emergency department is described as a local, regional district general hospital with no neurosciences unit or a non specialist centre whereas a neurosciences unit is described as a specialist centre or a unit that has neurosurgical and neurointensive care facilities.

The main outcome measures for including studies in this review were mortality neurological outcome, disability and hospital duration and at least one of these outcomes were reported in the studies. Studies were excluded where;

- data on head injury patients was not provided,
- the patient group was less than 50% non head injured patients,
- intervention was pre hospital care rather than transfer and
- the outcomes reported only duration of transfer and no other outcomes.
- Clinical evidence

One study[205] was identified that looked interhospital transfer (secondary transfer from one hospital to another). Three additional studies[111,114,212] looked at direct transport from the injury scene to a DGH or transfer to a neurosciences unit from a DGH.

The first study[205] a prospective observational study (level 2+ evidence) included patients of any age who were injured by blunt trauma between 1996-2003 (n=6921). These patients were treated by participating hospitals in the Trauma Audit and Research Network (TARN), in the United Kingdom. The intervention group (n=4616) patients received care at a neurosurgical centre (including those who had been transferred which was 53% (2677/4982)). The control group (n=2305) patients received all their care in hospitals without neurosurgical facilities on site. The mortality rate for all patients that were transported to a neurosciences unit was 35% (95% CI, 34-37%) and for those that

were transported to the emergency department was 61% (95% CI, 59-63%). The mortality rate for the subgroup (n=894) of patients with isolated, non-surgical severe head injury who were transported to a neurosciences unit was 26%, (95% CI, 22-29%) and for those that were transported to the emergency department the rate was 34% (95% CI, 39-40%), p=0.005.

The second study[111] a retrospective observational cohort study (level 2+ evidence) examined the issue of bypass, which obtained data from the New York State Trauma Registry from 1996-1998. The population consisted of adults more than 13 years of age with a GCS less than 14. A sub group of 2763 head injured patients from the data set of 5419 trauma patients was analysed. The patients in the intervention group (n=1430 (51.8%)) were transported to a regional trauma centre. These patients were assessed via the American Triage system (pre hospital care) and referred directly to the emergency department of a regional centre. The comparison group (n=1333 (48.2%)) were transferred to an area/non trauma centre. These patients were assessed via the American Triage system (pre hospital care) and referred directly to either an area centre or a non trauma centre. The mortality for transfer to regional centre versus non trauma centre was OR of 0.67 (95% CI, 0.53-0.85).

In another study[212] a low quality study (level 3 evidence) where patients were transported to neurosurgical care or secondarily transferred from a DGH. The population group were neurosurgical unit patients with an extradural haematoma requiring surgery (n=104). Group 1 patients (n=71) had a mean age of 22 years (±2SE) were directly transported to a neurosurgical centre. Group 2 patients (n=33) had a mean age 20 years (±3SE) and were transferred from the DGH to a neurosurgical centre. The results using the Glasgow Outcome Scale (GOS) show that mortality in group 1 was 4% (3/71) and in group 2 was 24% (8/33). The moderate/severe disability in group 1 was 10% (7/71) and group 2 was 27% (9/33). Recovery was good in 86% (61/71) of group 1 patients and 49% (16/33) in group 2, with p≤0.0002.

The final study[114] well designed cohort study (level 2++ evidence) looking at mortality outcomes between patients directly transferred to a trauma centre and those who were transferred first to a non-trauma centre, and then on to a trauma centre. This cohort study included severely traumatic brain injured patients. The data was collected as part of a multi-centre online database designed to track pre-hospital and in-hospital severe TBI patient data, called TBI-trac. All patients passing through the trauma centres were included, and selection criteria were applied. Therefore, out of 1449, only 1123 patients were included; the remainder were excluded on the basis of a well-defined criterion, which included the mechanism of injury, death, brain death, or otherwise not benefiting from the care on offer. The authors compared, using a logistic regression model, two-week mortality outcomes between patients directly transferred to a trauma centre (n=864, 77.3%), and those who were transferred first to a non-trauma centre, and then on to a trauma centre(n=254, 22.7%). The model controlled for baseline characteristics and clinical data including hypotension status on day one, if the patient was less than or more than 60 years old, pupil status on day 1, and the initial GCS. Admission time and time by transport status were found to not affect the significance of the results. Patients were found to have a significantly lower chance of mortality with direct transfer with an odds ratio of 1.48 (CI 1.03-2.12) and p=0.04.

9.6.2 Economics Evidence from 2007 update

There was no new economic evidence for this question found in the update.

9.6.3 Summary of evidence from 2007 update

Only one study[205] provides good evidence that all patients with severe head injuries (GCS 8 or less) would benefit from receiving treatment in a neurosurgical unit irrespective of any need for a neurosurgical operation instead of receiving treatment at the emergency department. This study found data which suggests that treatment in a neurosciences centre offers a better strategy for the management of severe head injury. This study did not address direct transfer from the scene, only

inter-hospital transfers. There is evidence[114,212] which suggests good recovery, better mortality and morbidity rates amongst severely injured patients who bypass the DGH and go to the neurosciences unit. However another study[111] suggests very little difference.

9.6.4 Rationale behind recommendation

A slight amendment to the previous recommendation was required (see 9.6.5).The GDG felt that there is evidence to support a recommendation for severely head injured to receive treatment in a neurosurgical unit irrespective of any need for a neurosurgical operation and have included an amendent to the recommendation below 64 (bullet 1).The GDG agreed that the studies[111,114,212] did not provide enough evidence for this question to demonstrate that all patients should be sent directly to patients to receive treatment in a neurosurgical unit irrespective of any need for a neurosurgical operation. This is because the GDG recognises that this would require a major shift of resources of between an additional 84,000 and 105,000 bed days to neurosurgery from the existing general surgical, orthopaedic, emergency department, paediatric and geriatric services that currently care for these patients. The GDG agreed that whilst there are not enough resources for all head injury patients to go to a neurosciences centre, we should aspire to improve the rate of transfer. The GDG opinion therefore is to propose this area for further research (see section 9.7.1.1).

9.6.5 Recommendation

64. Local guidelines on the transfer of patients with head injuries should be drawn up between the referring hospital trusts, the neuroscience unit and the local ambulance service, and should recognise that:

- **transfer would benefit all patients with serious head injuries (GCS 8 or less) irrespective of the need for neurosurgery**
- **if transfer of those who do not require neurosurgery is not possible, ongoing liaison with the neuroscience unit over clinical management is essential. [2003, amended 2007]**

65. The possibility of occult extracranial injuries should be considered for adults with multiple injuries, and they should not be transferred to a service that is unable to deal with other aspects of trauma. [2007]

66. There should be a designated consultant in the referring hospital with responsibility for establishing arrangements for the transfer of patients with head injuries to a neuroscience unit and another consultant at the neuroscience unit with responsibility for establishing arrangements for communication with referring hospitals and for receipt of patients transferred. [2003]

67. Patients with head injuries requiring emergency transfer to a neuroscience unit should be accompanied by a doctor with appropriate training and experience in the transfer of patients with acute brain injury. They should be familiar with the pathophysiology of head injury, the drugs and equipment they will use and working in the confines of an ambulance (or helicopter if appropriate). They should have a dedicated and adequately trained assistant. They should be provided with appropriate clothing for the transfer, medical indemnity and personal accident insurance. Patients requiring non-emergency transfer should be accompanied by appropriate clinical staff. [2003, amended 2007]

68. Provide the transfer team responsible for transferring a patient with a head injury with a means of communicating changes in the patient's status with their base hospital and the neurosurgical unit during the transfer. [2003, amended 2014] Update 2014

69. Although it is understood that transfer is often urgent, complete the initial resuscitation and stabilisation of the patient and establish comprehensive monitoring before transfer to avoid complications during the journey. Do not transport a patient with persistent hypotension, despite resuscitation, until the cause of the hypotension has been identified and the patient stabilised. [2003, amended 2007]

70. Intubate and ventilate all patients with GCS 8 or less requiring transfer to a neuroscience unit, and any patients with the indications detailed in recommendation 71. [2003]

71. Intubate and ventilate the patient immediately in the following circumstances:

- **Coma – not obeying commands, not speaking, not eye opening (that is, GCS 8 or less).**
- **Loss of protective laryngeal reflexes.**
- **Ventilatory insufficiency as judged by blood gases: hypoxaemia (PaO_2 < 13 kPa on oxygen) or hypercarbia ($PaCO_2$ > 6 kPa).**
- **Spontaneous hyperventilation causing $PaCO_2$ < 4 kPa.**
- **Irregular respirations. [2003, amended 2007]**

72. Use intubation and ventilation before the start of the journey in the following circumstances:

- **Significantly deteriorating conscious level (1 or more points on the motor score), even if not coma.**
- **Unstable fractures of the facial skeleton.**
- **Copious bleeding into mouth (for example, from skull base fracture).**
- **Seizures. [2003, amended 2007]**

73. Ventilate an intubated patient with muscle relaxation and appropriate short-acting sedation and analgesia. Aim for a PaO_2 greater than 13 kPa, $PaCO_2$ 4.5 to 5.0 kPa unless there is clinical or radiological evidence of raised intracranial pressure, in which case more aggressive hyperventilation is justified. If hyperventilation is used, increase the inspired oxygen concentration. Maintain the mean arterial pressure at 80 mm Hg or more by infusion of fluid and vasopressors as indicated. In children, maintain blood pressure at a level appropriate for the child's age. [2003, amended 2007]

74. Education, training and audit are crucial to improving standards of transfer; appropriate time and funding for these activities should be provided. [2003]

75. Give family members and carers as much access to the patient as is practical during transfer. If possible, give them an opportunity to discuss the reasons for transfer and how the transfer process works with a member of the healthcare team. [2003, amended 2014] Update 2014

These recommendations are based on level five evidence and are considered to be grade D recommendations.

9.7 Transfer of children (2003)

76. Recommendations 63 - 74 were written for adults, but apply these principles equally to children and infants, providing that the paediatric modification of the GCS is used. [2003]

77. Service provision in the area of paediatric transfer to tertiary care should also follow the principles outlined in the National Service Framework for Paediatric Intensive Care. These do not conflict with the principles outlined in this section. [2003]

78. The possibility of occult extracranial injuries should be considered for children with multiple injuries. Do not transfer them to a service that is unable to deal with other aspects of trauma. [2007]

79. Transfer of a child or infant to a specialist neurosurgical unit should be undertaken by staff experienced in the transfer of critically ill children. [2003]

80. Give family members and carers as much access to their child as is practical during transfer. If possible, give them an opportunity to discuss the reasons for transfer and how the transfer process works with a member of the healthcare team. [2003, amended 2014] Update 2014

These recommendations are based on level five evidence and are considered to be grade D recommendations.

9.7.1 Recommendations for research (2007)

The GDG also identified the following priority areas for research.

9.7.1.1 Research Question

8. Do patients with significant traumatic brain injury who do not require operative neurosurgical intervention at presentation, but are still cared for in specialist neurosciences centres, have improved clinical outcomes when compared to similar patients who are treated in non-specialist centres?

9.7.1.2 Why this research is important

Traumatic brain injury (TBI) is amongst the most important causes of death in young adults, with an overall mortality for severe TBI of over 50%. TBI care consumes one million acute hospital bed-days, and over 15,000 ICU bed-days annually, and patients who do survive significant TBI experience an enormous burden of long term physical disability, neurocognitive deficits, and neuropsychiatric sequelae. The financial impact is significant: the NHS spends over £1 billion on just the acute hospital care of the 10,000 patients with significant TBI. The costs of rehabilitation and community care are difficult to estimate, but probably total many multiples of the figure provided for acute care. These considerations make TBI a national healthcare priority and its outcome impact is consistent with its inclusion in the National Service Framework for Long Term Neurological Conditions.

Current referral of patients with acute traumatic brain injury practice is still dominated in many parts of the United Kingdom by the need for operative neurosurgical intervention at presentation. This may be inappropriate, since many patients with severe head injury have evidence of raised intracranial pressure in the absence of surgical lesions, and suffer morbidity and mortality equal to those with surgical lesions. Further, several studies provide strong circumstantial evidence that managing such “non-surgical” patients in specialist neurosciences centres may result in substantial improvements in mortality and functional outcome, probably due to specialist expertise in areas of non-operative management, such as neurocritical care. However, these results may be confounded by case-mix effects and referral bias, and the cost effectiveness of such specialist management remains uncertain. There is a strong case to address this question in the context of a formal study, since a change in practice could have a major impact on death and disability in a condition that is a major contributor to mortality in healthy young adults. Importantly, the results of such a study could

fundamentally alter the recommendations made by NICE, in terms of where patients with head injury are treated within the healthcare system, and result in better optimised (and potentially more cost effective) patient flows within the NHS.

The available evidence in this area has been addressed in the systematic review that contributed to the revision of NICE Guidelines on the early management of head injury. This review could find no high quality clinical evidence on the topic. This is unsurprising, since any study that addressed these issues would have to be undertaken within the context of a healthcare system and include ambulance services, district general hospitals and neuroscience referral centres. Such a study would therefore require the organisational backing of a body such as NICE, and careful design to account for confounds and biases. However, we believe that given careful design, such a study would be both ethically and logistically feasible. The patient group is well defined, and adequate numbers would be available to provide a definitive result within a reasonable time frame. While circumstantial evidence may support transfer of such patients to neurosciences centres, current practice is not influenced by this view in many regions, and many would argue that there is still clinical equipoise in this area. There are clear risks from transfer, and there could be clear harm, both in terms of clinical outcome and health economics, if the anticipated benefits were not realised. On the other hand, if the benefits from observational studies were confirmed by the trial, the resulting changes in management that could potentially reduce case-mix adjusted mortality by 26% and increase the incidence of favourable outcome in survivors by nearly 20%.

10 Discharge and follow-up

10.1 Introduction (2014)

The provision of appropriate information and support for patients and their carers when discharged from hospital after a head injury is important in ensuring that people are aware of typical symptoms following injury and any warning signs that require action or warrant further assessment. It is important also to provide patients and carers with sources of on-going support. This includes information for infants, children and adults in addition to family and carers.

The GDG wished to understand what patients who have been discharged from the Emergency Department or observation ward really want from discharge information and support in order to further inform existing recommendations in this area. The information and support needs of patients who have longer term rehabilitation and support needs have not been reviewed as this patient group are not the focus of this early management of head injury guideline. Further information about support resources can be found in section 10.8.3.

Update 2014

10.2 Introduction (2003)

One consequence of these guidelines will be a tendency to discharge a higher proportion of patients with head injury directly from the emergency department. At the same time it is anticipated that patients admitted for in-hospital observation will on average have sustained a more severe head injury than is currently the case. These changes to current admission practice will increase the need to ensure that patient discharge from hospital is safe and carefully planned. A very small number of patients will develop late complications despite normal CT results and an absence of signs and symptoms. A well designed system of high quality discharge advice and post-discharge observation by a carer is required to ensure that these patients receive appropriate care as soon as possible. The role of carers at home in the early post-discharge observation of patients is important and should be guided by clear and detailed information. There should be clearly defined pathways back to hospital care for patients who show signs of late complications.

10.3 Discharge of low risk patients with GCS equal to 15 (2003)

81. If CT is not indicated on the basis of history and examination the clinician may conclude that the risk of clinically important brain injury to the patient is low enough to warrant transfer to the community, as long as no other factors that would warrant a hospital admission are present (for example, drug or alcohol intoxication, other injuries, shock, suspected non-accidental injury, meningism, cerebrospinal fluid leak) and there are appropriate support structures for safe transfer to the community and for subsequent care (for example, competent supervision at home). [2003]

This recommendation is based on level five evidence and is considered to be a grade D recommendation.

10.4 Discharge of patients with normal imaging of the head (2003)

82. After normal imaging of the head, the clinician may conclude that the risk of clinically important brain injury requiring hospital care is low enough to warrant transfer to the community, as long as the patient has returned to GCS equal to 15, and no other factors that would warrant a hospital admission are present (for example, drug or alcohol intoxication, other injuries, shock,

suspected non-accidental injury, meningism, cerebrospinal fluid leak) and there are appropriate support structures for safe transfer to the community and for subsequent care (for example, competent supervision at home). [2003]

This recommendation is based on level five evidence and is considered to be a grade D recommendation.

10.5 Discharge of patients with normal imaging of the cervical spine (2003)

83. After normal imaging of the cervical spine the clinician may conclude that the risk of injury to the cervical spine is low enough to warrant transfer to the community, as long as the patient has returned to GCS equal to 15 and their clinical examination is normal, and no other factors that would warrant a hospital admission are present (for example, drug or alcohol intoxication, other injuries, shock, suspected non-accidental injury, meningism, cerebrospinal fluid leak) and there are appropriate support structures for safe transfer to the community and for subsequent care (for example, competent supervision at home). [2003]

This recommendation is based on level five evidence and is considered to be a grade D recommendation.

10.6 Discharge of patients admitted for observation (2003)

84. Patients admitted after a head injury may be discharged after resolution of all significant symptoms and signs providing they have suitable supervision arrangements at home. [2003]

This recommendation is based on level five evidence and is considered to be a grade D recommendation.

10.7 Discharge and GCS status (2003)

85. Do not discharge patients presenting with head injury until they have achieved GCS equal to 15, or normal consciousness in infants and young children as assessed by the paediatric version of the GCS. [2003]

This recommendation is based on level five evidence and is considered to be a grade D recommendation.

10.8 Review question: What information and support do patients with head injury say they want? What discharge information should be given to patients with head injury? (2014)

The review questions relating to patient information and support for discharge (what patients say they want and what they should be given) were searched for together. The studies identified have been looked at together and highlight where patients and professionals state what they want and should be given, respectively.

Qualitative studies were identified as the main source of evidence for this review and themes were identified. These were supplemented by surveys where available.

For full details see review protocol in Appendix D.

10.8.1 Clinical evidence

Three qualitative studies[86,93,142] and six surveys[80,87,119,165,254,288] were identified. The qualitative studies looked at a range of ages and severities of injury. Falk et al., 2008[86] and Gagnon et al., 2008[93] included children and adolescents, respectively, who had mild head injury. Keenan et al., 2010[142] focuses on adults with more severe head injury and reflects on their experience in the emergency department and information requirements early on in their recovery. Neither age or injury severity has been used to stratify the themes, but have been indicated within the text, where applicable. A summary of the study quality for the qualitative studies is presented in Table 21.

Table 21: Summary of studies included in the review – study quality

Study	Population	Methods	Analysis	Relevance to guideline population
Falk et al., 2008[86]	Well reported	Adequately reported	Adequately reported	Sweden. Families of children (0-15 years) with mild head injury.
Gagnon et al., 2008[93]	Well reported	Well reported	Well reported	Canada. Adolescents (12 - 16 years) and their parents after their mild TBI.
Keenan et al., 2010[142]	Well reported	Adequately reported	Adequately reported	Canada. Families of patients aged 16 to 65 with severe TBI.

In addition to supporting the identified themes, survey data also gave more general information about the use of patient discharge advice for head injury patients. Discharge advice was received by 57-82.5%[119,165] of patients with head injury, with 92%[165] of those who received advice having read it. Advice was received by 5.5 – 42%[119,165] of relatives or caregivers. Satisfaction with overall advice was positive for Mc Millan et al., 2009[165] with 84.5%, negative for 4.5%, and the remainder did not remember the advice. Falk et al., 2008[86] stated that 83% of families stated they "for the most part" (from a choice of 'in the most part/in some part/not at all') understood information concerning the injury that had been provided during the visit to the emergency department and 69% "for the most part" did get the information they needed about the head injury before discharge.[87]

10.8.2 Common themes

Themes were identified relating to what information people with head injury and their families say they want at discharge and views from healthcare professionals identified from qualitative studies. Survey data was used to support the themes, including what information was given and whether

patients understood or remembered this advice. Identification of themes was based on what the studies reported, no additional interpretation was conducted in order to minimise bias. The themes identified have been split into patient information and patient support:

Patient information

- Need for immediate information regarding the head injury
- Knowing when to return to the emergency department
- Need for information concerning return to everyday activities
- Return to sport
- Information about the recovery process
- Age appropriate information.

Patient support

- Reassurance and support for coping
- Support from family and friends
- Support from professionals
- Support from community partners

Some of these themes overlap.

10.8.2.1 Patient information

Theme 1. Need for immediate information regarding the head injury

Three qualitative studies describe the need for patients and their families wanting immediate information about the injury.[86,93,142] Gagnon et al.,[93] describes that adolescents with mild head injury looked for explanations from their families or professionals about what had happened and had experienced confusion, impaired memory loss or loss of consciousness at the time of injury. For parents, it was their absence at the time of injury or at the time their teenager was brought to hospital that created the need to find out about the circumstances of the injury.

Keenan et al 2010[142] supports this and highlights that the family expressed an intense "need to know" about their relative's severe TBI, including an accurate and prompt diagnosis and what the prognosis was. Most families wanted information that was consistent, understandable, honest and updated on a frequent basis. They wanted information specific to their relative, not based on statistics or probabilities. Most families felt well informed, but some were not reassured and felt they need more information. Gagnon et al., 2008[93] also found that there was a sense of urgency and that they found the waiting times in the emergency department unacceptable, as adolescents and parents considered a head injury to be a serious condition.

In addition, the families of children with mild head injury expressed the desire for healthcare staff to treat their child on the basis of their professional observations, as well as to inform the entire family of the results of these observations, for example "is this a concussion?" In addition, they wanted to be informed of the acute management strategy and what the immediate complications might be "could it be a brain injury? Is there any bleeding in the brain or fracture of the skull?".[86]

Theme 2. Knowing when to return to the emergency department

This theme describes how patients and family members want information on symptoms to look for once they have left the emergency department and what should trigger them to return to hospital or see their GP. Gagnon et al., 2008[93] explains that adolescents needed information on pain management following their mild TBI and how to manage other symptoms for example headaches, nausea or irritability, and also what to look for regarding impairments such as post-concussion symptoms or loss of consciousness. Adolescents who were admitted to hospital and required rehabilitation[93] (n = 5) expressed the need for management of more symptoms (dizziness, fatigue, sensitivity to noise and irritability) and indicated their needs were not always met and needed multiple visits to the emergency department or physician.

Five surveys[80,87,119,254,288] look at symptoms to be aware of after discharge that may form part of discharge advice, and whether patients received and understood this. Engel 2012 et al[80] studied patient's understanding of written discharge advice from the emergency department after receiving specific head injury advice, and found that 44.4% (13/29) had no or minimal understanding of symptoms or reasons to return the emergency department when asked "which symptoms or changes should cause you to come back to the emergency department?". Falk 2009[87] describes that 46% (20/45) of families of children aged 5 and over with mild head injury received information about common symptoms, compared to 20% (10/51) of <5 year olds. 17% (16/96) contacted healthcare services because of questions about the head injury after their visit to the emergency department, with no difference reported between age groups.

Yates et al., 2006[288] details a randomised controlled trial comparing a standard advice sheet to a simplified advice sheet for adults with head injury at discharge from the emergency department. Patients were asked questions to determine if they understood the advice and were then given the advice sheet they had not originally received and asked their preference. The study found that the simplified form was preferred by both study groups, with 94% (94/100) and 95% (95/100) preferring the simplified form in the standard and simplified group, respectively. Comprehension scores (questions answered correctly out of 10) were higher ($p<0.0001$) for those receiving the simplified advice sheet with a median of 9 for standard and 10 for simplified form. The study concludes that people of all literacy levels prefer, and have a better understanding of, simple written materials compared to complex material and goes on to state that common words should be used or difficult words explained, that short sentences and a large font be used for written discharge advice.

Heng et al.,2007[119] also explores patient's understanding of head injury advice and found that the maximum number of symptoms recalled was 6/9 (mean 1.9, n = 110). The commonest symptoms recalled were persistent vomiting (64%), dizziness (53%) and persistent headache (35%), with the least common recalled symptom being seizures (4%). Incorrect symptoms recalled included fever, numbness, feeling cold, tinnitus, sore throat and cold sweats. Recall scores did not vary statistically based on how the advice was given (verbally or printed, or both). Scores were statistically higher in females compared to males and there was no difference in age, race or nationality.

A survey looking at post-concussive symptoms in children[254] found that symptoms developed in 62.9% of 105 children with TBI. 69.5% of parents initially stated their child did not exhibit post-concussive signs or symptoms. When asked about each sign or symptom individually, 46.6% of parents who reported an asymptomatic child identified 1 or more symptoms in their child. In symptomatic children, there was a significant difference between those parents who were able to identify symptoms in their child and those who could not ($p <0.05$), supporting the hypothesis that parents of post-concussive children were unable to recognise symptoms in their children. Of parents who reported that their children were asymptomatic, when asked about the symptoms individually, the most common observed symptoms included headache (37%, 27/73), nausea (12.7%, 9/73) and feeling slow or sluggish (11%, 8/73). The study concludes that current methods of providing

discharge instructions to parents of children with concussion are ineffective and suggests individualised care planning to meet the needs of the family.

Theme 3. Need for information concerning return to everyday activities

Two qualitative studies[86,93] explore the theme of returning home. Families of children with head injury described wanting information concerning daily care of their child at home, "what should we be aware of?", "what should we look for in particular when we are at home?".[86] Parents also wanted to know about the type and level of care needed at home to facilitate recovery, including "different degrees and different symptoms" to look for and "possible solutions".[93] Additional information from a survey[80] states that there were severe knowledge deficits at discharge, with the most frequent being home care (defined in the paper as whether they were told to take care of this problem besides taking medication) (58.6%, 17/29).

Gagnon et al 2008[93] describes that information was requested about return to activities "what can my teen do now?" and how adolescents and families wanted information on return to school. Over 75% (n = 10) of parents of adolescents wanted details on how to facilitate return to school. Adolescents who were admitted to hospital and required rehabilitation services (n = 5), required reassurance and wanted more information on adjustments for return to school after their absence and what was required for a smooth return.[93] Parents in this study were worried about the impact of the injury on the child's academic performance and required information on return to physical activity, with parents of those who were admitted to hospital and required rehabilitation services being particularly concerned. This theme is also supported by Falk et al., 2008[86], with parents wanting information on possible restrictions on education.

Survey data[119] indicates that 29% (29/100) of patients with minor head injury were non-compliant to advice given at discharge, including 7% (7/100) who drove a vehicle within 24 hours of injury. Another survey[165] showed that of those who acknowledged receiving advice about specific categories after their head injury, few said they did not follow it; work (4%, 3/72), medication (0%, 0/76), alcohol/drugs (4%, 4/88), rest/sleep (6%, 7/112).

Theme 4. Return to sport

Two qualitative studies and one survey address the theme of return to sport. Gagnon et al., 2008[93] details that adolescents expressed a strong desire to return to their familiar surroundings and activities as soon as possible. They were worried that post-concussion symptoms could prevent their return to physical activities. Adolescents requested information about return to physical activities following a mild TBI, whereas teens with more severe head injury expressed a fear of poor performance and also information on prevention of future injuries. Parents expressed concern about "recurrent situations like this" and "what to look out for, what to do", as well as how it affected their child. This is also supported by Falk et al 2009[87], as parents wanted to know how active should they let their child be and what they are allowed to do in regards to "watching television, reading, computer games and physical activities".

One survey suggests that memory for advice was poor in adults and that only 36% (26/72) remembered advice correctly regarding sport. Of those who acknowledged receiving advice about sport, 1% (1/72) stated that they did not follow it.[165]

Theme 5. Information about the recovery process

Two qualitative studies describe how families wanted information on the recovery of their child, with questions asked such as "for how long will he/she feel like this?".[87] They also wanted to know about any long-lasting consequences of the injury. The parents of children less than 5 years of age asked questions like "will this injury lead to a delay in physical development?" that were not asked by parents of older children.[87] Gagnon et al., 2008[93] identified that adolescents and parents wanted to know what to expect following a mild TBI. All adolescents expressed the need to know as much as possible about the nature of their injury, sequelae and recovery and all parents wanted to know what to expect later. Parents sought information from sources other than the initial contact with the healthcare system even if it was from less reliable sources for example, internet or friends.

Theme 6. Age appropriate information

One qualitative study[93] and one survey[87] identify that children and young people want information specific to their age. Adolescents[93] expressed the need to exert some control over the situation (either during their hospital stay or when receiving care from their parents). Adolescents and parents felt that information should be readily available and that professionals should address the patient directly, not speaking only to their parents, and appear genuinely interested in them. There is also an overlap with return to school as the study describes the need for professionals to develop appropriate and timely communication with their teachers and high school to facilitate a progressive and smooth return to academic activities. Falk et al., 2009[87] states that 58% (26/45) of children aged 5 and over received age appropriate information compared to 16% (8/51) in the younger age group.

10.8.2.2 Reassurance and support

Theme 1. Need for reassurance and support for coping

Three qualitative studies discuss the need for reassurance and support for coping with a family member who has a head injury.[87,93,142] Falk et al., 2009[87] details that families had questions concerning the recovery of their child and sought reassurance "will he/she recover" and "will he/she get well?". The study goes on to state that families expressed a need to share their emotional burden, describing their anxiety and overall concern about the situation. They also sought assurance about guilt regarding their own management of their child's injury with questions like "should we have come to the hospital by ambulance?" and "should we have come to the hospital sooner?".[87] Another study describes that most families realised that there were no definite answers and indicate that healthcare staff are "there to support you".[142] Gagnon et al 2008[93] also reported that all parents wanted to be reassured about their child's condition.

Theme 2. Support from family and friends

Two qualitative studies[93,142] found that it was important for both the patient and their family to get support from friends and family. Adolescents reported the need to feel secure from injury throughout their care and to receive support from people they felt comfortable with (friends and family).[93] The same study reports that parents wanted to be close to their teenager and wanted professionals to facilitate their presence for example, "I didn't want to leave her", "I wanted to be with her at home". Emotional support from family and friends was described as a necessary part of the recovery for adults with severe TBI, so that family did not feel alone in dealing with challenges and that "it's very important to have that support because you're not in this alone, this continues to be a major part of our rehab, both my wife and mine, 'cause it's a long process and we need some support from friends and families and we're getting it, and it's helpful".[142]

Theme 3. Support from professionals

Adolescents in all groups wanted a trusting relationship with professionals, including healthcare workers and teachers.[93] This theme overlaps with return to school and sport as adolescents required support from professionals in these areas for example, "when I was in class, I was really tired, I got bad headaches…The teachers did not help at all." Parents expressed the need for a post admission follow-up and the name and telephone number of someone they could contact if needed. They felt that "You don't even have a name, you have the same paper for everyone, no doctor's name, no paper for school…that is, I would have liked to have a sheet that…that date, mild traumatic brain injury, the doctor that was seen, the hospital. After…I didn't even know the doctor's name so in that was it was pretty anonymous." Some of the adolescents reported receiving a follow-up telephone call and their parents stated that this met their need for support post-hospitalisation.

Keenan et al., 2010[142] describes the positive support provided by the team as a whole, with nurses identified as providing support most often. Nurses were identified as spending time with the patient (with severe TBI) and family, developing a close link and being described as competent and having effective communication. Physician support was often linked to brief communication that was delivered in a supportive manner.

Theme 4. Support from community partners

Gagnon et al., 2008 [93] reports that services in the community were lacking and adolescents and their parents wanted schools and sports providers to be more knowledgeable about their injury and how to support them. Suggestions for school included allowing gradual return and extra time for assignments, with adolescents saying that "The teachers, they could have probably, they could have understood what happened, they could have given me more time to hand in my work….They were getting mad at me because I was missing half days of school…". The need for a more formal link between the healthcare system and school systems or team coach was suggested by parents.[93]

10.8.3 Policies and other relevant documents

The GDG noted that there are a variety of existing guidance, including examples of information leaflets and fact sheets. Although these were not included in the review, as they did not meet the inclusion criteria for this clinical question, they are provided for information.

http://www.childbraininjurytrust.org.uk/downloads/information/factsheets/Leaving%20hospital.pdf

http://www.childbraininjurytrust.org.uk/downloads/information/factsheets/Acquired%20Brain%20Injury%20and%20Education.pdf

http://www.gosh.nhs.uk/medical-conditions/search-for-medical-conditions/head-injuries/head-injuries-information/

https://www.headway.org.uk/Factsheets.aspx

http://www.hscboard.hscni.net/RABIIG/Pathways/%20The%20Guide%20-%20Brain%20Injury%20Support%20in%20Northern%20Ireland/3%20Discharge%20and%20Leaving%20Hospital%20-%20PDF%20265KB.pdf

http://www.nhs.uk/Conditions/Head-injury-minor/Pages/Treatment.aspx

http://www.braininjuryhub.co.uk/information-library/hospital-stage

http://www.childbraininjurytrust.org.uk/information_forpap.html

10.9 Economic evidence

Published literature

No relevant economic evaluations comparing different strategies of giving information or support to patients with head injury were identified. No economic evaluations evaluating different strategies and content of discharge information given to patients with head injury with or without cervical spine injury were identified. There were no excluded studies.

10.10 Recommendations and link to evidence

Recommendations	**86. Give verbal and printed discharge advice to patients with any degree of head injury who are discharged from an emergency department or observation ward, and their families and carers. Follow recommendations in Patient experience in adult NHS services [NICE clinical guideline 138] about providing information in an accessible format). [new 2014]** **87. Printed advice for patients, families and carers should be age-appropriate and include:** • **Details of the nature and severity of the injury.** • **Risk factors that mean patients need to return to the emergency department (see recommendation 4 and 5).** • **A specification that a responsible adult should stay with the patient for the first 24 hours after their injury** • **Details about the recovery process, including the fact that some patients may appear to make a quick recovery but later experience difficulties or complications.** • **Contact details of community and hospital services in case of delayed complications.** • **Information about return to everyday activities, including school, work, sports and driving.** • **Details of support organisations. [new 2014]** **88. Offer information and advice on alcohol or drug misuse to patients who presented to the emergency department with drug or alcohol intoxication when they are fit for discharge. [2003]**
Relative values of different outcomes	The outcomes used in this review were any reported in the papers. The GDG considered any reported opinions of information provision equally important.
Trade off between clinical benefits and harms	The review identified several themes about what information patients want and should be given, including the need for immediate information regarding the head injury, knowing when to return to the emergency department (for example, which symptoms require attention from healthcare professionals), information concerning return to everyday activities (including sport) and information about the recovery process. The evidence also highlighted that patients and families want age appropriate information such as younger children require different information and different ways of explaining information compared to adolescents. The GDG extrapolated this to other levels of care required by different patient population for example, patients with cognitive impairment or those returning to nursing homes or

	residential care are likely to require additional explanation of information (including information for their family and carers) compared to those without cognitive impairment. The benefit of giving clear, accessible and appropriate information is that the patient will be reassured and know how to care for themselves (or be cared for by family or carers), which could lead to fewer repeat visits to healthcare professionals (emergency department or GP), or mean that should they have symptoms requiring further investigation they will know what to do (for example, return to the emergency department), which could improve their recovery/quality of life. No harm was identified in giving this intervention.
Economic considerations	No economic evidence was identified to inform this recommendation. The resource implications of patient information and follow-up strategies will vary depending on the specific strategy. Short term resource and costs will be those associated with implementing the strategy, for example those associated with staff time to give discharge advice, or the production costs of information leaflets. However, the review identified several themes regarding the content (not implementation) of the information as important (therefore ensuring the content is age appropriate, understandable, provides information on return to normal activities and on the recovery process). Changes in the content of the information does not need to come at great expense, whereas changes in method of delivery may incur additional costs. Downstream resource implications will in part depend on how effective the strategy is in modifying healthcare seeking behaviour, a key theme identified within the review that will alter the number of repeat healthcare contacts and improvement of recovery and quality of life. The cost effectiveness of interventions regarding discharge advice will therefore be in part driven by the likelihood of inappropriate care seeking in the absence of effective discharge advice and follow-up. The GDG concurred that the additional cost per patient of the discharge advice (costed within the hospital admission) is likely to be minimal in relation to the cost per patient of unnecessary future healthcare contacts (emergency department or GP) or, more importantly still, the associated costs of delayed treatment when failing to seek care when appropriate. In the absence of available data, the GDG came to a consensus that the potential resources and costs involved in a discharge and follow-up strategy were more than likely to be offset in part or completely by appropriate health care seeking. Ensuring the content is appropriate and effective is likely to reduce downstream costs and bring health benefit and therefore highly likely to be cost effective.
Quality of evidence	The qualitative studies were of adequate quality and common themes emerged from the studies.
Other considerations	The GDG feel that appropriate discharge information is important and agreed to update the recommendations for patient information from the original versions of the guideline. The GDG have included a new recommendation which directs readers to apply the principles of information sharing as outlined in the NICE Patient experience guideline (CG138). The following changes to the original recommendations have been made. In recommendation 86, 'Printed' has been inserted for clarity. "Card" has been removed as this is considered by the GDG as outdated terminology. The second sentence has been removed, which referred to patients with literacy problems, visual impairment and languages other than English. The GDG felt that it was more appropriate to link the patient experience guideline (http://www.nice.org.uk/cg138) (recommendation 1.5.13) as they want to emphasize the need for accessible

	information, whether it is via the internet or to meet needs such as those with visual or cognitive impairment. Recommendation 87 has been updated to include detail on themes identified from patient discharge information review (when to return to the emergency department, age appropriate information, details about the recovery process and return to everyday activities). 'Details of support services' originally in recommendation 1.8.4.1., as detailed in Appendix O, but considered to be best placed within this recommendation. The GDG highlighted the inconsistency in information given across the UK and thought that inserting more detail about what should be included in the discharge advice may help this (along with implementation support). They also felt strongly that accredited information standard compliant printed advice, should be used and that advertising from commercial organisations such as solicitors, was not appropriate. The GDG also discussed the particular needs of those presenting to the emergency department with an injury sustained while under the influence of alcohol or drugs. They felt that this was an important opportunity to provide patients with information about local drug and alcohol services and chose to make a consensus recommendation in this area. The GDG also felt that it was important to reflect the advice given in recommendation 91 in any printed advice given to the patient or carer at discharge and through consensus agreed to include it as an item in this recommendation. The GDG prioritised recommendations 86 and 87 as key priorities for implementation as they have a high impact on outcomes that are important to patients, have a high impact on reducing variation in care and outcomes, lead to a more efficient use of NHS resources and promote equalities

Recommendations	89. Inform patients and their families and carers about the possibility of persistent or delayed symptoms following head injury and whom to contact if they experience ongoing problems. [New 2014]
Relative values of different outcomes	The outcomes used in this review were any reported in the papers. The GDG considered any reported opinions of information provision or support equally important.
Trade off between clinical benefits and harms	The review identified several themes about what information patients want and should be given, including when to return to the emergency department (for example, which symptoms require attention from healthcare professionals) and information about the recovery process. The benefit of giving patients and their carers information about persistent or delayed symptoms is that the patient will be reassured and know how to care for themselves (or be cared for by family or carers), which could lead to fewer repeat visits to healthcare professionals (emergency department or GP), or mean that should they have symptoms requiring further investigation they will know what to do (such as return to the emergency department), which could improve their recovery/quality of life. No appreciable harm was identified in giving this intervention.
Economic considerations	No economic evidence was identified to inform this question. Giving appropriate advice about persistent or delayed symptoms is likely to only enhance appropriate care seeking, as explained in the above section. The GDG noted the key costs of staff time and production costs of printed materials, however did not expect this recommendation to have a large cost impact in this respect (in comparison to current practice). The recommendation could have an impact on referral patterns to services the patient should contact if problems persist, however patient information is most likely to ensure this contact is timely and appropriate. Ensuring that patients know when to contact healthcare services, on balance, was considered to be a strategy that will reduce downstream costs and bring health benefit, and therefore, highly likely to be cost effective.
Quality of evidence	The qualitative studies were of adequate quality and common themes emerged from the studies. The themes around reassurance and support were of direct applicability to this recommendation.
Other considerations	The GDG have agreed to update this recommendation by removing the second sentence about ‘details of support services’ and merging it with recommendation 87. Minor amendments have been made to reflect updated terminology and improve clarity.

Recommendations	**90. For all patients who have attended the emergency department with a head injury, write to their GP within 48 hours of discharge, giving details of clinical history and examination. This letter should also be shared with health visitors (for pre-school children) and school nurses (school-age children). If appropriate, provide a copy of the letter for the patient and their family or carer. [new 2014]**
Relative values of different outcomes	The outcomes used in this review were any reported in the papers. The GDG considered any reported opinions of information provision or support equally important.
Trade off between clinical benefits and harms	The review identified several themes about what information patients want and should be given, including patient support and the need for reassurance and support for coping, including support from family and friends, professionals and community partners. The benefit of giving clear, accessible and appropriate information and providing access to support services is that the patient will be reassured and know how to care for themselves (or be cared for by family or carers), which could lead to fewer repeat visits to healthcare professionals (emergency department or GP), or mean that should they have symptoms requiring further investigation they will know what to do (such as return to the emergency department), which could improve their recovery/quality of life. No appreciable harm was identified that could result from this strategy.
Economic considerations	No economic evidence was identified to inform this question. No appreciable cost impact was identified in relation to the update to this recommendation. Communication between health professionals and support services was considered integral to the patient's continuum of care.
Quality of evidence	The qualitative studies were of adequate quality and common themes emerged from the studies.
Other considerations	The GDG have agreed to update the recommendations for patient information and the following changes have been made. The addition of 'shared with health visitors (for pre-school children) and school nurses (school aged children).' Taken from recommendation 1.8.5.2 and 1.8.5.3 (as labelled in the previous guideline, see appendix O). Write to their GP within 48 hours (this was previously 1 week, but the GDG felt that 48 hours was more appropriate and that this was happening already in the majority of cases). The GDG propose to delete recommendations 1.8.52. and 1.8.5.3, (as labelled in the previous guideline, see appendix O). Details for school aged children and pre-school children have now been combined into this recommendation. The GDG also noted that it may be appropriate to give a copy of the letter to the patient or their family or carer but that there may be circumstances when the inclusion of potentially sensitive information (such as safeguarding concerns) in this letter may indicate that this may not be appropriate. The GDG felt that clinicians should apply clinical judgement in these circumstances.

Suggested printed advice for patients and carers is provided in Appendix O.

10.11 Discharge of patients with no carer at home (2003)

91. All patients with any degree of head injury should only be transferred to their home if it is certain that there is somebody suitable at home to supervise the patient. Discharge patients with no carer at home only if suitable supervision arrangements have been organised, or when the risk of late complications is deemed negligible. [2003]

This recommendation is based on level five evidence and is considered to be a grade D recommendation.

10.12 The best tool for identifying the patients who should be referred to rehabilitation services following the initial management of a head injury (2003)

10.12.1 Introduction and rationale for the clinical question

It is well known that some patients labelled as having had a minor head injury may experience long term disability following discharge from hospital. Symptoms such as headache, dizziness, memory deficits, slowness of thought, poor concentration, communication problems, inability to work and problems with self-care have been described. These patients are categorised by the International Classification of Diseases (ICD-10) as having post-concussional syndrome (PCS).

Five papers were classed as level two evidence due to the quality of the study design in the original guidleine.[17,172,213,217,271] However from these papers, only one paper[17] explicitly constructed a decision rule that could be used in the acute setting to identify patients at risk of PCS. This rule identifies a high-risk group that has an 89% risk of PCS and a low risk group with a risk of PCS of 9%. Unfortunately, 50% of patients then fall into a medium risk category, where the risk is 47% for PCS. Therefore, the only category that may be of use for excluding patients from follow-up is the low risk category, but this category was derived from only eleven patients. Therefore this study, although being the only paper to attempt the derivation of a rule, is still really only of use to researchers looking to improve on their findings.

Of the remaining papers: length of post-traumatic amnesia, period of loss of consciousness, abnormal initial GCS, gender, age, positive radiological findings and various neuropsychometric tests have been advocated as being associated with an increased risk of PCS, but there is no data as to how these variables might combine as a decision rule for the safe exclusion of low risk patients from follow-up.

In the original guideline, there was insufficient evidence for the recommendation of any decision rules that can safely exclude a patient from follow-up although several high-risk variables have been reported.

UPDATE 2007:

In this update, no clinical evidence review was carried out due to a vast amount of evidence in this area and the limited framework of this update. Therefore a thorough evidence map was conducted to aid future research in this area.

10.12.2 Clinical evidence (2007)

A search was developed to identify papers which attempted to develop, compare or validate a clinical prediction rule which would identify those patients, using variables collected during the acute

phase of care, who would suffer long term sequelae and whom would therefore benefit from rehabilitation. We considered systematic reviews, RCTs, non-randomised controlled trials, cohort studies, and case series.

In total, 394 relevant studies were included and put through a rigorous coding procedure. The following pieces of information were coded for each study using the abstract:

- Aim of the study – whether explicitly or implicitly about referral for rehabilitation, and also whether it aimed to compare, develop or validate a tool, or if attempted to carry out a multivariate analysis and thus infer a referral tool.
- Population – age group, injury severity. Other details were recorded under the variables section. Infants are children more than 1 year, adults are over 18. Injury severity was defined using the GCS system or if the authors used the words 'mild', 'moderate', or 'severe' in the abstract.
- Study design – type of study.
- Variables considered – these were categorised into certain groups. Every piece of information explicitly collected about the patient was categorised and noted. Therefore variables included predictors, outcomes, demographics, classifying information and so on.

Ninety two studies were identified as being explicitly about tools for referral. However, the remaining 302 studies were included as in a complete systematic review they would contain useful information; for example, the authors may have investigated variables which could be used to form a clinical prediction rule without making this explicit in the abstract.

A wide spread of variables was identified which included; GCS/GOS or other measure of injury severity, S100B, Tau protein, Interleukin, other blood marker, other clinical data, cognitive measure, behavioural measure, disability measure, sensory measure, imaging measure, quality of life measure, social functioning, employment outcomes, length of stay, mortality, motor skills, demographics, psychosocial measure and somatosensory evoked potentials (SEPs).

The population characteristics of age and injury severity were not reported in the majority of the reports. However, the most commonly studied populations appeared to be children (93 studies) and severely head injured patients (133 studies).

10.12.3 Economics evidence (2007)

A full literature review for this question was not conducted. However, below is an overview of relevant papers retrieved:

Economic evaluations of early versus late/no rehabilitation:

- 3 studies published since 2002: Berg2004,[19] Worthington2006,[287] Hashimoto-Keiji2006[115]
- 3 studies found from reviews: Aronow1987,[9] Cope1982,[51] Wood1999[286]

Economic evaluations of intensive versus less intensive rehabilitation

- 1 study published since 2002: Ponsford2006[211]
- 2 studies found from reviews: Ashley1997,[11] Salazar2000[228]

Reviews of economic evaluations

- 4 studies published since 2002: Turner2004,[274] Berg2004,[19] Wehman2005,[280] Turnerstokes2004[275]

We did not include in this evidence list studies of the following nature:

- Studies costing a single rehabilitation programme, including before and after comparisons
- Other non-comparative studies
- Studies evaluating length of stay and productivity but not cost

- Studies assessing the accuracy of tools in predicting cost.

10.12.4 Conclusion (2007)

The amount of literature identified by this search and evidence map was too diverse and too great to be systematically reviewed within the framework of this update. Moreover, the GDG felt it would be inappropriate to develop a recommendation about rehabilitation, given that the economic details about rehabilitation are limited. Rehabilitation covers a vast time span after injury and can encompass many different health professionals and is measured using many different types of outcomes. To derive a single rule, given the lack of clear evidence in this field, will be a challenging task. However, the GDG felt that a rigorous systematic review should be carried out to facilitate the development of the clinical prediction rule. The GDG therefore decided to write a research recommendation on this topic.

10.12.5 Recommendations for research (2007)

The GDG identified the following priority area for research.

10.12.5.1 Research Question

9. Research is needed to summarise and identify the optimal predictor variables for long term sequelae following mild traumatic brain injury. A systematic review of the literature could be used to derive a clinical decision rule to identify relevant patients at the time of injury. This would in turn lay the foundation for a derivation cohort study.

Why this research is important

We performed a review of the literature in this area, repeated in this update process. While 394 studies were identified that attempted to use a wide range of variables and tests to predict a range of longer term outcome measures, no robust clinical decision tools has successfully been derived and validated to identify patients at the time of injury who could be considered for follow-up due to a higher risk of long term sequelae. A systematic review of the literature would summarise and identify the optimal predictor variables for such a clinical decision rule and also identify the optimal outcome variables, thus laying the foundation for a derivation cohort study.

The derivation cohort study to create this clinical decision rule could potentially be conducted in conjunction with the validation of the CHALICE rule, with follow-up of patients involved in this study at 6 months-1 year. This would ensure optimal value for money for funders and ensure good results in a large cohort of patients. Separate studies could also be performed in adults but the initial study may in fact be more urgent in the childhood population.

Identification of patients likely to suffer from long term sequelae will allow targeted research regarding responsiveness to, or effectiveness of focused rehabilitation programmes. Preventative action could potentially be taken, thus reducing the strain on resources further down the care pathway. Furthermore, patient outcomes could potentially be improved by early identification and treatment (both curative and preventive) of problems. However, further research is required before we can be certain that a robust framework exists with which to cope with individuals identified by the clinical prediction rule proposed above.

Update 2014

Although this recommendation was first made in 2007, the GDG felt that this is still an area of high priority for research and the question remains unanswered. The diagnosis of traumatic brain injury is essentially a clinical one.[168,226] However, although this approach provides the best current solution it can be imprecise, particularly in mild traumatic brain injury (TBI), where conventional imaging may be normal and cognitive abnormalities may be due to confounders such as pre-existing dementia, hypoxia or hypotension from associated injuries, alcohol or recreational drugs, and/or other conditions (such as post-traumatic stress disorder) which result in overlapping phenotypes (and possibly even imaging findings).[226]

The availability of novel, objective methods of detecting brain injury provides an attractive means of better defining the presence of TBI in these contexts, with improvements in epidemiological precision. Perhaps more importantly, there is an increasing recognition that even mild TBI can result in prolonged cognitive and behavioural deficits,[21,42,68,120,153,242,271] and the ability to identify patients at risk of these sequelae would aid clinical management, help determine which patients need novel therapeutic interventions, and refine resource allocation. The techniques that have been explored in this regard include advanced neuroimaging with magnetic resonance imaging (MR), electroencephalographic (EEG) based diagnosis, and circulating biomarkers. The relative effectiveness and cost effectiveness of these techniques, individually and in combination, is not yet completely defined, and their role in contributing to a clinical decision rule that allows triage of patients to specific management pathways needs definition. A systematic review would be the first step in collating the available evidence in this area, followed by a rational application of available evidence, identification of key research questions that need to be addressed, and definition of the data collection needed in a derivation cohort study that allows these questions to be addressed.

10.13 Outpatient appointments (2003)

92. When a patient who has undergone imaging of the head and/or been admitted to hospital experiences persisting problems, ensure that there is an opportunity available for referral from primary care to an outpatient appointment with a professional trained in assessment and management of sequelae of brain injury (for example, clinical psychologist, neurologist, neurosurgeon, specialist in rehabilitation medicine). [2003]

These recommendations are based on level five evidence and are considered to be grade D recommendations.

10.14 Prognosis in severe head injury (2003)

A recent systematic review focusing only on severe head injuries examined evidence on early indicators of prognosis.[30] The review found that certain variables had a high positive predictive value for poor prognosis. While this level one evidence is useful in identifying patients at highest risk for poor outcome, it is unclear what course of action should be pursued with these patients. Guidelines on the rehabilitation of adults following traumatic brain injury have been prepared by the British Society of Rehabilitation Medicine. These are based on a full systematic review of the literature as well as drawing on the recommendations of existing consensus documents. The guidelines were published in December 2003[220] and include information on the rehabilitation of patients following acquired brain injury.

10.15 Re-attendees (2003)

There is evidence that patients who re-attend in the days immediately after head injury are a high risk group for intracranial complications.[277]

93. Patients who return to an emergency department within 48 hours of transfer to the community with any persistent complaint relating to the initial head injury should be seen by or discussed with a senior clinician experienced in head injuries, and considered for a CT scan. [2003]

This recommendation is based on level two evidence and is considered a grade B recommendation.

11 Admission and observation

11.1 Introduction (2003)

These guidelines place the emphasis on the early diagnosis of clinically important brain and cervical spine injuries, using a sensitive and specific clinical decision rule with early imaging. Admission to hospital is intrinsically linked to imaging results, on the basis that patients who do not require imaging are safe for discharge to the community (given that no other reasons for admission exist) and those who do require imaging can be discharged following negative imaging (again, given that no other reasons for admission exist). However, observation of patients will still form an important part of the acute management phase, for patients with abnormal CT results that do not require surgery and/or for patients with unresolved neurological signs. Observation should occur throughout the patient's hospital episode, whether in the emergency department or after admission following abnormal imaging results. As noted above, all care professionals should use a standard head injury proforma in their documentation when assessing and observing patients with head injury. Separate adult, and child/infant specific proformas should be used. Again, the adult and paediatric GCS and derived scores should form the basis of observation, supplemented by other important observations.

An important result of these guidelines will be that the typical patient admitted for in hospital observation after head injury will have a more severe profile. It is presumed that the guidelines will lead to a substantially lower number of patients requiring admission, but these patients will have either confirmed abnormal imaging, have failed to return to normal consciousness or have other continuing signs and symptoms of concern to the clinician. The emphasis will shift therefore from vigilance for possible deterioration, to active care of patients where an ongoing head injury complication has been confirmed.

11.2 Admission (2003)

94. Use the criteria below for admitting patients to hospital following a head injury:

- **Patients with new, clinically significant abnormalities on imaging.**
- **Patients whose GCS has not returned to 15 after imaging, regardless of the imaging results.**
- **When a patient has indications for CT scanning but this cannot be done within the appropriate period, either because CT is not available or because the patient is not sufficiently cooperative to allow scanning.**
- **Continuing worrying signs (for example, persistent vomiting, severe headaches) of concern to the clinician.**
- **Other sources of concern to the clinician (for example, drug or alcohol intoxication, other injuries, shock, suspected non-accidental injury, meningism, cerebrospinal fluid leak). [2003]**

95. Be aware that some patients may require an extended period in a recovery setting because of the use of general anaesthesia during CT imaging. [2003, amended 2007]

96. Admit patients with multiple injuries under the care of the team that is trained to deal with their most severe and urgent problem. [2003]

These recommendations are based on level five evidence and are considered to be grade D recommendations.

11.3 Good practice in observation of patients with head injury (2003)

There is some evidence that emergency department observation wards are more efficient than general acute wards at dealing with short stay observation patients, with more senior supervision, fewer tests and shorter stays.[106] There have also been concerns about the experience and skills of staff on general and orthopaedic acute wards in head injury care.[224] This lead to a recommendation by the Royal College of Surgeons of England in 1999 that adult patients needing a period of observation should be admitted to a dedicated observation ward within or adjacent to an emergency department.[224]

97. In circumstances where a patient with a head injury requires hospital admission, admit the patient only under the care of a team led by a consultant who has been trained in the management of this condition during their higher specialist training. The consultant and their team should have competence (defined by local agreement with the neuroscience unit) in assessment, observation and indications for imaging (see recommendations 26 - 31 and 45 - 50); inpatient management; indications for transfer to a neuroscience unit (see recommendations 64 to 80); and hospital discharge and follow-up (see recommendations 82 - 93). [2003, amended 2007]

98. In-hospital observation of patients with a head injury should only be conducted by professionals competent in the assessment of head injury. [2003]

These recommendations are based on level five evidence and are considered to be grade D recommendations.

The service configuration and training arrangements required to ensure this occurs are beyond the scope of these guidelines but it is hoped that this issue will be addressed by future NHS policy guidance.

11.4 Minimum documented observations (2003)

99. For patients admitted for head injury observation the minimum acceptable documented neurological observations are: GCS; pupil size and reactivity; limb movements; respiratory rate; heart rate; blood pressure; temperature; blood oxygen saturation. [2003]

This recommendation is based on level five evidence and is considered to be a grade D recommendation.

11.5 Frequency of observations (2003)

As the risk of an intracranial complication is highest in the first 6 hours after a head injury, observations should have greatest frequency in this period.[150]

100. Perform and record observations on a half-hourly basis until GCS equal to 15 has been achieved. The minimum frequency of observations for patients with GCS equal to 15 should be as follows, starting after the initial assessment in the emergency department:

- **Half-hourly for 2 hours.**
- **Then 1-hourly for 4 hours.**
- **Then 2-hourly thereafter. [2003]**

101. Should the patient with GCS equal to 15 deteriorate at any time after the initial 2-hour period, observations should revert to half-hourly and follow the original frequency schedule. [2003]

These recommendations are based on level five evidence and are considered to be grade D recommendations.

11.6 Patient changes requiring review while under observation (2003)

102. Any of the following examples of neurological deterioration should prompt urgent reappraisal by the supervising doctor.

- **Development of agitation or abnormal behaviour.**
- **A sustained (that is, for at least 30 minutes) drop of 1 point in GCS score (greater weight should be given to a drop of 1 point in the motor response score of the GCS).**
- **Any drop of 3 or more points in the eye-opening or verbal response scores of the GCS, or 2 or more points in the motor response score.**
- **Development of severe or increasing headache or persisting vomiting.**
- **New or evolving neurological symptoms or signs such as pupil inequality or asymmetry of limb or facial movement. [2003, amended 2007]**

103. To reduce inter-observer variability and unnecessary referrals, a second member of staff competent to perform observation should confirm deterioration before involving the supervising doctor. This confirmation should be carried out immediately. Where a confirmation cannot be performed immediately (for example, no staff member available to perform the second observation) the supervising doctor should be contacted without the confirmation being performed. [2003]

These recommendations are based on level five evidence and are considered to be a grade D recommendation.

11.7 Imaging following confirmed patient deterioration during observation (2003)

104. If any of the changes noted in recommendation 102 are confirmed, an immediate CT scan should be considered, and the patient's clinical condition re-assessed and managed appropriately. [2003, amended 2007]

This recommendation is based on level five evidence and is considered to be a grade D recommendation.

11.8 Further imaging if GCS equal to 15 not achieved at 24 hours (2003)

105. In the case of a patient who has had a normal CT-scan but who has not achieved GCS equal to 15 after 24 hours' observation, a further CT scan or MRI scanning should be considered and discussed with the radiology department. [2003]

This recommendation is based on level five evidence and is considered to be a grade D recommendation.

11.9 Observation of children and infants (2003)

106. Observation of infants and young children (that is, aged under 5 years) is a difficult exercise and therefore should only be performed by units with staff experienced in the observation of infants and young children with a head injury. Infants and young children may be observed in normal paediatric observation settings, as long as staff have the appropriate experience. [2003]

This recommendation is based on level five evidence and is considered to be a grade D recommendation.

11.10 Training in observation (2003)

107. Medical, nursing and other staff caring for patients with head injury admitted for observation should all be capable of performing the observations listed in 99, 102 and 103 above. [2003]

108. The acquisition and maintenance of observation and recording skills require dedicated training and this should be available to all relevant staff. [2003]

109. Specific training is required for the observation of infants and young children. [2003]

This recommendation is based on level five evidence and is considered to be a grade D recommendation.

11.11 Support for families and carers (2003)

Early support can help the patient's family or carer(s) prepare for the effects of head injury. This support can reduce the psychological sequelae experienced by the family or carer and result in better long term outcomes for both the patient and their family. Patient's family members can find the hospital acute care setting overwhelming and this can cause additional tension or stress. It can be a particularly traumatic experience for a child visiting a sibling or parent with a head injury.

110. Staff caring for patients with a head injury should introduce themselves to family members or carers and briefly explain what they are doing. [2003, amended 2014]

111. Ensure that information sheets detailing the nature of head injury and any investigations likely to be used are made available in the emergency department. NICE's 'Information for the public' about this guideline may be helpful. [2003]

112. Staff should consider how best to share information with children and introduce them to the possibility of long-term complex changes in their parent or sibling. Literature produced by patient support groups may be helpful. [2003]

These recommendations are based on level five evidence and are considered to be grade D recommendations.

The presence of familiar friends and relatives at the early stage following admission can be very helpful. The patient recovering consciousness can easily be confused by strange faces and the strange environment in which they find themselves. Relatives or carers are often willing to assist with simple tasks which, as well as helping nursing staff, helps families to be part of the recovery process rather than just an observer.

113. Encourage family members and carers to talk and make physical contact (for example, holding hands) with the patient. However, it is important that relatives and friends do not feel obliged to spend long periods at the bedside. If they wish to stay with the patient, encourage them to take regular breaks. [2003, amended 2007]

This recommendation is based on level five evidence and is considered to be a grade D recommendation.

Voluntary support groups can speak from experience about the real life impact post head injury and can offer support following discharge from hospital. This is particularly important where statutory services are lacking.

114. Ensure there is a board or area displaying leaflets or contact details for patient support organisations either locally or nationally to enable family members and carers to gather further information. [2003]

This recommendation is based on level five evidence and is considered to be a grade D recommendation.

12 Medical radiation

12.1 Introduction (2007)

The medical use of radiation for diagnosis and therapy is the largest source of radiation exposure to humans outside natural background radiation. The main diagnostic sources of radiation are X-ray examinations, particularly those involving CT. Magnetic Resonance Imaging does not involve ionising radiation. Recent advances in CT technology, particularly the advent of multislice helical CT, have led to dramatic improvements in image quality and speed of acquisition. These have resulted in more clinical applications for CT imaging and an explosive growth in the number of CT examinations performed in countries that have access to this technology. The radiation doses received by the patient remain considerably larger for CT compared to conventional X-ray imaging, but dose-saving features introduced into the latest scanners and the adoption of more optimised scanning protocols have led to small reductions in patient dose for some CT examinations over the past few years. In 1998 CT examinations accounted for 4% of all X-ray imaging procedures in the UK and contributed 40% of the collective dose to the population.[240] By 2002 these figures had risen to 7% and 47% respectively.[113]

National patient dose surveys for CT examinations have been carried out in the UK in 1989[241] and in 2003[239]. Both surveys show significant variations in patient dose across the country for the same CT examination, by factors of 10 to 40, due to differences in scanner design and institutional-specific examination techniques. There consequently still appears to be considerable scope for standardising examination techniques to protect the patient from unnecessary exposure without reduction in image quality.

Patient doses were generally lower by 10-40% in the 2003 survey compared to 1989. Lowering patient dose is possible with adjustments of scan technique, tube current and filtration factors, alterations in pitch, and image reconstruction parameters.[45,97,132] Increased awareness of these dose-reduction techniques has probably led to better-optimised scan protocols being used in the later survey. Automatic tube current modulation according to the thickness and density of the part of the patient being scanned, is also helping to reduce doses in the latest CT scanners.

12.2 Patient doses from head CT (2007)

Specific dosimetry techniques and dose quantities have been developed for measuring patient radiation exposure. To relate the exposures to the risk of radiation-induced cancer (or deleterious hereditary effects), an estimate of the absorbed dose to a number of radiosensitive organs or tissues in the body is required.

The absorbed dose to an organ or tissue dose, usually expressed in milligray (mGy), reflects the energy deposited by X-rays per gram of irradiated body tissue, averaged over the particular organ or tissue.

The effective dose, usually expressed in millisieverts (mSv), is a calculated weighted sum of organ doses that takes into account organ differences in radio-sensitivity and is a useful comparative index related to the total radiation-induced cancer risks from varying radiological procedures.

The latest UK CT patient dose survey[239] shows the typical effective dose from a routine head CT examination on adults to be 1.5 mSv. This remains much the same for examinations on 10 year old and 5 year old children but rises to about 2.5 mSv for examinations on babies (0-1 years old). In comparison to conventional X-ray examinations of the skull with a typical effective dose of 0.06 mSv[112], CT head examinations involve about 25 times more radiation exposure. In the 1998 UK survey, the eyes, thyroid and breasts typically received doses of about 50 mGy, 2 mGy and 0.03 mGy,

respectively, from a head CT scan.[241] Since the effective dose for a CT head scan has come down by about 20% between the 1989 and 2003 surveys, these organ doses have probably seen a similar reduction.

For comparison, the average natural background radiation level in the UK gives rise to an annual effective dose of 2.2 mSv, with regional averages ranging from 1.5 mSv to 7.5 mSv per year.

12.3 Patient doses from cervical spine CT (2007)

A small proportion of patients is currently deemed suitable for CT examination of the cervical spine, usually carried out in conjunction with CT of the head. Unfortunately cervical spine scans were not included in the 2003 patient dose survey but the mean value for the effective dose on adult patients receiving CT of the cervical spine in the 1989 UK national survey [241] was 2.6 mSv. This compares to 1.8 mSv for CT of the head alone in the 1989 survey. The effective dose for cervical spine CT is higher because the thyroid is directly irradiated (mean thyroid dose equal to 44 mGy). NRPB models[146] indicate that the effective dose received by children and infants from head and neck CT scans is higher, if the scan parameters are unchanged from those used on adult patients. The increase amounts to a factor of 2.3 for newborns, a factor of 1.5 for 5 year olds and a factor of 1.2 for 10 year olds. These factors emphasise the need to match the scan parameters to the size of the patient. The doses involved for all age groups may now be smaller due to increased awareness of this need and the introduction of multislice helical CT, as has been seen for CT head scans.

12.4 Summary of effective doses from CT and conventional X-ray examinations of the head and cervical spine (2007)

A summary of estimates of the effective doses received by adults, children and infants from CT and conventional radiographic examinations of the head and cervical spine are detailed in Table 9.1 below. The estimates for CT head examinations are based on the 2003 survey[241] and reflect UK practice at that time for selecting CT scan parameters for adult and paediatric patients. The estimates for CT cervical spine examinations are based on the 1989 survey for adult patients and paediatric enhancement factors that assume that the same CT technique parameters are used for children and adults (which has been common practice until recently). They consequently are likely to overestimate patient doses from current practice.

The estimates for conventional radiographic examinations are based on typical effective doses for adults in a further NRPB survey.[112]

Effective doses for children from these radiographic examinations have been assumed to be the same as those for adults, since the technique parameters are usually adapted to the size of the patient.

Table 22: Effective radiation doses for different imaging techniques by age group

	Effective dose (mSv)			
	Head		**Cervical spine**	
Patient Age (y)	Radiographs[(a)]	CT	Radiographs[(b)]	CT
0-1	0.06	2.5	0.07	6.0
5	0.06	1.5	0.07	3.9
10	0.06	1.6	0.07	3.1
Adult	0.06	1.5	0.07	2.6

(a) assumes 1 PA + 1 AP + 1 lateral radiograph per examination
(b) assumes 1 AP + 1 lateral radiograph per examination

12.5 Cancer risks (2007)

The risk of radiation-induced malignancies from a single CT exposure is difficult to assess. There have been no published epidemiological studies of increased incidence of cancer among CT exposed patients. Current estimates of the risks from medical X-rays are based on the long term follow-up of populations exposed to large doses of radiation.[278] The 1990 recommendations of the International Commission on Radiological Protection (ICRP) report a nominal probability coefficient of 5% per Sv effective dose for the lifetime risk of fatal cancer in a population of all ages and both sexes exposed to radiation at the relatively low doses used in CT examinations. [131]

The lifetime fatal cancer risk will vary with age at exposure and sex and the way that it does so varies from organ to organ. As a rough guide, assuming uniform whole body irradiation, the NRPB estimates that the lifetime risk for radiation-induced cancer per unit dose is about twice as high in children (0-15 years old) than in adults (20-60 years old).[186] This would put the lifetime risk of fatal cancer following exposures in childhood at about 10% per Sv effective dose, compared to about 5% per Sv for exposures to adults between 20 and 60 years old. The risks drop dramatically at ages above 60 years due mostly to the reduced lifetime available in which these delayed effects of radiation can occur.

More specifically, Brenner et al estimated that the lifetime cancer mortality risks from CT examinations on a one-year-old child are approximately an order of magnitude higher than the risks for CT-scanned adults.[33] This is due to both an increased dose for children having CT scans in the USA at the time (2001) compared to adults, and an estimated increase in risk per unit dose of about a factor of 3 for a one year old child. While this paper calculates a projected 500 additional cancer deaths per year in the USA from the number of paediatric CT examinations performed in 2001, this only represents a 0.35% increase in the background cancer death rate.

In summary, the best available evidence suggests that paediatric CT will result in increased lifetime risks of cancer compared to adult CT due to both the higher radiation doses currently delivered to children and their increased sensitivity to radiation-induced cancer over a longer life span.

12.6 Radiation exposure management (2003)

115. In line with good radiation exposure practice, make every effort to minimise radiation dose during imaging of the head and cervical spine, while ensuring that image quality and coverage is sufficient to achieve an adequate diagnostic study. [2003]

In spite of the potential risks of increased radiation exposure as a result of these guidelines, the consensus opinion of the Guideline Development Group is that this is justified by the increased effectiveness in identifying and managing patients with significant brain injuries. [2003]

These recommendations are based on level five evidence and are considered to be grade D recommendations.

13 Economic evaluation

13.1 Introduction (2003)

The explicit use of economic evaluation in clinical guideline development is a recent but international phenomenon. In the USA, the Committee on Clinical Practice Guidelines has recommended that every clinical guideline include cost information for alternative patient management strategies.[49] In the UK, the remit of NICE is to produce national clinical guidelines that address cost effectiveness as well as clinical effectiveness.

The reasoning behind the application of economic criteria to clinical guidelines is that no health system anywhere in the world has enough resources to provide every potentially beneficial preventative, diagnostic, curative and palliative procedure. Therefore, there is a need to re-deploy resources to those procedures where the potential health gain is greatest. This requires abandoning practices that are relatively poor value for money.

There is a well-developed methodological literature for assessing the relative cost effectiveness (value for money) of different healthcare procedures.[72,180,281] There is still some debate over some of the specific methods of economic evaluation in healthcare but essentially there are six steps to evaluating the relative efficiency of any procedure.

1. Identify the target group (for example, patients attending emergency departments with GCS greater than 12), the procedure to be evaluated (for example, head CT scanning) and its alternative strategy (for example, skull X-ray).
2. Identify all the important health and resource outcomes that are likely to differ between the procedure and its alternative.
3. Measure the differences in identified health and resource outcomes.
4. Estimate the value of the health gain and the value of the resource use. (Resource use is valued in terms of its monetary value, its economic cost. Health gain is sometimes valued in monetary terms but more often a non-pecuniary measure such as the quality-adjusted life-year, QALY, is used).
5. Estimate the ratio of net health gain to net resource cost (for example, the cost per QALY gained) and compare this with the ratios estimated for other commonly used health programmes to assess its relative efficiency. The estimation of net health gain and net cost requires some kind of model (such as a decision analysis) to combine probability and outcome information.
6. Consider the robustness of the cost-effectiveness estimate in terms of statistical precision and generalisability to other settings.

Ideally one would repeat each of these steps for each procedure considered within the guideline (and within each procedure, for each relevant patient subgroup). This would allow us to see for which group of patients the procedure is good value for money. In practice we are limited by the availability of data.

13.2 Methods (2003)

The guideline development group identified two main areas where the potential impact of alternative strategies could be substantial.

- Diagnosis of life-threatening important brain injuries in patients with minor head injury
- Identifying cervical spine damage in patients with head injury.

A third area, identification of patients most likely to experience long term sequelae, was also considered for economic evaluation. However, the lack of satisfactory clinical decision rules in this area means that this area remains an issue only on the research agenda at this time.

UPDATE 2007:

For both of the identified areas, a review of the literature was conducted followed by simple economic modelling of the cost effectiveness in England and Wales of different strategies. The costs in these models were updated to 2005-6 prices for the 2007 update and the evidence summaries were modified accordingly.

A full literature review for the rehabilitation question was not conducted during the 2007 update either. The list of the relevant papers retrieved can be found in 10.12.3.

A fourth area was added during the 2007 update – the issue of which patients can bypass the nearest emergency department and go straight to a neurosciences centre from the scene of injury – see 13.6.

13.2.1 Literature review

Using the same search strategy as for the main systematic reviews but with an additional filter to locate costing information, a search (Appendix 1) was performed of:

- Medline (PubMED)
- Embase
- Health Economic Evaluations Database (HHED) - http://www.ohe-heed.com.
- NHS Economic Evaluations Database (NHS EED) - http://nhscrd.york.ac.uk/nhsdhp.htm.

These strategies were designed to find any economic study related to head injury. Abstracts and database reviews of papers found were reviewed by the health economist and were discarded if they appeared not to contain any economic data or if the focus of the paper was not imaging after trauma. Relevant references in the bibliographies of reviewed papers were also identified and reviewed.

13.2.2 Modelling of cost effectiveness – intracranial haematoma

A cost analysis was performed for the use of CT scanning on patients who have minor/mild head injury (that is, GCS greater than 12) but some loss of consciousness or amnesia at the time of the impact or thereafter. The reason for selecting this group is that it is assumed that those patients with a more significant loss of consciousness receive CT scanning automatically or are referred to neurosurgery. It is assumed that those who do not experience loss of consciousness or amnesia will not receive CT scanning. These assumptions mirror the methods used to derive the Canadian CT-head rule.

Four alternative strategies were selected for the model (Table 23). The first is an approximation of the current (pre-2003) UK system, based on skull X-ray for patients who have experienced loss of consciousness or amnesia. The second and third are the Canadian head rules, which avoid skull X-ray, but allow greater access to CT scanning. Patients with a negative CT scan would be discharged. The fourth strategy is comprehensive scanning and admission of all patients, essentially what happens in the US system.

Table 23: Description of different strategies for the target group

	Indications for test		
	Skull X-ray	24 hour admission	CT
Current (pre-2003) UK system[187]	All	headache, vomiting or other neurological indication	skull fracture or deterioration in 24 hours
Canadian CT Head 5-rule[258]	None	+ve CT scan	suspected fracture (open, depressed, basal), age greater than or equal to 65 years, GCS of 13 or 14 at 2 hours, 2 or more vomiting episodes
Canadian CT Head 7-rule[258]	None	+ve CT scan	As for 5-rule but also CT if pre-impact amnesia greater than 30mins or dangerous mechanism
4. US system	None	All	All

The cost per patient for each strategy was calculated on the basis of the expected usage of skull X-ray, head CT scan and 24 hour observation. It was not possible to quantify differences in health outcomes and other cost outcomes (Table 24, outcomes 4-10).

Table 24: Health and resource consequences of Canadian CT head rule versus current (pre-2003) UK system

Outcome	Net social effect
Definite or likely outcomes	
1. Reduced use of skull X-ray	+ve
2. Increased use of CT scanning	-ve
3. Reduced inpatient stay	+ve
Possible outcomes	
4. Improved neurosurgical outcomes	+ve
5. Increased incidence of cancer as a result of increased radiation exposure	-ve
6. Change in health service resource use as a result of 4 and 5.	+ve/-ve
7. Change in patient/family resource use as a result of 3	+ve/-ve
8. Change in patient/family resource use as a result of 4 and 5	+ve/-ve
9. Reduction in litigation costs	+ve
10. Change in primary care use as a result of 3, 4 and 5	+ve/-ve

Note: Any increase in resource use has a negative effect for society because those resources can't then be used for some other beneficial purpose.

Usage figures were derived from Nee et al [187] for the current (pre-2003) UK system and from Stiell et al [258] for the Canadian rules (Table 25). For the US model, usage was determined by the model definition.

Table 25: Proportion of target group receiving each test

	Proportion of target group		
	Skull X-ray	24 hour admission	CT
1. Current (pre-2003) UK system[187]	100%	26% (24%, 27%)	4% (3%, 5%)
2. Canadian CT Head 5-rule[258]	0%	9%[(a)] (8%, 10%)	32% (30%, 34%)
3. Canadian CT Head 7-rule[258]	0%	9%[(a)] (8%, 10%)	54% (52%, 56%)
4. US system	0%	100%	100%

(a) Stiell et al{Stiell, 2001 STIELL2001 /id} propose discharging patients that have a negative CT scan, although they are only half way through their validation study, which applies this strategy. This figure is based on their prevalence of complications.

Stiell et al have not yet put their model into practice, therefore the admission rate figure is provisional. For this model it was assumed that only those with a positive CT scan (ICH or other complication) would be admitted. Another problem was that Stiell et al had already excluded patients without any loss of consciousness or amnesia, whereas the UK paper had not. This problem was tackled by assuming that patients in the UK study who were discharged without a skull X-ray or CT scan were also very low risk (that is, had no loss of consciousness or amnesia).

13.2.3 Modelling of cost effectiveness – cervical spine injuries

We compared the cost of the two alternative strategies identified as being derived using relatively high quality methods:

- NEXUS study rule [121]
- Canadian cervical spine rule [259]

These systems evaluate all patients with head trauma, the same cohort as for the intracranial haematoma model.

The expected cost for each strategy was calculated on the basis of the expected usage of cervical spine X-ray, and cervical spine CT scan. It was not possible to quantify differences in health outcomes and other cost outcomes (Table 26, outcomes 3-8). Usage figures were derived from the original studies. In the case of the Canadian cervical spine rule, there has not been a validation study hence the figures are from the original derivation study. It was assumed that, for both strategies, 39% of X-rays are inadequate [121] and that these are followed up with a CT scan.

Table 26: Outcomes from cervical spine scanning

1. Use of cervical spine X-ray
2. Use of cervical spine CT scanning
3. Number of surgical interventions resulting from detection of fractures
4. Incidence of paralysis
5. Incidence of cancer as a result of radiation exposure
6. Change in health service resource use as a result of 4 and 5.
7. Change in patient/family resource use as a result of 4 and 5
8. Change in litigation costs

13.2.4 Unit costs

Average unit costs for X-ray, CT scan and 24 hour observation were taken from the NHS Reference Costs 2005-6.[62] A unit cost of 24-hour observation was estimated approximately using the median cost of an excess bed day for a 'Head injury without significant brain injury: uncomplicated'.

Table 27: Unit cost estimates for the UK NHS (updated in 2007)

	Cost per patient tested (2005-6 UK£):[(a)]		
	Lower	Mid	Upper
X-ray	15	19	23
CT scan	62	77	100
24 hour observation[(b)]	183	224	277

(a) NHS Reference costs 2005-6[59,62] 25th, 50th and 75th centiles. Costs include staff time, equipment cost and consumable cost and overheads.

(b) Cost per day of an inpatient stay for a 'Head injury without significant brain injury: uncomplicated' (n=1563 excess bed days).

The NHS reference cost database contains accounting cost data from every NHS hospital trust. Each trust reports an average cost per hospital episode, categorised by type of visit (for example, out-patient, elective in-patient, etc) clinical specialty and Healthcare Resource Group (HRG). Accounting practices do vary between hospitals but the costs should reflect the full cost of the service (including direct, indirect and overhead costs), as described in the NHS Costing Manual.

Sensitivity analyses were conducted to test the sensitivity of the results to the model parameters:

- for the unit costs, the inter-quartile range was used,
- for the probabilities, the confidence intervals were used.

13.3 Diagnosis of intracranial haematoma in patients with a minor/mild head injury (2003)

CT represents the gold standard in the diagnosis of intracranial haematoma following head injury. However, the number of CT scanners and trained staff in the NHS is limited and the cost of testing substantial. Therefore CT scanning in the NHS is currently restricted mainly to those with significant loss of consciousness (either on arrival or after deterioration) and those with a skull fracture, as diagnosed through skull X-ray. The question arises as to whether CT scanning would be cost effective (that is, value for money) if extended to a larger group of patients.

13.3.1 Literature review

Six studies have evaluated the overall impact of different diagnostic testing strategies for patients with minor/mild head injury. The UK studies date back to the early 1980s (pre-CT scanning) and advocate that both skull X-ray and in-patient observation be reduced to save costs.[166,222,223]

Three overseas studies have compared CT scanning with alternative strategies. Ingebrigtsen and Romner [129] found that in-patient observation was not necessary with CT. Therefore CT screening was less costly than skull X-ray screening in Norway because it reduced in-patient stays. Shackford et al [235] and Stein et al [251] had already come to the same conclusion for the USA. However, Stein et al also considered the potential use of X-ray screening without in-patient observation and not surprisingly found this to be the least costly strategy.

Essentially all three studies have concluded that a system of CT scanning high risk patients followed by discharge after a negative CT scan is less costly than skull X-ray and admission for all of these

patients. However, this comparison is not strictly relevant to the context of England and Wales because the current system does not admit all patients.

The published evidence from the six studies is not ideal because:

- the resource use and cost for CT scanning is not specific to the UK NHS context or is dated; and
- they have sought to quantify and cost outcomes 1-3 only. For example, the studies did not measure the cost savings and health gain associated with early diagnosis. Stein et al suggested that for those patients who are not diagnosed early there are lost wages and increased costs relating to in-patient stay, rehabilitation, treatment, medication and orthotic devices.

Additional evidence retrieved in 2007 can be found below in 13.3.7.

13.3.2 Cost-effectiveness model – imaging of the head

Using the unit costs and frequencies of testing, the cost per patient of each strategy is shown in Table Table 28. The least cost strategy is the 5-point Canadian CT Head rule. Although the cost of CT scanning is higher than for the current (pre-2003) UK system, the extra cost is more than offset by the reduction in skull X-rays and admissions.

Table 28: Cost per patient for each strategy

	Component costs (£)			Total cost (£)
	Skull X-ray	24 hour admission	CT	
1. Current (pre-2003) UK system	19	57	3	79
2. Canadian CT Head five point rule	0	20	25	45
3. Canadian CT Head seven point rule	0	20	42	62
4. US system	0	224	77	301

Both Canadian rules could save the NHS money. It would require investment in additional CT scanning facilities but these costs would, be offset by the freeing up of ward space and X-ray capacity.

These results were largely insensitive to the unit costs and probabilities used (Table 29). Only when both costs and probabilities were set to favour the current (pre-2003) UK system was the Canadian seven point rule more costly.

Table 29: Sensitivity analysis for head CT scanning rules

	Additional cost per patient (£) - Canadian seven point rule compared with current (pre-2003) UK system
Baseline	-17.72
Sensitivity to unit costs*	-38.05, 4.62
Sensitivity to proportion of patients scanned**	-25.55, -9.89
Sensitivity to both unit costs and proportions	-46.89, 11.96

(a) Lower limit: High skull X-ray cost, High admission cost, Low CT cost. Upper limit: Low skull X-ray cost, Low admission cost, High CT cost (see table 11.5)

(b) Lower limit: using confidence limits that favour the Canadian seven point rule. Upper limit: using confidence limits that favour the UK system (see Table 11.3).

This cost analysis was limited because the frequency of testing and admission for each strategy could only be estimated approximately given the currently available data. The Canadian head rule is less costly than the current (pre-2003) UK system because it is assumed that it reduces the number of admissions. In fact Stiell et al [258] have not yet put their model into practice, therefore the admission rate figure is provisional. For this model it was assumed that only those with a positive CT scan (ICH or other complication) would be admitted. If the number of admissions were somewhat higher then this strategy would not be the least cost strategy. Assuming all other parameters in the model remain the same, the five point Canadian head rule is least cost if it reduces in-patient admissions by at least 37%. The seven point Canadian head rule appears to be more expensive even if admissions were entirely eliminated.

Another model parameter which was estimated very approximately was the level of CT use in the current system, because CT scanning use was lower during the Nee et al (1993) study than in the present UK system.

The sensitivity of the results to these particular assumptions is presented in a two-way sensitivity analysis (Table 30).

Table 30: Additional cost per patient (£) - Canadian seven point rule compared with current (pre-2003) UK system - two-way sensitivity analysis. (Updated 2007)

Reduction in admissions	CT Scanning rate in current (pre-2003) UK system							
	0%	2.5%	5%[(a)]	10%	20%	40%	60%	80%
0%	22.82	20.89	18.97	15.12	7.42	-7.98	-23.38	-38.78
2.5%	21.39	19.46	17.54	13.69	5.99	-9.41	-24.81	-40.21
5%	19.96	18.04	16.11	12.26	4.56	-10.84	-26.24	-41.64
10%	17.10	15.18	13.25	9.40	1.70	-13.70	-29.10	-44.50
20%	11.39	9.47	7.54	3.69	-4.01	-19.41	-34.81	-50.21
40%	-0.03	-1.96	-3.88	-7.73	-15.43	-30.83	-46.23	-61.63
60%[(a)]	-11.46	-13.38	-15.31	-19.16	-26.86	-42.26	-57.66	-73.06
80%	-22.88	-24.81	-26.73	-30.58	-38.28	-53.68	-69.08	-84.48

(a) This scenario most closely approximates to the model's base case

Another problem was that the study that presented data on the Canadian rules had already excluded patients without loss of consciousness or amnesia, whereas the UK paper had not – this problem was tackled by assuming that patients who were discharged did not receive a skull X-ray. Furthermore the analysis did not include outcomes 4-10 from Table 24.

Evidence retrieved in 2007 provides real data on the impact of the Canadian head CT rule on the NHS - see below in 13.3.3.

13.3.3 Health outcomes

4 and 5, see Table 24

A strategy that increases NHS costs would be economically justified if there were associated health gains. Intuitively, we might expect surgical outcomes to improve if intracranial haematomas (ICHs) are detected earlier. There is no direct evidence that a strategy of CT scanning can improve neurosurgical outcomes although there is some evidence that outcomes have been improved in patients with more serious head injuries.[215]

UPDATE 2007:

However, there is cohort study evidence suggesting reduced mortality associated with prompt surgery.[167,232] A paper retrieved during the 2007 update[253] had estimated the quality-adjusted life-years (QALYs) gained from prompt surgery by comparing the recovery and mortality rates in different case series (see 13.3.7 below).

Any health gains associated with detection could be partially offset by increased cancer risk. There is no direct evidence that exposure to medical X-rays does increase the incidence of cancer, however, there is a general association between radiation and genetic mutation and it is clear that the exposure level is considerably higher with CT scanning than with skull X-ray (see Chapter 9).

13.3.4 Other health service costs

6, see Table 24

The change in health outcomes just mentioned would lead to considerable changes in health service resource use for the particular patients affected. However in both cases the net change in health service costs could go up or down. For example, if an improvement in neurosurgical outcome leads to more patients surviving but those that survive require long term care for chronic brain injury then costs would increase. Alternatively if both mortality and disability were reduced then long term costs are likely to be reduced. However, whichever direction the change is in, the average change in costs per patient scanned is likely to be small given the low likelihood of a change in health outcome.

13.3.5 Patient costs

7 and 8, see Table 24

The costs (time, lost income, medication purchased, etc) to patients and their families associated with changes in health outcome could be considerable. As with health service costs we could not be certain what the net effect would be for the family. Again when averaged across all patients these cost changes could be quite small because the incidence of these changes in outcomes will be small.

There may be substantial costs associated with the decision to admit but these are likely to differ according to the situation of the family. For example, if a parent is admitted then there might be a need for child-minders but on the other hand the act of regular observation at home is costly in itself and families might find it easier if this burden were undertaken by the hospital.

13.3.6 Litigation costs

9, see Table 24

It has been suggested that litigation might be reduced if more patients were scanned. However, Bramley et al [32] have estimated that only one in 10,000 patients subsequently turn out to have an

intracranial haematoma after being discharged without a CT. Therefore the potential costs saved per patient screened are likely to be small. It should also be born in mind that successful litigation usually arises out of organisations not abiding by guidelines.

13.3.7 Update 2007

We found three new studies that evaluated diagnostic tools: a decision analysis[3] and an RCT[191] were comparing admission with CT scanning, and a case series[88] was evaluating the use of head MRI as an addition to CT.

A further three new studies evaluated diagnostic decision rules. We found two studies evaluating the implementation of the head CT rule recommended in the original edition of this guideline. A third study compared the Canadian Head CT Rule with various imaging strategies.

A decision analysis[3] compared CT scanning (and discharge after a negative scan) with admission in head injury patients with a GCS of 15 (mild head injury). They found the CT strategy to be cost saving compared with admission. The same team confirmed the results of this study with a randomised controlled trial of 2600 mild head injury patients.[191] Outcomes were followed up for three months. There were no differences in clinical outcomes (survival and extended Glasgow Outcome scale GOS) but costs were £133 less per patient in the CT arm.

A retrospective case series of 40 patients[88] was used to evaluate the addition of an MRI to CT scanning in patients with traumatic brain injury. The number of lesions diagnosed by CT but not by MRI was 9 out of 40, while the lesions detected by MRI but not by CT were 24 out of 40. The addition of MRI cost more than £1,500 in additional charges per extra lesion diagnosed. However the identification of the additional lesions did not lead to a change in the treatment path and therefore the addition of MRI to CT was neither effective nor cost effective. However, the cohort was small for estimating the effectiveness with any precision.

A UK cohort study[116] evaluated the consequences of implementing the NICE guideline. The X-ray and admission-based practice was replaced with the Canadian CT head rule. Cases of head injury were followed up in a regional neurosciences hospital and in a district general hospital for one month, six months before and for one month after the guideline implementation. In the case of the neurosciences hospital the cost per patient was reduced by £34 and it was reduced by £3 per patient at the general hospital. In contrast in a similar cohort study[238] of 992 patients, costs were found to increase by £77 per patient. Table 1 shows the resource use observed in both studies compared with the predictions in the original edition of this guideline. The evidence from the cohorts suggests that compared with our predictions there was a more modest increase in CT and a more modest decrease in X-ray.

The variation in impact between centres could be due to a number of factors including variation in the baseline position and completeness of adherence to the NICE guideline in the after period of the studies. In the centre that showed an increase in cost, X-rays were very low in number to start with and therefore there was less scope for cost savings; furthermore admissions had inexplicably increased slightly compared with the reductions seen at the other centres. The large amount of variation between centres means that the impact of our recommendations at a national level remains uncertain.

Table 31: Resource use before and after implementation of NICE head CT rule

	NCC-AC2003		Shravat2006	
	Model		DGH	
	Before	After	Before	After
CT	2%	29%	2%	8%
SXR	54%	0%	11%	0%
admission	14%	4%	8%	9%
	Hassan2005		Hassan2005	
	Neurosciences		DGH	
	Before	After	Before	After
CT	3%	18%	1%	9%
SXR	37%	4%	19%	1%
admission	9%	4%	7%	5%

One of the centres in the Hassan study[116] had modified the protocol so that elderly patients with a GCS of 15 seen out of hours could be admitted instead of getting urgent CT. The reasoning involves a combination of factors: a) the cost of out-of-hours radiology was relatively high, b) the elderly represent quite a large group and there are often difficulties in trying to discharge them over night. Hence, the modification is lower cost since out-of-hors radiology is avoided and most would need admission anyway. We don't have evidence of effectiveness for this specific patient group but the randomised evidence for the general population showed no difference in outcomes between observation and CT scan.[191] The GDG agreed that this was an acceptable deviation from the head rule and the guideline recommendations were modified accordingly.

A decision analysis[253]compared the Canadian head CT rule with several strategies including 'CT all', 'admit all', 'discharge all' and 'X-ray all' in a US context. Quality-adjusted life-years (QALYs) and costs were estimated for both prompt and delayed surgery by comparing the mortality and recovery rates in different case series. The Canadian rule dominated the other strategies, that is to say it gave the highest number of QALYs and the lowest cost. However, the study did not evaluate the earlier UK guidelines based on skull X-ray and admission. The CT all strategy was just as clinically effective but more costly. The results were sensitive to the probability that prompt surgery leads to a good outcome.

13.4 Identifying cervical spine damage in patients with head injury (2003)

Table 27 identifies the resource and health outcomes that could differ between different diagnostic strategies.

13.4.1 Literature review

There are three cost-effectiveness studies in this area:

- Kaneriya et al [138] estimated that five view X-ray could save $24 per patient scanned compared with three-view because it reduced the number of subsequent CTs associated with inadequate X-rays by 48%.
- Tan et al [265] estimated the cost effectiveness of CT scan after inadequate X-ray. They found a cost of $16,900 per potentially (or definitely) unstable fracture and $50,600 per definitely unstable fracture. This is cost effective given the consequences of paralysis.

- Blackmore et al [26], using test sensitivities pooled from the published literature, compared CT scanning of the cervical spine with conventional cervical spine X-ray. Using their own risk rating scale, they found CT scanning to be a cost-effective strategy ($16,000 per quality-adjusted life-year gained) for the 'high' and 'moderate' risk groups (high energy mechanism and age under 50 or moderate energy mechanism and age greater than 50) but not for the low risk group ($84,000 per QALY gained). Unlike the other studies, incorporated into these figures are the costs and morbidity associated with paralysis.
- In addition, two more studies estimated the costs that could be saved by moving from current practice at a particular institution to a particular scanning protocol.[15,121]

The above studies are not strictly relevant to the context of England and Wales, not least because the unit costs and the patient groups used in the studies are not from the UK. Furthermore they only attempted to include outcomes 1 and 2 (and in the case of Blackmore et al 4 and 6 as well) and crucially do not address the long term effects of medical radiation, which are likely to be greater in CT scanning of the neck than in CT scanning of the head (see Chapter 9).

The Blackmore analysis suggests for a patient group that is at particularly high risk of paralysis, cervical spine CT could be preferable to X-ray by both improving health outcomes and lowering costs. However, they do not take into account the impact of the large radiation dose received by the thyroid from a cervical spine CT scan. This would be very difficult to model given the lack of empirical evidence on the long term effects of this medical radiation. It was the consensus of the Guideline Development Group that the benefits from CT scanning of the cervical spine do not obviously outweigh the risks.

In light of the review of new clinical and cost-effectiveness evidence, the GDG modified its position to recommend CT scanning in high risk patients. Additional cost-effectiveness evidence retrieved in 2007 can be found below in 13.4.3.

13.4.2 Cost-effectiveness model – imaging of the cervical spine

We conducted our own tentative cost analysis comparing the NEXUS and the Canadian cervical spine rules. We estimated that the Canadian rule could save about £14 per patient (Table 11.10).

Table 32: Comparison of the Canadian and NEXUS cervical spine rules (Updated 2007)

Strategy	Proportion of patients receiving test		Cost of testing (£) per patient		
	X-ray	CT	X-ray	CT	Total
Canadian	58.2%	22.8%	11.05	17.53	28.58
NEXUS	87.4%	34.2%	16.60	26.31	42.91
Increment					14.33

The assumption that a CT scan will be performed after all inadequate X-rays may over-estimate the actual cost savings; if we omit them then the cost-savings are £4 per patient scanned. Sensitivity ranges are presented in Table 11.11.

Table 33: Sensitivity analysis for cervical spine scanning rules

	Incremental cost per patient (£) of NEXUS rule compared with Canadian cervical spine rule	
	X-ray costs only	X-ray and CT cost
Baseline estimate	5.54	14.33
Sensitivity to unit costs	4.38, 6.71	11.45, 18.12
Sensitivity to proportions tested	5.28, 5.80	13.65, 15.01
Sensitivity to both unit costs and proportions	4.17, 7.02	10.91, 18.95

The Canadian cervical spine rule could save valuable health service resources but it is yet to be validated and if it was found to be less sensitive it might not be the most cost-effective strategy due to the morbidity and high costs associated with paralysis. This cost analysis was limited because of the use of overseas data and the simplified assumptions regarding dealing with inadequate X-rays. Furthermore the analysis did not include outcomes 3-8 from Table 26.

13.4.3 Update 2007

Five new studies were found: a non-randomised controlled trial,[2] two cohort studies,[6,89] a case series[163] and a decision model.[103] One study[89] was evaluating the role of MRI scanning in children, another study [2] was comparing helical CT scanning with X-ray in children, and the rest were comparing CT scanning with X-ray in adults.

A non-RCT [2] compared the costs of helical CT with those of X-ray in a population of 136 children who required cervical spine radiography in addition to cranial CT. The imaging costs including follow-up tests were £100 and £130 respectively for the radiography and CT diagnostic strategies (significance not reported).

A retrospective cohort study [6] based on an adult population of 573 trauma patients undergoing spinal imaging (the proportion with head injury was not reported) compared the costs of helical CT with X-ray. Unlike the non-RCT, this study found the cost of CT was no greater than X-ray (£36 vs £35) due to the staff time involved with CT being substantially less.

In a case series study,[163] 407 adult patients in a trauma centre underwent both X-ray and helical CT (again the proportion with head injury was not reported). The reference standard was represented by two radiologists independently reviewing both the HCT and plain X-ray results together with hospital case notes. The sensitivity yielded by X-ray was 45% while the sensitivity yielded by the helical CT intervention was 98%. The helical CT strategy was more costly than a strategy of helical CT after inadequate X-ray. From their figures, we calculate that this strategy costs an extra £7,300 per fracture detected. Using the model by Blackmore and colleagues,[26] as follows, we can see that this is highly cost effective. The model estimated that 5% of fractures would lead to paralysis and that paralysis is associated with 16 QALYs lost. Hence £7,300 per fracture detected would translate to only £9,125 per QALY gained and that is without taking in to account the considerable cost savings from averting paralysis.

The decision analysis of helical CT vs X-ray of the cervical spine in patients undergoing cranial CT for head injury by Grogan et al[103] was based on an earlier model by Blackmore and colleagues[26] looking at conventional CT vs X-ray. It considered only patients at medium and high risk:

- Focal neuro-deficit or severe head injury or high energy impact, or
- Moderate energy impact and age more than 50.

Helical CT cost an additional £37,000 per paralysis averted in this group. This would imply that the helical CT strategy is cost saving when the very high cost of treating paralysis is taken into account.

A retrospective cohort study with a historical control published in 2002[89] evaluated a protocol of MRI scanning patients whose cervical spine had not been cleared within 72 hours. The control strategy was not clearly defined. This study was conducted in a specific population of patients consisting of 102 children (age 0 to 17) who were intubated at the time of hospital admission and who remained in the intensive care unit for at least 3 days. Among the 51 patients in the control group, 19 underwent MRI, whereas it was required for 31 patients in the post-protocol group.

The MRI group had reduced hospital charges (£18,000 vs £24,000; significance not reported) attributable to reduced stay in hospital and in intensive care. However, sample variation and a general trend over time towards reduced stay might explain this difference.

13.5 Discussion (2007)

A simple cost model demonstrates that some strategies that increase head CT scanning could potentially reduce costs if patients that have a negative scan are discharged without admission. However, there are health outcomes and some additional changes to resource use that cannot be quantified using currently available data – notably those associated with the impact of radiation exposure.

Table 34(below) summarises the estimated changes in imaging and admission volumes and cost in England and Wales as a result of these guidelines. This is based on Table 34, Table 28 and Table 32 and assumes an incidence of 700,000 head injury attendees to emergency departments per year.

We would like to emphasise the tentativeness of these estimates. There is uncertainty over these figures for a number of reasons. Data were taken from four different sources to estimate the number of scans (currently and with the new system).[121,187,258,259] Various assumptions had to be made to make the denominator of the estimates from these studies comparable. Some of the evidence was not from a UK population. Empirical studies found in the 2007 update (Table 11.9) show great variation between centres and therefore help little to reduce the uncertainty about the numbers of each scan before and after the guideline.

The reduction in skull X-rays is likely to be an overestimate, as some skull X-rays may still have to take place for non-accidental injuries and other reasons. The reduction in in-patient observation is also uncertain. This assumes that clinicians are able to discharge patients who have had a negative CT scan. This will not be the case for patients who have other comorbid traumatic symptoms.

Table 34: Imaging and admission volumes and costs England and Wales associated with different clinical decision rules (updated 2007)

	Number per year (000)			Cost per year (£m)		
	Current (pre-2003)	New (post-2003)	Change	Current (pre-2003)	New (post-2003)	Change
Head						
Skull X-ray	378	0	-378	7.2	0.0	-7.2
Head CT	16	205	189	1.2	15.8	14.6
24-hr Obs	96	33	-63	21.6	7.5	-14.1
Cervical spine						
X-ray	330	220	-110	6.3	4.2	-2.1
CT	129	86	-43*	10.0	6.6	-3.3
All				46.2	34.1	-12.1

Note: Note that the 2003 recommendations should lead to reduced spine imaging generally (including CT), as given here. However the 2007 update should lead to increased CT scanning compared with the 2003 recommendations (figures not given).

The Canadian head CT rule, adopted by the consensus of the Guideline Development Group is expected to reduce costs. There are also likely to be improvements in quality of care. In the short term this will mean fewer patients being diagnosed on 'deterioration', patients getting reassurance sooner rather than later and hopefully improvements in long term outcomes (although this is not based on high quality evidence). If patient outcomes are improved then this in turn might lead to additional cost-savings. It was the decision of the Guideline Development Group that the potential benefits of adopting this rule are likely to outweigh the potential costs.

The NEXUS cervical spine rule and the Royal College of Radiologists guidelines appear to be almost identical. Given this, on the basis of a simple cost model, the adoption of the Canadian cervical spine rule could save valuable health service resources. This rule is yet to be validated, however, and if it was found to be less sensitive it might not be the most cost-effective strategy due to the morbidity and high costs associated with paralysis. On the other hand, the thyroid is known to be susceptible to radiation damage and strategies that reduce the need for radiological examination of the neck may reduce subsequent morbidity and health service cost.

Our simple analyses estimated an additional scanning cost of £17 per head trauma patient associated with adopting the Canadian head CT and a cost saving of £14 associated with adopting the Canadian cervical spine rule. This suggests a combined impact of £31 saved per patient. For England and Wales, assuming an incidence of head injury of around 700,000 cases a year, of which 54% satisfy the criteria for scanning, a modest saving of £12.1m that could be reinvested in the health service would result. However, we should be very cautious about this figure. The longer term impact of changing imaging strategies on health outcomes and health service costs is even less certain. Staff shortages in radiology mean that implementation of these changes could take some time or else use up extra resources. Another reason why these cost savings might not be realised in the short term is that they are likely to require investment in new CT scanning equipment.

It is probable that we have not taken into account fully the implementation costs of the guideline. To some extent this is true, as our remit does not include the details of implementation. For example, we acknowledge that full implementation of the guideline will require staff training, the cost of which we have not been in a position to quantify.

It is also possible that the costs incorporated into our cost analyses do not reflect the real costs of the services. For example, the increased utilisation of CT scanners may necessitate the purchase of additional scanners, although the capital cost of CT scanners should be incorporated into the unit costs that we have used in our cost-effectiveness model. There is also a possibility of the expansion of out of hours practice, which may push up the unit cost of scanning. The shortage of radiology and radiography staff, especially those with appropriate experience in CT scanning of the head, may again mean that the real cost of increasing CT scanning is greater than our calculations would suggest or at least that implementation will have to be delayed.

One issue raised throughout the guideline consensus process was the need for additional staff training at many levels. Achieving this goal, nationally, could require substantial resources, especially when shortages in specialist staff (for example, radiographers) are already constraining the system.[27]

We have suggested a number of reasons in the guideline document why the cost savings we have predicted might not occur. These include:

- in-patient observation may not be reduced despite the increase in CT scanning (evidence since 2003 is mixed – see Table 31);
- cervical spine CT might be quite rare at present and therefore the reductions won't take place;

- some skull X-rays will still have to take place for penetrating injury and other reasons (for example, suspected non-accidental injury);
- we have postulated that the similarity between the NEXUS guidelines and those of the RCR suggests that the NEXUS study represents current practice for cervical spine imaging in the UK. If this is not the case then a move to the Canadian cervical spine rule might not lead to cost savings.

It is clear that the long term morbidity associated with injury to the head and cervical spine and the lack of evidence concerning suitable rehabilitation are a major problem. Not only does it reduce the quality of life for these individuals and their carers but also it places a substantial burden on society in general through time off work and social security payments.[39] Hence the development of effective rehabilitation programmes should be placed high up the research agenda.

The other elements of the guideline are probably more conservative and therefore the overall impact on health service resources is probably small although it remains uncertain.

13.5.1 Conclusions from the 2007 update

A randomised controlled trial has confirmed that to discharge patients with mild head injury (GCS15) after a negative CT scan, as recommended in this guideline, is both safe and cost saving.

The impact of the Canadian CT rule as advocated in the original edition of this guideline has varied considerably but reassuringly in some centres it has reduced costs. A published model that took into account long term treatment costs and health consequences indicated that the Canadian head CT rule is more cost effective than a number of alternative strategies based on CT, X-ray or admission. However, none of the evidence has taken into account the impact of the increased radiation exposure.

Updating the costs to 2005-6 prices makes the Canadian CT head rule even more cost effective, since the cost of imaging has fallen.

A modification of the rule so that elderly patients with a GCS of 15 seen out of hours could be admitted instead of getting urgent CT is a safe strategy and could be cost saving for services where out of hours radiography costs are prohibitively high.

The new studies add to existing evidence, in suggesting that CT scanning of the cervical spine is cost effective in higher risk groups who are already undergoing head CT. However, none of these studies have taken into account the costs and health consequences associated with the increased radiation exposure – it is possible that CT is no longer cost effective when these are taken into account. It is difficult to model the impact of radiation exposure on cost effectiveness since there are a large number of uncertainties: a) the amount of radiation received at different parts of the body, b) the relationship between exposure and cancer, c) the types of cancer caused, d) the pattern of resource use in the diagnosis and treatment of the cancer, and e) the timing of cancer, treatment and death. Another limitation with regard to cervical spine imaging is that all the studies were conducted in the USA; the observed healthcare costs and savings might not be transferable to a UK NHS setting. As the cost of CT scanning, as with most medical care, is lower in the UK, it might lead one if it is cost effective in the USA then it is likely to be cost effective for the NHS. However, the cost savings from paralysis care averted are also likely to be lower.

13.6 Addendum 2007 – Direct transport from injury scene to a specialist neurosciences centre (2007)

13.6.1 Literature review

We did not find any cost-effectiveness evidence for this question but we did find two simulation models, which we will refer to as the London and Staffordshire models. We have reviewed these models in some detail, as follows.

13.6.2 London model

The report[243] summarises the findings of a review conducted by the London Severe Injury Working Group focusing on the Trauma services provided in London, including care, treatment and transfer of severely injured patients. Severe injury was defined as the need for Intensive Care.

The analysis of the current service highlights some key issues:

- high secondary referral rate (two thirds of the severely injured patients group),
- evidence of problems associated with such transfers (adverse clinical events during transfer, delay to definitive intervention, low level of staff and standard of care), and
- difficulties for hospitals in transferring patients for specialist care, especially for neurosurgery (stabilisation of patient first, co-ordination between the first hospital and the specialist hospital and consequent long delays).

Methods

A modelling of the flow of trauma patients was carried out to determine the best trauma service configuration for adult trauma patients with severe injury in the London area. The model was designed to estimate the time from injury to:

- Critical Intervention (urgent lifesaving interventions such as intubation); these interventions are crucial for all trauma patients
- Definitive Intervention (specialist interventions such as neurosurgery); these interventions vary according to the site of the trauma

The specific aims of the modelling exercise were to evaluate the effect on time to intervention of:

1. different bypass strategies
2. improving the current system by reducing time taken in pre-hospital and in-hospital trauma management.
3. a doctor in the pre-hospital phase provided by the London Helicopter Emergency Medical Service (HEMS).

The model simulated results based on about 10,000 actual severe injuries from the London region. Of these 33% had isolated head injury and a further 18% had non-isolated head injury.

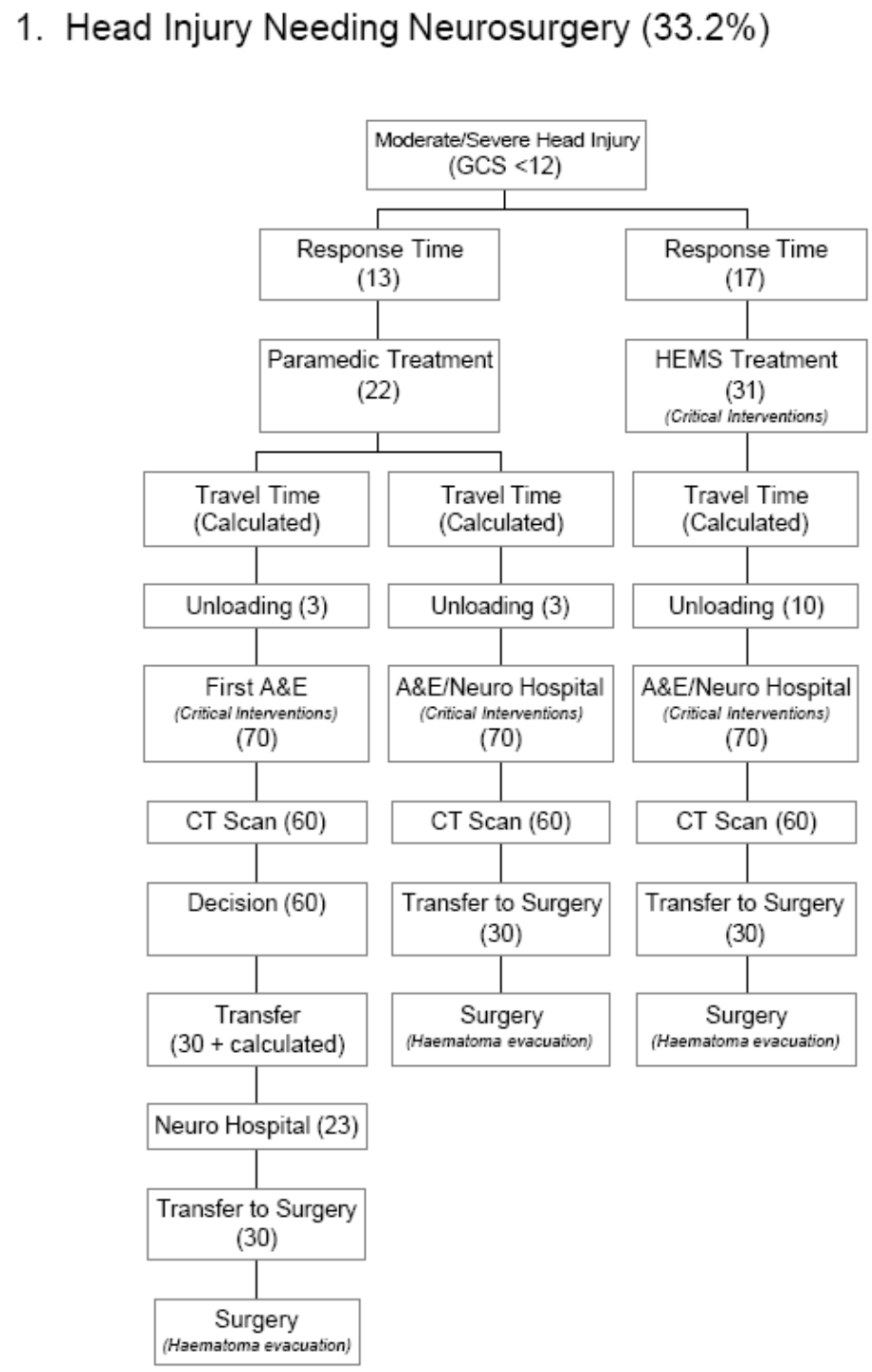
The model estimates time to intervention using flow charts. Figure 1 shows the flowchart for an isolated head injury patient with the average times based on current practice. Similar flowcharts were devised for the different types of trauma. The timings were based on ambulance service records and expert opinion.

For each type of injury, a group of clinical experts decided on a target time for intervention. For head injury, it was considered that it was crucial to carry out neurosurgery within 4 hours of the injury, based on some evidence.[232] For each service configuration scenario, the primary outcomes were:

- the median times to critical and definitive interventions.

- the proportion of patients receiving critical and definitive interventions within the relevant time target.

Figure 6: London Model flowchart for isolated head injury patients (figures in parentheses are average time in minutes)



Notes:
a. The 'Decision' box includes decision, communication, obtaining specialist opinion, finding a bed and arranging the transfer.

Table 35: London Model: Median time (hours) to critical/definitive interventions, by bypass strategy

	Current timings			Timings improved at LAS* & hospitals		
Bypass strategy	none	15	20	none	15	20
critical intervention (minutes)	41	43	45	32	34	36
head injury	4.8	3.7	3.4	3.8	2.9	2.7
head and chest injury	4.9	3.8	3.5	3.9	3.0	2.7
head, chest and orthopaedic injury	6.9	5.9	5.6	6.0	5.2	4.9
chest injury	4.6	3.8	3.4	3.7	3.0	2.7
orthopaedic injury	2.2	2.3	2.3	1.7	1.7	1.7
head and orthopaedic injury	6.8	5.8	5.5	5.8	5.1	4.8
chest and orthopaedic injury	6.7	5.9	5.5	5.7	5.1	4.8
head, chest and abdominal injury	7.0	5.9	5.6	6.0	5.2	4.9
chest and abdominal injury	6.6	5.9	5.5	5.7	5.1	4.8
orthopaedic and abdominal injury	3.2	3.2	3.2	2.5	2.5	2.6
abdominal injury	3.2	3.2	3.2	2.5	2.5	2.6
facial injury	3.8	3.8	3.5	3.0	3.0	2.7
head and facial injury	4.8	3.8	3.5	3.8	3.0	2.7
spinal injury	5.7	4.8	4.4	4.6	4.0	3.6
head and spinal injury	4.8	3.8	3.4	3.8	3.0	2.7
head, orthopaedic and abdominal injury	6.8	5.8	5.5	5.8	5.1	44.8
orthopaedic and vascular injury	6.9	5.9	5.6	5.9	5.2	4.9
traumatic amputation	4.7	3.8	3.5	3.7	3.0	2.7

Note: LAS=London Ambulance Service

Table 36: London Model: Proportion of patients receiving critical/definitive interventions within target time, by bypass strategy

	Current timings			Timings improved at LAS* & hospitals		
Bypass strategy	none	15	20	none	15	20
critical intervention (within 60 minutes)	91%	88%	84%	98%	97%	96%
head injury (within 4hs)	23%	60%	74%	63%	81%	90%
head and chest injury (within 2hs)	0%	0%	0%	2%	4%	5%
head, chest and orthopaedic injury (within 2hs)	0%	0%	0%	0%	0%	0%
chest injury (within 2hs)	0%	0%	1%	3%	6%	8%
orthopaedic injury (within 2hs)	30%	27%	25%	84%	82%	79%
head and orthopaedic injury (within 4hs)	0%	1%	1%	3%	8%	10%
chest and orthopaedic injury (within 2hs)	0%	0%	0%	0%	0%	0%
head, chest and abdominal injury (within	0%	0%	0%	0%	0%	0%

	Current timings			Timings improved at LAS* & hospitals		
2hs)						
chest and abdominal injury (within 2hs)	0%	0%	0%	0%	0%	0%
orthopaedic and abdominal injury (within 2hs)	1%	0%	0%	9%	8%	7%
abdominal injury (within 2hs)	1%	0%	0%	9%	8%	7%
facial injury (within 3hs)	23%	22%	27%	49%	50%	63%
head and facial injury (within 3hs)	9%	22%	27%	19%	50%	63%
spinal injury (within 6hs)	62%	79%	88%	93%	96%	97%
head and spinal injury (within 4hs)	21%	55%	70%	61%	78%	88%
head, orthopaedic and abdominal injury (within 2hs)	0%	0%	0%	0%	0%	0%
orthopaedic and vascular injury (within 4hs)	0%	1%	1%	3%	7%	9%
traumatic amputation (within 4 hs)	30%	55%	70%	66%	78%	87%

Note: LAS=London Ambulance Service

Model Results

Table 35 shows the median time to critical/definitive intervention by type of injury and by bypass strategy used. On the left side of the table the results are based on current timings. On the right hand side the results are based on improved timings. In the case of the isolated head injury patient the median time to neurosurgery is 4.8 hours currently but would fall to 3.4 hours when bypassing patients who are less than 20 minutes from a specialist centre.

Table 36 shows the proportion of patients that receive interventions within the target time. In the case of the isolated head injury patient the number receiving neurosurgery within 4 hours would increase from 23% with no bypass to 74% with bypassing patients who are less than 20 minutes from a specialist centre. However, on the negative side with this bypass strategy only 84% (compared with 91%) would receive critical intervention within 60 minutes. The group that is made worse off by bypass is those patients with isolated orthopaedic injury: only 25% would receive their definitive intervention within their 2 hour target (compared with 30% without bypass).

For the injuries that can be treated in every hospital the most rapid movement to Definitive Intervention was achieved by the models without bypass, and with improvement in hospital times.

For injuries requiring specialist management the best models for providing early Definitive Intervention included 20 minutes bypass, improvement in hospital times and use of the London HEMS.

Report conclusions

The bypass protocol proposed is based on the 20 minutes of distance from a Multi-Specialty Centre, as this time gives the best trade off between longer time to Critical Interventions, and shorter time to Definitive Intervention. However, the best balance between these opposing effects had to be struck by clinical judgement, as little evidence was available.

The report recommended that within a 20 minute drive time of an appropriate specialist unit, a patient should be driven directly to the specialist unit rather than to the local hospital, and that a triage system for London should be gradually introduced, allowing training of pre-hospital personnel and evaluation of the effectiveness of each of the triage criteria. For head injury the initial criterion could be based on GCS and additional criteria could then be added. This would avoid the flooding of Multi-Specialty Centres.

Review

The report has a number of limitations:

- The model, especially the target times, was based more on expert judgement than hard evidence of clinical effectiveness.
- In reality there will be a continuum of risk rather than a time cut-off.
- The model assumes that the specialist hospital has a range of different specialist services in addition to neurosciences.
- The trade off between the need for immediate access to critical interventions (e.g. intubation) and the need for faster access to definitive interventions (e.g. surgery) was made on the basis of expert judgement rather than health outcomes.

13.6.3 Staffordshire model

The link between time and health outcomes missed by the London model was captured to some extent in the Staffordshire model[255].

It evaluated the impact of 10 different transport strategies on survival of patients with serious or worse HI (AIS more than 2). In the model, survival was determined by a number of variables including: a) head AIS score, b) non-head AIS score, c) time to surgery, d) grade of staff during transfer, e) incidence of hypoxia and hypotension, g) distance from hospitals. Some of these variables are patient-specific (a,b,g), some are service-specific (d) and some are determined by the transport strategy (c,e). The data used in the model came from a variety of sources including a large trauma database, the published literature and expert opinion. Monte Carlo simulation (that is repeatedly generating new results by simultaneously drawing at random from the distribution of each model parameter) was used to simulate 10,000 head injury patients and their outcomes under each strategy.

Table 37 shows the results for each strategy. All direct transport strategies had higher expected survival than a strategy of sending all patients to the nearest emergency department but strategies 2-6 were the most effective. Among these strategies, strategy 4 (direct transport of patients with critical head injury, AIS=5) required the least number of patients being diverted to specialist centres. The results were not sensitive to the parameters that were determined by expert opinion.

An important limitation that was acknowledged by the authors was that AIS score is determined after treatment and therefore assessment of patients at the scene of the injury is less accurate. The implication is that the survival gain observed in this model is probably larger than can be achieved in reality, although the pattern should be the same. There are different costs associated with each strategy and therefore a cost-effectiveness analysis is needed to assess which of the 10 strategies is the most cost effective.

In conclusion, the simulation study shows that survival of severe head injury patients could be substantially improved by transporting patients directly from the injury scene to a hospital with a specialist neurosciences centre. Cost effectiveness of these strategies was determined as described in 13.6.4.

13.6.4 Comparison with the London model

The Staffordshire model went a step further than the London model by estimating the impact of different strategies on survival (as well as time) in order to trade off the different outcomes.

Both models rely on evidence combined with expert opinion to estimate the time to intervention. For the Staffordshire model, expert opinion is also used to estimate the survival rates. For the London model, expert opinion is also used to estimate the target times. Thus there must still be uncertainty around the results of both studies as they are not based on hard evidence.

Both research teams recommend bypass if the specialist hospital is ≤20 minutes from the injury scene. The Staffordshire model estimated substantial survival gains from bypass even if the specialist hospital is much further away (53 minutes). There are no obvious contradictions between the two models but the authors of the London report have been more cautious in recommending bypass over longer distances.

Table 37: Stevenson's Transport model - results

Criteria for transporting patients directly to Neurosciences Hospital	Percentage of patients bypassing DGH	Survival gain vs 1) (Neurosciences Hospital far)	Survival gain vs 1) (Neurosciences Hospitla near)
1) None	0%	0.00%	0.00%
2) HI AIS>2	100%	3.40%	4.50%
3) HI AIS>3	78%	3.50%	4.60%
4) HI AIS=5	44%	3.40%	4.30%
5) Non-HI AIS<4	89%	3.30%	4.00%
6) Non-HI AIS<5	95%	3.40%	4.50%
7) Isolated head injury	75%	2.80%	3.60%
8) Intubated pre-hospital	20%	1.70%	1.90%
9): 7) and 8)	5%	1.30%	1.50%
10) Out of hours	40%	1.50%	2.00%

13.6.5 Cost-effectiveness model – Direct transport

We conducted a cost-effectiveness analysis of transporting patients with serious head injury directly from the injury scene to a specialist neurosciences hospital (NSH). This was compared to initially transporting such patients to the nearest emergency department and then later transferring them to the NSH after stabilising the patient.

The following general principles were adhered to:

- The GDG was consulted during the construction and interpretation of the models.
- The sources of data are published studies and expert opinion.
- Model assumptions were reported fully and transparently.
- The results were subject to sensitivity analysis and limitations were discussed.
- We followed the methods of the NICE reference case. Therefore costs were calculated from a health services perspective. Health gain was measured in terms of quality-adjusted life-years (QALYs) gained.

13.6.5.1 General method

The model is represented by a decision tree (Fig.2): once the ambulance crews arrive at the accident scene, the patient can be transported either to the nearest District General Hospital (DGH) or to a

Neurosciences Hospital (NSH). Severe head injury patients initially admitted to the DGH will be subsequently referred to the NSH. Patients that survive will require rehabilitation and frequently some kind of long term care. The number of survivors is different in the different strategies.

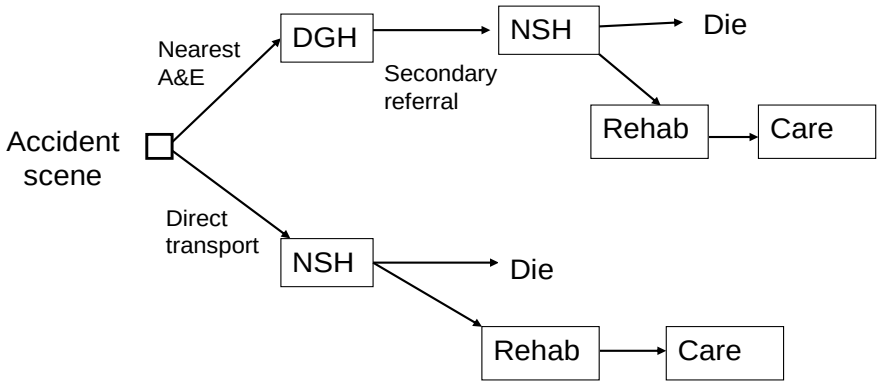
To assess the cost effectiveness of direct transport we need to assess not just changes to ambulance and emergency department costs associated with each strategy but also any changes in rehabilitation and long term care costs arising from the different strategies. These have to be balanced against the health gain.

We could not find evidence of effectiveness that perfectly suits this question. We therefore constructed two similar models based on different empirical studies:

Model A: We based this model on the only study in the clinical literature review that reported both mortality and health status (Glasgow Outcome Scale, GOS) in head injury patients– Poon et al 1991[212]. This study compared a cohort of patients that had been directly transported to NSH to another cohort that were transferred from DGH. This study allows us to estimate both the QALYs gained and the cost savings attributable to improved care status in patients being directly transported. However, there was concern that this study was biased, since case-mix was not properly controlled for. For this reason we developed a more conservative model.

Model B, a conservative model, calculates only the health gain attributable to those patients who survive with direct transport but would not survive with a secondary transfer strategy. The number of these extra survivors is estimated using the results of a decision model that was explicitly answering our question – Stevenson et al 2001[255] (see 13.6.3). Model B does not take into account health gain for patients who survive under both strategies but have an improved health status with the direct transport strategy.

Figure 7: Transport model decision tree



Each model has advantages and limitations (Table 38).

Table 38: Summary of the models

	Description	Advantages	Limitations
Model A	Mortality & GOS: Cohort study - NSH direct vs NSH secondary referral (Poon1991).	Both mortality and health state outcomes considered. Data coming from the same study.	Poon data seems overly optimistic and did not control for case-mix.
Model B	Mortality: Simulation study – NSH direct vs DGH (Stevenson 2001) GOS: retrospective cohort study (Patel 2002).	More conservative and hopefully less biased than Poon data.	Outcomes include only mortality, not differences in health status.

For each strategy in both models, the expected healthcare costs and the expected QALYs were calculated by estimating the costs and QALYs for each GOS state and then multiplying them by the proportion of patients that would be in that state as determined by the strategy taken. Health state defined by the GOS state was assumed to be fixed over the lifetime.

The base case models assume that only patients with serious head injury would be transported. A concern is the ability of ambulance crews to determine the severity of the head injury at the scene. There might be a risk of overestimating the number of severely injured patients and therefore of sending too many patients to the NSH, which would mean that cost-effectiveness is reduced and would be risky for patients with multiple trauma. For this purpose, we conducted a sensitivity analysis on the number of false positives (patients erroneously deemed having a serious head injury) that would be transported to the specialist centre without requiring neurosurgical care.

13.6.5.2 Methods: Effectiveness

In Model A, the mortality rate together with the outcomes were derived from a study by Poon at al [212] in which a group of patients having an extradural haematoma was directly transported to the NSH while another group was only secondarily transferred there (Table Table 39). The mortality and the outcomes were assessed six months after the injury.

Table 39: GOS score and death rate after neurosurgical care in a NSH (Model A)

GOS	% DGH then NSH patients 6 months after injury Poon 1991	% NSH patients 6 months after injury Poon 1991
Good Recovery	49%	86%
Moderate Disability/Severe Disability	27%	10%
Death	24%	4%

The survival gain in Model B was derived from the results of a simulation model by Stevenson et al[255], where the target patient population were adults with a serious head injury (AIS of 3 or more) – see 13.6.3.

The model evaluated 10 different strategies of transporting patients directly to the NSH, which selected patients by different criteria (relating to level of AIS score, presence of multiple injuries, possibility of pre-hospital intubation, out of hours). Directly transporting all serious head injury patients to the NSH led to an estimated increase in survival of 4.5% for injury scenes near to the NSH and 3.4% for more distant injury scenes.

Stevenson et al estimated only mortality and not health status. We assumed that health status in the additional survivors would be similar to the general population of patients with serious head injury

treated in a NSH. We used 6-month GOS data from the surviving patients in a UK study, Patel 2002[206] (Table 40). The study population had all had a severe head injury (GCS 8 or less) and had been treated in a Neurosciences Critical Care Unit.

Table 40: GOS score after neurosurgical care in a NSH (Model B)

GOS	% NSH patients 6 months after injury Patel 2002
Good Recovery	49.6%
Moderate Disability	27.1%
Severe Disability	20.3%
Vegetative State	3.0%

We estimated the health loss associated with false positives. In fact, for these patients the longer the journey from the accident scene to the hospital, the higher is the risk of death from hypotension. In the case of a distant NSH (53 minutes, as reported in Stevenson's model), the mortality increases by 0.05%, while it increases by 0.03% if the NSH is near (20 minutes). These figures derived from the calculation of the probability of death based on clinical estimates (see 13.6.5.7).

13.6.5.3 Methods: Estimating QALYs

For each health state we estimated QALYs (Quality-Adjusted Life Years) by multiplying the discounted life expectancy by the utility score associated with each state. The expected QALYs for each strategy are then estimated by summing up the QALYs for each state weighted by the proportion of patients in that state.

In order to calculate the QALYs we combined data on life expectancy with data on quality of life.

Life expectancy

The life expectancy of patients in a vegetative state (VS) was assumed to be 10 years.[237,260] In the case of a 60 year old patient in a VS, the life expectancy would be shorter and was assumed to be the same as for a patient in the severe disability state (see below).

To calculate the life expectancy for health states other than VS, we applied the standardised mortality rate (SMR), reported for 2,320 traumatic brain injured patients in Shavelle 2001 [236], to the general population of England and Wales, using the Life Tables. According to Shavelle, the SMR decreases during the first 4 years post-injury but remains constant afterwards. In Shavelle 2001 the SMR was distinguished according to three levels of ambulation: a) none, b) some, c) stairs, which we matched approximately to the levels of disability of the GOS (a=SD, b=MD and c=GR).

Life expectancy was discounted at a rate of 3.5% per year, as required by NICE.

For our base case analysis we estimated life expectancy for men aged 40 (the average age of a patient in the Stevenson study). For our sensitivity analysis, we also calculated life-years for patients aged 20 and 60.

Quality of life

The utility scores in Table 41 are a measure of the quality of life associated with each of the health states on a scale from 0 (death) to 1 (perfect health). For the good recovery (GR) outcome, we used the EQ-5D score of 0.83 reported for the United Kingdom population.[147] The other utility scores were taken from a decision analysis, Aoki 1998.[7] The mean utilities for each GOS score were elicited from a sample of 140 subjects with a clinical background using the standard-gamble method. The GOS states

in this study were expressed as the degree of disability due to brain damage caused by subarachnoid haemorrhage.

The Poon et al study (Model A) did not distinguish between patients that were severely disabled (SD) and those that were moderately disabled (MD). For these patients we used the simple average of the two SMRs and the simple average of the two utilities.

Another study was found, Tsauo 1999,[273] which reported the utility scores associated with each GOS score obtained from health professionals in the UK using the standard gamble method. We did not use this study in our base case model for the following reasons:

- scores were presented for a number of time points and there seemed to be inconsistency between the estimates
- the figures were skewed towards high values (i.e. the utility associated with a moderate disability was higher than the average EQ5D utility score for the general population in the UK[147])
- the value for the vegetative state was missing
- the number of the health professionals interviewed for the elicitation of the utility scores was not reported.

Therefore, we used this study only for the purpose of sensitivity analysis.

Table 41: Health Utilities by Glasgow Outcome Scale (GOS) state

GOS	Utility score (base case analysis)	Source	Utility score (sensitivity analysis) Tsauo 1999
Model A			
Good Recovery	0.83	,Kind 1998 (UK general population)	0.931
Moderate Disability/Severe Disability	0.45	Aoki 1998 (mean of two states)	0.788
Death	0		0
Model B			
Good Recovery	0.83	Kind 1998 (average utility in the UK)	0.931
Moderate Disability	0.63	Aoki 1998	0.908
Severe Disability	0.26	Aoki 1998	0.668
Vegetative State	0.08	Aoki 1998	0.08
Death	0		0

In the sensitivity analysis on the assessment at the scene, we assumed that the false positives, if they survive the longer transport, would have had the same expected QALYs as the good recovery (GR) patient.

Calculating QALYs gained

For Model A, the QALYs gained are calculated as follows:

QALYs gained= Q1-Q0

Qi = (PiGR x LEGR x UGR) + (PiD x LED x UD)

where

Qi =the expected QALYs per patient (i=1: with bypass, i=0: without bypass)

PiGR, PiD, = proportion of patients in each of the GOS states at 6 months by strategy (where D is both mild disability and severe disability combined).

LEGR, LED, = the discounted life expectancy of patients by GOS states at 6 months

UGR, UD, = the utility score for each GOS state.

For Model B, the QALYs gained are calculated as follows:

QALYs gained=Qi-Q0= ESi x ((PGR x LEGR x UGR) + (PMD x LEMD x UMD) + (PSD x LESD x USD) + (PVS x LEvs x Uvs))

where

Qi =the expected QALYs per patient associated with bypass strategy i,

Q0 = the expected QALYs per patient associated with no bypass,

ESi = extra survivors=the proportion of patients surviving under strategy i that would not have survived under the no bypass strategy

PGR, PMD, PSD, PVS, = the proportion of extra survivors in each of the GOS states at 6 months

LEGR, LEMD, LESD, LEVS, = the discounted life expectancy of patients by GOS states at 6 months

UGR, UMD, USD, UVS, = the utility score for each GOS state.

13.6.5.4 Methods: Ambulance and emergency department costs

Emergency department costs in our models are the staff costs associated with secondary referral. While the cost of the primary transport to the DGH or to the NSH is similar, an inter-hospital transfer would be more costly than transport from the injury scene because it requires additional staff and tasks. In fact, an anaesthetist and a nurse would always accompany a patient who required urgent transfer, which constitutes 90% of the transfers for head injury. The GDG experts estimated the total cost of the transfer as equal to three-hour time of a nurse and an anaesthetist, given the time necessary to activate a secondary transfer team at the DGH, the time spent in stabilising the patient, and the actual transfer time. Moreover, on arrival at the NSH the patient would need other treatment for complications due to the transfer. With the average cost of a nurse at £19 per hour, and the cost of an anaesthetist (specialist registrar) of £34 per hour;[54] the total cost per patient transferred was estimated to be £159.

The cost of patient management at the emergency department in the two hospitals was not expected to be different, according to the GDG experts' estimates, since the staff grades would not be different.

All the cost figures are expressed in 2006 Pound Sterling. Costs related to previous years were inflated using the Hospital and Community Health Services Prices Index.[54]

We have not calculated transportation and emergency department costs in much detail but would argue that this is not a major flaw since these costs are small compared with the additional rehabilitation and care costs incurred by survivors.

We calculated the increased transport cost associated with false positives, as they will be transported to a more distant hospital. The cost was obtained from the unit cost of an ambulance per minute, £6.50,[54] multiplied by the distance of the accident scene to the hospital, which was 20 minutes (near) or 53 minutes (far) in the simulation study.[255]

13.6.5.5 Methods: Rehabilitation and care costs

We derived the cost of rehabilitation from two UK studies: one, Wood 1999,[286] applicable to the severely disable patients and the other one, Nyein 1999,[193] applicable to the moderately disabled patients (Table 42). The length of rehabilitation for the severely disabled group was 14 months, while it was 75 days for the moderately disabled group. We assumed patients who had a good recovery to undergo the same intensity of rehabilitation as the moderately disabled group, given the fact that the good outcome was assessed six months post-injury. Patients in a vegetative state were assumed not to receive any specific rehabilitative therapy. If any rehabilitation service was provided to them, its cost was assumed to be incorporated in to the cost of long term care.

The same two UK studies were used to calculate the annual care costs (Table 42); in the case of severely disabled patients, the long term care was the community care support required after rehabilitation and it was based on the cost of a support worker. Similarly, the long term annual cost for the moderate disability group was calculated from the weekly cost of care three months after discharge from the rehabilitation. Patients having a good recovery were assumed not to incur any long term costs. Patients in a vegetative state were assumed to have the same annual care costs as those who are in the severe disability state.

Care costs were discounted at a rate of 3.5% per year, as required by NICE.

Table 42: Cost of rehabilitation and long term care

	total cost of rehabilitation	annual care costs
GR	19,575	0
MD	19,575	7,472
SD	108,874	45,450
VS	0	45,450

Thus the model takes into account the increased costs of rehabilitation and care due to people surviving under direct transport, who would not survive under the current system. It could be that costs of neurosurgery and intensive care are also increased if patients are now making it to the NSH who would have died in transit. Since we do not have data on the timing of deaths, we have not included such costs in the base case. However, for a sensitivity analysis we added on the cost of 3 days of level 3 neurosurgical intensive care for each additional survivor. The costs of care in an ICU were calculated from the NHS Reference Costs 2005-2006[62] at £1,338 per day.

Calculating incremental cost

For Model A the incremental cost is calculated as follows:

Incremental cost = CostNSU - CostDGH

CostNSU = (PNSUGR x (RHGR + LEGR x ACCGR))

+ (PNSUD x (RHD + LED x ACCD))

CostDGH = (PDGHGR x (RHGR + (LEGR x ACCGR)))

+(PDGHD x (RHD + (LED x ACCD)))

+ TC

where

CostNSU = the expected cost per patient associated with direct transport to the NSU

CostDGH = the expected cost per patient associated with a secondary referral to the NSU from a DGH

PNSUGR, PNSUD = the proportion of survivors in good recovery or mild/severe disability at 6 months with direct transport to the NSU

PDGHGR, PDGHD = the proportion of survivors in good recovery or mild/severe disability at 6 months with a secondary referral

RHGR, RHD = the cost of rehabilitation by GOS state at 6 months (where D is both mild disability and severe disability combined)

LEGR, LED = the discounted life expectancy of patients by GOS state at 6 months

ACCGR, ACCD = annual care cost by GOS state at 6 months

TC = cost of transport in secondary referral

For Model B the incremental cost is calculated as follows:

Incremental cost = Cost i - Cost 0

= ESi x ((PGR x (RHGR + (LEGR x ACCGR))) + (PMD x (RHMD + (LEMD x ACCMD)))

+(PSD x (RHSD + (LESD x ACCSD))) + (PVS x (RHVS + (LEVS x ACCVS))))

– (TC x PDT)

where

Costi = the expected cost per patient associated with bypass strategy i

Cost0 = the expected cost per patient associated with secondary referral

ESi = the proportion of patients surviving under strategy i that would not have survived under the no bypass strategy

PGR, PMD, PSD, PVS, = the proportion of extra survivors in each of the GOS states at 6 months

RHGD, RHMD, RHSD, RHVS = the cost of rehabilitation by GOS states at 6 months

LEGR, LEMD, LESD, LEVS, = the discounted life expectancy of patients by GOS states at 6 months

ACCGR, ACCMD, ACCSD, ACCVS = annual care cost by GOS states at 6 months

TC = cost of transport in secondary referral

PDT = proportion of patients directly transported to the NSU

13.6.5.6 Probabilistic sensitivity analysis

A probabilistic sensitivity analysis was performed to assess the robustness of the model results to plausible variations in the model parameters.

This analysis was applied exclusively to the strategy of transporting all patients to the NSU (strategy 2) compared no bypass in the conservative model B.

Probability distributions were assigned to each model parameter, where there was some measure of parameter variability (Table 43). We then re-estimated the main results 5000 times, each time each

of the model parameters were set simultaneously selecting from the respective parameter distribution at random.

Table 43: Parameters used in the probabilistic sensitivity analysis

Description of variable	Mean value	Probability distribution	Parameters	Source
Percentage of patients with good recovery at 6months	49.6%	Dirichlet	44, 24, 18,3 where each parameter refers to the number of people in each category	Patel 2002
Percentage of patients with mild disability at 6 months	27.1%	Dirichlet		Patel 2002
Percentage of patients with severe disability at 6 months	20.3%	Dirichlet		Patel 2002
Percentage of patients in a vegetative state at 6 months	3.0%	Dirichlet		Patel 2002
SMR up to 4 years post-injury (GR)	1.5	Lognormal	SE = 0.402	Shavelle 2001
SMR up to 4 years post-injury (MD)	4.5	Lognormal	SE= 0.254	Shavelle 2001
SMR up to 4 years post-injury (SD)	16.4	Lognormal	SE= 0.249	Shavelle 2001
SMR up to 4 years post-injury (VS)	16.4	Lognormal	SE= 0.249	Shavelle 2001
SMR after 4 years (GR)	1.3	Lognormal	SE= 0.245	Shavelle 2001
SMR after 4 years (MD)	2.4	Lognormal	SE= 0.178	Shavelle 2001
SMR after 4 years (SD)	6.4	Lognormal	SE= 0.168	Shavelle 2001
SMR after 4 years (VS)	6.4	Lognormal	SE= 0.168	Shavelle 2001
Utility value of GR	0.83	none		Aoki1999
Utility value of MD	0.63	Gamma of 1-U	SE= 0.27, α= 1.878 , β=0.197	Aoki1999
Utility value of SD	0.26	Gamma of 1-U	SE= 0.25, α= 8.762, β= 0.084	Aoki1999
Utility value of VS	0.08	Gamma of 1-U	SE= 0.16, α= 33.063, β= 0.028	Aoki1999
Cost of rehabilitation (GR)	19,575	Gamma	SE= 7986, α= 6.01, β= 3258	Nyein 1999
Cost of rehabilitation (MD)	19,575	Gamma	SE= 7986, α= 6.01, β= 3258	Nyein 2000
Cost of rehabilitation (SD)	108,874	none		Wood 1999
Cost of rehabilitation (VS)	0	none		
Annual care costs (GR)	-	none		
Annual care costs (MD)	7,472	Gamma	SE= 12347, α= 0.37, β= 20402	Nyein 1999
Annual care costs (SD)	45,450	none		Wood 1999

Description of variable	Mean	Probability	Parameters	Source
Annual care costs (VS)	45,450	none		Wood 1999
Survival gain (all patients taken to the NSU if within 20minutes)	4.50%	Gamma	SE= 0.32%, α= 198, β= 0.0002	Stevenson's model

13.6.5.7 Results of the cost-effectiveness analysis

According to Model A there are large QALY gains and large cost savings associated with direct transport to the NSH – direct transport is dominant (Table 44). With Model B – the conservative model - the QALYs gained are smaller and costs are not decreased overall (Table 45 and Table 46). However, even with this conservative model, direct transport is cost effective (below £20,000 per QALY gained).

We chose the group of patients who were 40 years old at the time of injury to represent the results (Table 44, Table 45 and Table 46). In the tables we report the results for the groups of patients of 20 and 60 of age as well. In these cases, direct transport was the dominant strategy in Model A and the incremental cost-effectiveness ratio was still below the threshold of £ 20,000 per QALY in Model B.

After running the Model B 5,000 times, the probability that directly transporting all the patients to the NSU is cost effective (i.e. probability that the cost-effectiveness ratio is below £20,000 per QALY gained) is 73% when the NSU near the incident scene (within 20 minutes). In the cases of a patient aged 20 or 60, the probability falls to 66%.

For Model B, we performed a sensitivity analysis on the length of stay in the ICU: assuming that the most costly level 3 of care applies to all the outcome grades, the analysis shows that the direct transport would still be cost effective as long as the increased length of stay does not exceed 3 days per additional survivor. Furthermore, even if the LOS were longer than this, these costs could be counteracted by additional complications in those patients who are secondarily transported to the NSH and had delayed surgery.

Table 44: Results - Model A.

	Mean cost	QALYs	Incremental cost per QALY gained vs 1)
Base case – Age 40			
1) First to DGH	225,109	9.99	-
2) Direct to NSH	93,422	14.99	NSH dominates DGH
Age 20			
1) First to DGH	297,236	13.06	-
2) Direct to NSH	120,136	18.35	NSH dominates DGH
Age 60			
1) First to DGH	76,069	3.02	-
2) Direct to NSH	38,222	4.76	NSH dominates DGH

Table 45: Results - Model B – Far from NSU

	Incremental cost	QALYs gained	Incremental cost per QALY gained
Direct to NSH vs First to DGH (base case age 40)	7,058	0.41	17,228
Direct to NSH vs First to DGH (age 20)	9,382	0.51	18,343
Direct to NSH vs First to DGH (age 60)	2,259	0.12	18,367

Table 46: Results - Model B – Near from NSU

	Incremental cost	QALYs gained	Incremental cost per QALY gained
Direct to NSH vs First to DGH (base case age 40)	9,393	0.54	17,323
Direct to NSH vs First to DGH (age 20)	12,469	0.68	18,419
Direct to NSH vs First to DGH (age 60)	3,041	0.16	18,683

Using model B, we conducted a threshold sensitivity analysis to take into account the negative effects of overestimating the number of patients to be taken to the NSH. We define the positive predictive value as the proportion of patients transported directly to the NSH who are correctly diagnosed with a severe head injury. It is the number of true positives divided by the sum of both the true positives and false positives. In the case that the NSH is far from the accident scene (53 minutes), the strategy of taking all the patients directly to the NSH is cost effective as long as the positive predictive value is more than 28%. If the NSH is near the accident scene (20 minutes), the direct transport to the NSH is marginally cost-effective strategy even if the positive predictive value is as low as 10%.

Using model B we performed a sensitivity analysis by using an alternative set of utility scores. The result was that direct transport strategy proved to be even more cost effective than in the original model (Table 47).

Table 47: Results of the sensitivity analysis on the utility – Model B

	Incremental cost	QALYs gained	Incremental cost per QALY gained
Far NSU – Direct to NSH vs First to DGH (base case age 40)	7,058	0.53	13,369
Near NSU – Direct to NSH vs First to DGH (base case age 40)	9,393	0.70	13,442

13.6.5.8 Discussion

We found that direct transport is potentially cost saving if the health status of patients are substantially improved as was indicated by the Poon study. Even in our conservative model we find that direct transport is cost effective. But our analysis is limited for a number of reasons.

First, some of our assumptions regarding cost and survival were based on proxies or were extrapolated in to the long term.

Our conservative model, Model B, was based on the mortality results of a previous simulation model. Some of the parameters in the simulation model were based on expert judgement (those listed in Table 48). The main clinical outcomes from which the probability of death derives were estimated by experts. In particular, experts were asked to estimate the number of patients that would have survived assuming they received the appropriate care (critical intervention or neurosurgery) at time zero. The actual time elapsed since the accident and its related probability of death was taken from the database. Having these two points on the probability of death graph, a straight line was drawn. The authors found that the results were not sensitive to the slope of the line. However, the curve representing the real relationship between time to intervention and probability of death could have a different shape.

Table 48: Parameters for which the value was estimated by clinicians.

Deaths from injuries in areas excluding the head if medical intervention could be given immediately
Deaths from a head injury that required neurosurgery if neurosurgical intervention could be given immediately
Deaths from a head injury that did not require neurosurgery if medical intervention could be given immediately
Reduction in transfer deterioration due to staff expertise
Delays administering intubation and delay before making a neurosurgical decision (according to the level of staff expertise)
Increased mortality risk due to a secondary referral
Extra risk of mortality if the patient suffers hypotension or full hypoxia

For simplicity, neither model considers the change in health status during the patient's lifetime - they assume that the GOS score (assessed six months after the head injury) remains constant. If instead patients continue to improve after 6 months then our conservative model is underestimating the health gain and cost effectiveness associated with direct transport. Likewise, our assumption that mortality is increased compared with the general population for survivors over their entire lifetime is a conservative one.

We have probably underestimated the cost savings attributable to direct transport because we included only hospital personnel (one anaesthetist and a nurse), omitting for the costs of drugs, equipment and ambulance. However, we have also omitted additional acute costs associated with direct transport in the treatment of complications such as hypoxia and hypotension, which are less likely if the patient has been stabilised earlier. This would require additional treatments such as volume replacement, blood transfusion, and in some extreme cases they would require surgery or ventilatory support for weeks.

A strategy of direct transport from the injury scene to an NSH will inevitably mean that the unit sees more patients than previously, even though many patients currently being taken to the nearest emergency department are subsequently transferred to the NSH. From the viewpoint of the NSH there will be a substantial cost impact in particular in terms of ITU beds.

In the long-term, this should not represent an increase in cost to the NHS since patients and their treatment costs are merely being shifted from one hospital to another. Furthermore we have no reason to believe that ITU costs are higher at the NSH; indeed according to the 2006 Reference

Costs,[62] the cost of a bed in a neurosurgical ITU is lower than the cost of a bed in a general ITU . Hence we did not include ITU costs in our base case analysis.

In the short-term, the resource impact is less clear and will depend on local circumstances. A DGH might not achieve the full cost savings from seeing fewer patients as typically it would be losing only ¼ of an ITU bed. However, staff costs and consumables would be re-deployed almost immediately. The bed could also be re-deployed if there is currently under-capacity. If so more patients would be treated in ITU as a result of the increased capacity at DGHs but this would not necessarily see a reduction in costs to the Trust. However, this increase in ITU capacity could lead to cost savings from reduced transfers.

To implement a direct transport strategy, NSH units will need to invest in extra ITU beds. This will be offset by cost savings at DGHs. However the cost savings will not necessarily offset the cost fully in the short-term. The implementation costs associated with shifting patients will have to be taken in to account in any cost impact analysis conducted for the purposes of implementation.

A US study[56] reports a successful rate of GCS assessment (410/412 patients) by ambulance crews at the incident site, after an 8-hour training course. Hence, training for ambulance staff in the assessment of head injury patients would be necessary to safeguard the effectiveness and cost effectiveness of the direct transport strategy.

Since we do not have survival outcomes for the other simulation model based in London (see 13.6.2) we could not use it to estimate cost effectiveness. However, there is no reason to believe that it would effect our conclusions for near hospitals: if the specialist hospital is ≤20 minutes from the injury scene then direct transport is likely to be cost effective. For distances greater than 20 minutes, the authors of the London model have erred on the side of caution by not recommending bypass. It seems logical that the further away is the specialist hospital the more risky is direct transport. Given the uncertainty of the evidence in this area, if we are to recommend direct transport at all then it probably is better to use some kind of cut-off but it is unclear how the authors of the London model made this decision since analyses based on transport times longer than 20 minutes are not present in the report.

The London model assumed that not just neurosciences but also other specialist services were available at the specialist centres. If specialist centres contain the whole range of services then the issue of whether ambulance crews can diagnose isolated head injury becomes less of an issue (this problem had been raised by several stakeholders), as long as specialist hospitals have adequate provision of beds, etc. Perhaps we should be recommending that bypass strategies are developed at a regional level to take into account local service configurations.

13.6.5.9 Direct transport model: Conclusions

- A simulation model and some empirical studies have shown reduced mortality associated with directly transporting patients with serious head injury to an NSH.
- If ambulance crews can assess patients accurately then a policy of direct transport to an NSH is likely to produce a net cost saving to emergency department services (because of the resources involved with stabilising and transferring patients).
- Long term care costs might increase or decrease depending on the extent that health status (quality of life) is improved by direct transport.
- We found that even with conservative estimates about long term care costs, direct transport is likely to be cost effective in spite of the very high costs of caring for patients with severe disability.
- If ambulance crews (unintentionally) overestimate the number of patients to be treated in the Neurosciences Centre, some patients will experience journeys that are longer than necessary and may incur complications– in which case health gain might be decreased and costs increased for these patients. Nevertheless, a sensitivity analysis showed that the number of overestimated

patients would have to be quite high for the direct transport strategy to be no longer cost effective.

14 Acronyms and abbreviations

ABC	Airways, breathing, circulation.
ALS	Advanced Life Support
APLS	Advanced Paediatric Life Support
ARR	Absolute risk reduction
ATLS	Advanced trauma life support
AVPU	AVPU score
BLS	Basic Life Support
CATCH	Canadian Assessment of Tomography for Childhood Injury
CC	Cerebral Contusions
CCHR	Canadian Head CT Rule
CCR	Canadian Cervical Spine Rule
CHALICE	Children's Head injury Algorithm for the prediction of Important Clinical Events
CHIP	CT in Head Injury Patients
CT	Computed tomography
ED	Emergency Department
EMD	Emergency Medical Dispatch
EPLS	European Paediatric Life Support
FN	False-negative
FP	False-positive
GCS	Glasgow Coma Scale or Score
GDG	Guideline Development Group
GOS	Glasgow Outcome Scale
HTA	Health Technology Assessment
ICER	Incremental cost-effectiveness ratio
ICH	Intracranial Haematoma
ICI	Intracranial injury
JRCALC	Joint Royal Colleges Ambulance Liaison Committee
ITLS	International Trauma Life Support
LOC	Level of Consciousness

MHI	Minor head injury
MRI/MR	Magnetic Resonance Imaging
NAI	Non-accidental injury
NCWFNS	Neurotraumatology Committee of the World Federation of Neurosurgical Societies
NEXUS	National Emergency X-Radiography Utilization Study
NHS	National Health Service
NICE	National Institute for Health and Care Excellence (formeerly the National Institute for Health and Clinical Excellence).
NOC	New Orleans Criteria
NRPB	National Radiological Protection Board
NSE	Neuron-specific enolase
QALY	Quality Adjusted Life Year
QUADAS	Quality Assessment of Diagnostic Accuracy Studies
PECARN	Paediatric Emergency Care Applied Research Network
PEPP	Paediatric Education for Pre-hospital Professionals
PHPLS	Pre-hospital Paediatric Life Support course
PHTLS	Pre-hospital Trauma Life Support course
PRCT	Prospective Randomised Controlled Trial
S100B	S100 calcium-binding protein B
SICH	Spontaneous Intracerebral Haemorrhage
STICH	Surgical Trial in Intracerebral Haemorrhage
TBI	Traumatic Brain Injury
TICH	Traumatic Intracerebral Haemorrhage
TN	True-negative
TP	True-positive

15 Glossary

Absolute risk	Measures the probability of an event or outcome occurring (for example, an adverse reaction to the drug being tested) in the group of people under study. Studies that compare two or more groups of patients may report results in terms of the Absolute Risk Reduction.
Absolute Risk Reduction (ARR)	The ARR is the difference in the risk of an event occurring between two groups of patients in a study – for example if 6% of patients die after receiving a new experimental drug and 10% of patients die after having the old drug treatment then the ARR is 10% - 6% = 4%. Thus by using the new drug instead of the old drug 4% of patients can be prevented from dying. Here the ARR measures the risk reduction associated with a new treatment. See also Absolute risk.
Abstract	Summary of a study, which may be published alone or as an introduction to a full scientific paper.
Acute sector	Hospital-based health services which are provided on an in-patient, day case or out-patient basis.
Advanced Paediatric Life Support (APLS) course	A course for healthcare professionals run by the Advanced Life Support Group which teaches a practical systematic approach to the management of acutely ill or injured babies and children. (See http://www.alsg.org)
Advanced Trauma Life Support (ATLS) course	A course with the aim to teach a simple systematic approach to the management of trauma patients through interactive tutorials, skills teaching and simulated patient management scenarios. (see http://www.rcseng.ac.uk/education/courses/trauma_life_support_advanced.html)
Algorithm (in guidelines)	A flow chart of the clinical decision pathway described in the guideline, where decision points are represented with boxes, linked with arrows.
Allocation concealment	The process used to prevent advance knowledge of group assignment in a randomised controlled trial (RCT). The allocation process should be impervious to any influence by the individual making the allocation, by being administered by someone who is not responsible for recruiting participants.
Amnesia	Partial or total loss of memory, usually resulting from shock, psychological disturbance, brain injury, or illness.
Applicability	The extent to which the results of a study or review can be applied to the target population for a clinical guideline.
Appraisal of evidence	Formal assessment of the quality of research evidence and its relevance to the clinical question or guideline under consideration, according to predetermined criteria.
ARR	See Absolute Risk Reduction.
Arm (of a clinical study)	Sub-section of individuals within a study who receive one particular

	intervention, for example placebo arm
Association	Statistical relationship between two or more events, characteristics or other variables. The relationship may or may not be causal.
Baseline	The initial set of measurements at the beginning of a study (after run-in period where applicable), with which subsequent results are compared.
Basal skull fracture	A fracture involving the base of the cranium.
Battle's sign	Bruising which sometimes occurs behind the ear in cases of fracture of the base of the skull (basal skull fracture).
Before-and-after study	A study that investigates the effects of an intervention by measuring particular characteristics of a population both before and after taking the intervention, and assessing any change that occurs.
Best available evidence	The strongest research evidence available to support a particular guideline recommendation.
Bias	Influences on a study that can lead to invalid conclusions about a treatment or intervention. Bias in research can make a treatment look better or worse than it really is. Bias can even make it look as if the treatment works when it actually doesn't. Bias can occur by chance or as a result of systematic errors in the design and execution of a study. Bias can occur at different stages in the research process, for example, in the collection, analysis, interpretation, publication or review of research data. For examples see Selection bias, Performance bias, Information bias, Confounding, Publication bias.
Blinding or masking	The practice of keeping the investigators or subjects of a study ignorant of the group to which a subject has been assigned. For example, a clinical trial in which the participating patients or their doctors are unaware of whether they (the patients) are taking the experimental drug or a placebo (dummy treatment). The purpose of 'blinding' or 'masking' is to protect against bias. See also Double blind study, Single blind study, Triple blind study.
C-spine	Cervical spine or bony part of the neck
Carer (caregiver)	Someone other than a health professional who is involved in caring for a person with a medical condition.
Case-control study	A study that starts with the identification of a group of individuals sharing the same characteristics (for example, people with a particular disease) and a suitable comparison (control) group (for example, people without the disease). All subjects are then assessed with respect to things that happened to them in the past, for example, things that might be related to getting the disease under investigation. Such studies are also called retrospective as they look back in time from the outcome to the possible causes.
Case report (or case study)	Detailed report on one patient (or case), usually covering the course of that person's disease and their response to treatment.
Case series	Description of several cases of a given disease, usually covering the

	course of the disease and the response to treatment. There is no comparison (control) group of patients.
Causal relationship	Describes the relationship between two variables whenever it can be established that one causes the other. For example there is a causal relationship between a treatment and a disease if it can be shown that the treatment changes the course or outcome of the disease. Usually randomised controlled trials are needed to ascertain causality. Proving cause and effect is much more difficult than just showing an association between two variables. For example, if it happened that everyone who had eaten a particular food became sick, and everyone who avoided that food remained well, then the food would clearly be associated with the sickness. However, even if leftovers were found to be contaminated, it could not be proved that the food caused the sickness – unless all other possible causes (for example, environmental factors) had been ruled out.
Cerebrospinal fluid (CSF)	Clear fluid which is continuously being produced and absorbed by and in the brain, flowing in the ventricles (cavities) within the brain and around the surface of the brain and spinal cord
CSF otorrhea	Escape of CSF from the brain into the ear canal
Cervical spine	The cervical spine is the area of the vertebral column commonly referred to as the neck. The cervical spine is made up of seven vertebrae, refered to by 'C', appended with an identifying number. The number indicates the level of the spine in which the particular vertebra is located. The top vertebra is C1, the lowest C7
Cervico-dorsal junction	The junction between the bottom of the cervical spine and the top of the dorsal (or thoracic) spine.
Clinical audit	A systematic process for setting and monitoring standards of clinical care. Whereas 'guidelines' define what the best clinical practice should be, 'audit' investigates whether best practice is being carried out. Clinical audit can be described as a cycle or spiral. Within the cycle there are stages that follow a systematic process of establishing best practice, measuring care against specific criteria, taking action to improve care, and monitoring to sustain improvement. The spiral suggests that as the process continues, each cycle aspires to a higher level of quality.
Clinician	A healthcare professional providing direct patient care, for example doctor, nurse or physiotherapist.
Clinical decision rule	A clinical tool that quantifies the individual contributions that various factors provide for example, history, physical examination, and basic laboratory results make towards, in the context of this guideline, the diagnosis in a patient. These rules attempt to formally test, simplify, and increase the accuracy of clinicians' diagnostic assessments to suggest a course of action.
Clinical efficacy	The extent to which an intervention is active when studied under controlled research conditions.

Clinical effectiveness	The extent to which an intervention produces an overall health benefit in routine clinical practice.
Clinical effectiveness	The extent to which a specific treatment or intervention, when used under usual or everyday conditions, has a beneficial effect on the course or outcome of disease compared to no treatment or other routine care. (Clinical trials that assess effectiveness are sometimes called management trials.) Clinical 'effectiveness' is not the same as efficacy.
Clinical impact	The effect that a guideline recommendation is likely to have on the treatment, or treatment outcomes, of the target population.
Clinical question	This term is sometimes used in guideline development work to refer to the questions about treatment and care that are formulated in order to guide the search for research evidence. When a clinical question is formulated in a precise way, it is called a focused question.
Clinical trial	A research study conducted with patients which tests out a drug or other intervention to assess its effectiveness and safety. Each trial is designed to answer scientific questions and to find better ways to treat individuals with a specific disease. This general term encompasses controlled clinical trials and randomised controlled trials.
Clinician	A healthcare professional providing patient care, for example, doctor, nurse, physiotherapist.
Closed head injury	A blow to the head or a severe shaking causing tearing, shearing or stretching of the nerves at the base of the brain, blood clots in or around the brain or oedema (swelling) of the brain. There is no penetration of the skull or brain tissue by an object; the skull may be fractured but this does not result in a direct connection between the brain and the outside. (see Penetrating Brain Injury)
Cluster randomisation	A study in which groups of individuals (for example, patients in a General Practitioner surgery or on a hospital ward) are randomly allocated to treatment groups. Take, for example, a smoking cessation study of two different interventions – leaflets and teaching sessions. Each General Practitioner surgery within the study would be randomly allocated to administer one of the two interventions. See also Cluster, Cluster design.
Coagulopathy	A condition affecting the blood's ability to form a clot.
Cochrane Collaboration	An international organisation in which people find, appraise and review specific types of studies called randomised controlled trials. The Cochrane Database of Systematic Reviews contains regularly updated reviews on a variety of health issues and is available electronically as part of the Cochrane Library.
Cochrane Library	The Cochrane Library consists of a regularly updated collection of evidence-based medicine databases including the Cochrane Database of Systematic Reviews (reviews of randomised controlled trials prepared by the Cochrane Collaboration). The Cochrane Library is available on CD-ROM and the Internet.

Cohort	A group of people sharing some common characteristic (for example, patients with the same disease), followed up in a research study for a specified period of time.
Cohort study	An observational study that takes a group (cohort) of patients and follows their progress over time in order to measure outcomes such as disease or mortality rates and make comparisons according to the treatments or interventions that patients received. Thus within the study group, subgroups of patients are identified (from information collected about patients) and these groups are compared with respect to outcome, for example, comparing mortality between one group that received a specific treatment and one group which did not (or between two groups that received different levels of treatment). Cohorts can be assembled in the present and followed into the future (a 'concurrent' or 'prospective' cohort study) or identified from past records and followed forward from that time up to the present (a 'historical' or 'retrospective' cohort study). Because patients are not randomly allocated to subgroups, these subgroups may be quite different in their characteristics and some adjustment must be made when analysing the results to ensure that the comparison between groups is as fair as possible.
Coma	A sleep-like state in which a person is not conscious.
Co-morbidity	Co-existence of a disease or diseases in the people being studied in addition to the health problem that is the subject of the study.
Community health services	General Practice, ambulance crews, NHS walk-in centres and dental practitioners.
Comparability	Similarity of the groups in characteristics likely to affect the study results (such as health status or age).
Computed tomography (CT) scan	A scan which produces images of a cross sectional plane of the body. The scan is produced by computer synthesis of X-ray images taken in many different directions in a given plane.
Concordance	This is a recent term whose meaning has changed. It was initially applied to the consultation process in which doctor and patient agree therapeutic decisions that incorporate their respective views, but now includes patient support in medicine taking as well as prescribing communication. Concordance reflects social values but does not address medicine-taking and may not lead to improved adherence.
Concussion	The common result of a blow to the head or sudden deceleration usually causing an altered mental state, either temporary or prolonged. Physiological and/or anatomical disruption of connections between some nerve cells in the brain may occur. Often used by the public to refer to a brief loss of consciousness.
Confidence interval	A way of expressing certainty about the findings from a study or group of studies, using statistical techniques. A confidence interval describes a range of possible effects (of a treatment or intervention) that are consistent with the results of a study or group of studies. A wide confidence interval indicates a lack of certainty or precision about the

	true size of the clinical effect and is seen in studies with too few patients. Where confidence intervals are narrow they indicate more precise estimates of effects and a larger sample of patients studied. It is usual to interpret a '95%' confidence interval as the range of effects within which we are 95% confident that the true effect lies.
Confounder or confounding factor	Something that influences a study and can contribute to misleading findings if it is not understood or appropriately dealt with. For example, if a group of people exercising regularly and a group of people who do not exercise have an important age difference then any difference found in outcomes about heart disease could well be due to one group being older than the other rather than due to the exercising. Age is the confounding factor here and the effect of exercising on heart disease cannot be assessed without adjusting for age differences in some way.
Consciousness	An alert cognitive state in which you are aware of yourself and your situation
Consensus development conference	A technique used for the purpose of reaching an agreement on a particular issue. It involves bringing together a group of about 10 people who are presented with evidence by various interest groups or experts who are not part of the decision making group. The group then retires to consider the questions in the light of the evidence presented and attempts to reach a consensus. See also Consensus methods.
Consensus methods	A variety of techniques that aim to reach an agreement on a particular issue. Formal consensus methods include Delphi and nominal group techniques, and consensus development conferences. In the development of clinical guidelines, consensus methods may be used where there is a lack of strong research evidence on a particular topic.
Consistency	The extent to which the conclusions of a collection of studies used to support a guideline recommendation are in agreement with each other. See also Homogeneity.
Control group	A group of patients recruited into a study that receives no treatment, a treatment of known effect, or a placebo (dummy treatment) - in order to provide a comparison for a group receiving an experimental treatment, such as a new drug.
Controlled clinical trial (CCT)	A study testing a specific drug or other treatment involving two (or more) groups of patients with the same disease. One (the experimental group) receives the treatment that is being tested, and the other (the comparison or control group) receives an alternative treatment, a placebo (dummy treatment) or no treatment. The two groups are followed up to compare differences in outcomes to see how effective the experimental treatment was. A CCT where patients are randomly allocated to treatment and comparison groups is called a randomised controlled trial.
Cost-benefit analysis	A type of economic evaluation where both costs and benefits of healthcare treatment are measured in the same monetary units. If benefits exceed costs, the evaluation would recommend providing the

	treatment.
Cost-consequences analysis	A type of economic evaluation where various health outcomes are reported in addition to cost for each intervention, but there is no overall measure of health gain.
Cost-effectiveness analysis	A type of economic evaluation that assesses the additional costs and benefits of doing something different. In cost-effectiveness analysis, the costs and benefits of different treatments are compared. When a new treatment is compared with current care, its additional costs divided by its additional benefits is called the cost-effectiveness ratio. Benefits are measured in natural units, for example, cost per additional heart attack prevented.
Cost-effectiveness model	An explicit mathematical framework, which is used to represent clinical decision problems and incorporate evidence from a variety of sources in order to estimate the costs and health outcomes.
Cost-utility analysis	A special form of cost-effectiveness analysis where benefit is measured in quality adjusted life years. A treatment is assessed in terms of its ability to extend or improve the quality of life.
Cranial	Pertaining to the cranium.
Craniocervical junction	The junction between the base of the skull and the top of the cervical spine.
Credible Interval	The Bayesian equivalent of a confidence interval.
Crossover study design	A study comparing two or more interventions in which the participants, upon completion of the course of one treatment, are switched to another. For example, for a comparison of treatments A and B, half the participants are randomly allocated to receive them in the order A, B and half to receive them in the order B, A. A problem with this study design is that the effects of the first treatment may carry over into the period when the second is given. Therefore a crossover study should include an adequate 'wash-out' period, which means allowing sufficient time between stopping one treatment and starting another so that the first treatment has time to wash out of the patient's system.
Cross-sectional study	The observation of a defined set of people at a single point in time or time period – a snapshot. (This type of study contrasts with a longitudinal study which follows a set of people over a period of time.)
Data set	A list of required information relating to a specific disease.
Decision analysis	A systematic way of reaching decisions, based on evidence from research. This evidence is translated into probabilities, and then into diagrams or decision trees which direct the clinician through a succession of possible scenarios, actions and outcomes.
Derivation study	Original research to identify factors with predictive power. In the context of this guideline 3 or more factors are combined into a clinical decision rule that best meet the performance characteristics (for example to provide the highest diagnostic sensitivity or specificity) within the population tested.

Diagnostic study	A study to assess the effectiveness of a test or measurement in terms of its ability to accurately detect or exclude a specific disease.
Dominance	An intervention is said to be dominated if there is an alternative intervention that is both less costly and more effective.
Double blind study	A study in which neither the subject (patient) nor the observer (investigator/clinician) is aware of which treatment or intervention the subject is receiving. The purpose of blinding is to protect against bias.
Discounting	Costs and perhaps benefits incurred today have a higher value than costs and benefits occurring in the future. Discounting health benefits reflects individual preference for benefits to be experienced in the present rather than the future. Discounting costs reflects individual preference for costs to be experienced in the future rather than the present.
Drop-out	A participant who withdraws from a trial before the end.
Drowsiness	A state of impaired awareness associated with a desire or inclination to sleep.
Dura Mater	The thick lining of the brain and spinal cord
Economic evaluation	Comparative analysis of alternative courses of action in terms of both their costs and consequences.
Effectiveness	See Clinical effectiveness.
Efficacy	The extent to which a specific treatment or intervention, under ideally controlled conditions (for example, in a laboratory), has a beneficial effect on the course or outcome of disease compared to no treatment or other routine care.
Elective	Name for clinical procedures that are regarded as advantageous to the patient but not urgent.
Emergency Department (ED or A&E)	A clinical department in a district general or teaching hospital which has trained staff and equipment able to receive, resuscitate, investigate and initially manage the full spectrum of emergencies. Most units accept patients of all ages, some are restricted to adults, others to children. All should be open at all times and all its facilities should be available at all times.
Emergency Department Clinician	A medically qualified member of an emergency department or an appropriately trained nurse working in an emergency department.
Empirical	Based directly on experience (observation or experiment) rather than on reasoning alone.
Epidemiology	Study of diseases within a population, covering the causes and means of prevention.
European Paediatric Life Support course (EPLS)	The EPLS provider course is intended to provide training for multi-disciplinary healthcare professionals in the early recognition of the

	child in respiratory or circulatory failure and the development of the knowledge and core skills required to intervene to prevent further deterioration towards respiratory or cardiorespiratory arrest. (see http://www.resus.org.uk)
EQ-5D (EuroQol-5D)	A standardise instrument used to measure a health outcome. It provides a single index value for health status.
Event rate	The proportion of patients in a group for whom a specified health event or outcome is observed. Thus, if out of 100 patients, the event is observed in 27, the event rate is 0.27 or 27%. Control Event Rate (CER) and Experimental Event Rate (EER) are the terms used in control and experimental groups of patients respectively.
Evidence based clinical practice	Evidence based clinical practice involves making decisions about the care of individual patients based on the best research evidence available rather than basing decisions on personal opinions or common practice (which may not always be evidence based). Evidence based clinical practice therefore involves integrating individual clinical expertise and patient preferences with the best available evidence from research
Evidence table	A table summarising the results of a collection of studies which, taken together, represent the evidence supporting a particular recommendation or series of recommendations in a guideline.
Exclusion criteria	See Selection criteria.
Experimental study	A research study designed to test if a treatment or intervention has an effect on the course or outcome of a condition or disease - where the conditions of testing are to some extent under the control of the investigator. Controlled clinical trial and randomised controlled trial are examples of experimental studies.
Experimental treatment	A treatment or intervention (for example, a new drug) being studied to see if it has an effect on the course or outcome of a condition or disease.
Extended dominance	If Option A is both more clinically effective than Option B and has a lower cost per unit of effect, when both are compared with a do-nothing alternative then Option A is said to have extended dominance over Option B. Option A is therefore more efficient and should be preferred, other things remaining equal.
External validity	The degree to which the results of a study hold true in non-study situations, for example, in routine clinical practice. May also be referred to as the generalisability of study results to non-study patients or populations.
EXTRADURAL (OR EPIDURAL) HAEMORRAGE	A collection of blood between the skull inner surface and the dura mater caused by damage to the blood vessels running on the surface of the dura mater – often associated with a fracture of the skull. The underlying brain injury may not be severe initially but the increasing pressure caused by the bleeding inflicts further damage.
Extradural space	The space on the outer side of the dura mater.

Extrapolation	The application of research evidence based on studies of a specific population to another population with similar characteristics.
Focal Neurological Deficit	Any focal (that is, restricted to a particular part of the body or a particular activity) neurological deficit since the injury (examples include problems understanding, speaking, reading or writing; loss of feeling in part of the body; problems balancing; general weakness; any changes in eyesight; and problems walking).
Follow-up	Observation over a period of time of an individual, group or initially defined population whose appropriate characteristics have been assessed in order to observe changes in health status or health-related variables.
Forest plot	A graphical display of results from individual studies on a common scale, allowing visual comparison of results and examination of the degree of heterogeneity between studies.
Funnel plot	Funnel plots are simple scatter plots on a graph. They show the treatment effects estimated from separate studies on the horizontal axis against a measure of sample size on the vertical axis. Publication bias may lead to asymmetry in funnel plots.
Generalisability	The extent to which the results of a study hold true for a population of patients beyond those who participated in the research. See also External validity.
Glasgow Coma Scale	A standardised system used to assess the degree of brain impairment and to identify the seriousness of injury in relation to outcome. The system involves three determinants: eye opening, verbal responses and motor response all of which are evaluated independently according to a numerical value that indicates the level of consciousness and degree of dysfunction.
Gold standard	A method, procedure or measurement that is widely accepted as being the best available.
GRADE / GRADE profile	A system developed by the GRADE Working Group to address the shortcomings of present grading systems in healthcare. The GRADE system uses a common, sensible and transparent approach to grading the quality of evidence. The results of applying the GRADE system to clinical trial data are displayed in a table known as a GRADE profile.
Harms	Adverse effects of an intervention.
Head Injury	For the purposes of this guideline, head injury is defined as any trauma to the head other than superficial injuries to the face.
Haematoma	An accumulation of blood in or under the tissues.
Haemotympanum	A collection of blood in the middle ear space
Health economics	A field of conventional economics which examines the benefits of healthcare interventions (for example, medicines) compared with their financial costs.
Health-related quality of	A combination of an individual's physical, mental and social well-

life (HRQoL)	being; not merely the absence of disease.
Heterogeneity	Or lack of homogeneity. The term is used in meta-analyses and systematic reviews when the results or estimates of effects of treatment from separate studies seem to be very different – in terms of the size of treatment effects or even to the extent that some indicate beneficial and others suggest adverse treatment effects. Such results may occur as a result of differences between studies in terms of the patient populations, outcome measures, definition of variables or duration of follow-up.
Hierarchy of evidence	An established hierarchy of study types, based on the degree of certainty that can be attributed to the conclusions that can be drawn from a well conducted study. Well-conducted randomised controlled trials (RCTs) are at the top of this hierarchy. (Several large statistically significant RCTs which are in agreement represent stronger evidence than say one small RCT.) Well-conducted studies of patients' views and experiences would appear at a lower level in the hierarchy of evidence.
High energy head injury	For example, pedestrian struck by motor vehicle, occupant ejected from motor vehicle, a fall from a height of greater than 1 m or more than five stairs, diving accident, high-speed motor vehicle collision, rollover motor accident, accident involving motorized recreational vehicles, bicycle collision, or any other potentially high-energy mechanism.
Homogeneity	This means that the results of studies included in a systematic review or meta analysis are similar and there is no evidence of heterogeneity. Results are usually regarded as homogeneous when differences between studies could reasonably be expected to occur by chance. See also Consistency.
Hyperventilation	Abnormally rapid breathing. Hyperventilation results in excessive intake of oxygen and increased elimination of carbon dioxide, which may eventually lead to a disturbance in the blood chemistry.
Hypoglycaemia	Abnormally low levels of glucose in the blood, leading to muscular weakness, confusion, sweating and, in severe cases, coma. Hypoglycaemia is a complication of many anti-diabetic treatments.
Imprecision	Results are imprecise when studies include relatively few patients and few events and thus have wide confidence intervals around the estimate of effect.
Inclusion criteria	See Selection criteria.
Incremental analysis	The analysis of additional costs and additional clinical outcomes with different interventions.
Incremental cost	The mean cost per patient associated with an intervention minus the mean cost per patient associated with a comparator intervention.
Incremental cost-effectiveness ratio (ICER)	The difference in the mean costs in the population of interest divided by the differences in the mean outcomes in the population of interest for one treatment compared with another.

Incremental net benefit (INB)	The value (usually in monetary terms) of an intervention net of its cost compared with a comparator intervention. The INB can be calculated for a given cost-effectiveness (willingness to pay) threshold. If the threshold is £20,000 per QALY gained then the INB is calculated as: (£20,000 x QALYs gained) – Incremental cost.
Indeterminate imaging	Describes a situation where the synthesis of clinical and radiological information does not allow for exclusion of significant injury.
Indirectness	The available evidence is different to the review question being addressed, in terms of PICO (population, intervention, comparison and outcome).
Infant	Aged under 1 year.
Intention to treat analysis	An analysis of a clinical trial where patients are analysed according to the group to which they were initially randomly allocated, regardless of whether or not they had dropped out, fully complied with the treatment, or crossed over and received the alternative treatment. Intention-to-treat analyses are favoured in assessments of clinical effectiveness as they mirror the non-compliance and treatment changes that are likely to occur when the treatment is used in practice.
Internal validity	Refers to the integrity of the study design.
Intervention	Healthcare action intended to benefit the patient, for example, drug treatment, surgical procedure, psychological therapy, etc.
Interventional procedure	A procedure used for diagnosis or treatment that involves making a cut or hole in the patient's body, entry into a body cavity or using electromagnetic radiation (including X-rays or lasers). The National Institute for Health and Care Excellence (NICE) has the task of producing guidance about whether specific interventional procedures are safe enough and work well enough for routine use.
Intracranial	Originating within the cranial (brain) cavity.
Intracranial haematoma	A collection of blood inside the cranium caused by damage to brain tissue or the rupture of a blood vessel. The resulting swelling can compress the brain.
Intracranial haematoma	Rupture of a blood vessel that causes blood to leak and form a blood clot (hematoma) that compresses brain tissue.
Intracranial haemorrhage	A bleed inside the brain tissue.
Intracranial Injury	Defined as any intracranial abnormality detected on CT or MR scan due to trauma (HTA definition).
Intracranial lesion	A lesion of the brain.
Infant	Aged under 1 year.
Kappa statistic	A statistical measure of inter-rater agreement that takes into account the agreement occurring by chance.

Length of stay	The total number of days a participant stays in hospital.
Licence	See 'Product licence'.
Life-years gained	Mean average years of life gained per person as a result of the intervention compared with an alternative intervention.
Likelihood ratio	The likelihood ratio combines information about the sensitivity and specificity. It tells you how much a positive or negative result changes the likelihood that a patient would have the disease. The likelihood ratio of a positive test result (LR+) is sensitivity divided by 1-specificity.
Literature review	A process of collecting, reading and assessing the quality of published (and unpublished) articles on a given topic.
Long-term care	Residential care in a home that may include skilled nursing care and help with everyday activities. This includes nursing homes and residential homes.
Longitudinal study	A study of the same group of people at more than one point in time. (This type of study contrasts with a cross sectional study which observes a defined set of people at a single point in time.)
Magnetic resonance imaging (MR imaging)	An imaging technique using strong magnets and pulses of radio waves to manipulate the natural magnetic properties in the body, producing images of organs and soft tissues. This technique is particularly useful when imaging the brain and spine, as well as the soft tissues of joints and the interior structure of bones.
Mandible	The lower jaw as a functional unit, regardless of which bones or cartilage make up the lower jaw in a particular organism.
Markov model	A method for estimating long-term costs and effects for recurrent or chronic conditions, based on health states and the probability of transition between them within a given time period (cycle).
Meningism	Stiffness of the neck associated with backwards extension of the cervical spine.
Meta analysis	Results from a collection of independent studies (investigating the same treatment) are pooled, using statistical techniques to synthesise their findings into a single estimate of a treatment effect. Where studies are not compatible for example, because of differences in the study populations or in the outcomes measured, it may be inappropriate or even misleading to statistically pool results in this way. See also Systematic review & Heterogeneity.
Methodology	The overall approach of a research project, for example, the study will be a randomised controlled trial, of 200 people, over one year.
Methodological quality	The extent to which a study has conformed to recognised good practice in the design and execution of its research methods.
Monte Carlo simulation	A modelling technique that uses random numbers to capture the effects of uncertainty. Multiple simulations are run (usually somewhere between 1,000 and 10,000). For each simulation, the

	value of each uncertain variable in the analysis is selected at random from a probability distribution for the value of that variable. The simulation results are compiled, providing a probability distribution for the overall result.
Motor response	Movement in response to an external stimulus
Multicentre study	A study where subjects were selected from different locations or populations, for example, a co-operative study between different hospitals; an international collaboration involving patients from more than one country.
Multivariate model	A statistical model for analysis of the relationship between two or more predictor (independent) variables and the outcome (dependent) variable.
Need for neurosurgical intervention	Defined as any ICI seen on CT or MR imaging scanning that required neurosurgery (HTA definition). Neurosurgical intervention includes any of craniotomy for evacuation of intracranial haematoma, debridement of open fractures, and insertion of ICP monitor.
Negative predictive value	The proportion of individuals with a negative test result who do NOT have the disease.
Neurorehabilitation services	A programme of clinical and vocational services with the goal of returning brain injured patients to a satisfying occupation,.
Neurosurgery	A surgical specialty for the treatment of diseases and disorders of the brain, spinal cord and nerves.
Non-experimental study	A study based on subjects selected on the basis of their availability, with no attempt having been made to avoid problems of bias.
Non-systematic review	See Review.
Number needed to treat (NNT)	The number of patients that who on average must be treated to prevent a single occurrence of the outcome of interest.
Objective measure	A measurement that follows a standardised procedure which is less open to subjective interpretation by potentially biased observers and study participants.
Observational study	In research about diseases or treatments, this refers to a study in which nature is allowed to take its course. Changes or differences in one characteristic (for example, whether or not people received a specific treatment or intervention) are studied in relation to changes or differences in other(s) (for example, whether or not they died), without the intervention of the investigator. There is a greater risk of selection bias than in experimental studies.
Occipital condyle	The articulation point between the skull and the first cervical vertebra.
Odds ratio	Odds are a way of representing probability, especially familiar for betting. In recent years odds ratios have become widely used in reports of clinical studies. They provide an estimate (usually with a confidence interval) for the effect of a treatment. Odds are used to convey the idea of 'risk' and an odds ratio of 1 between two treatment

	groups would imply that the risks of an adverse outcome were the same in each group. For rare events the odds ratio and the relative risk (which uses actual risks and not odds) will be very similar. See also Relative risk, Risk ratio.
Opportunity cost	The loss of other health care programmes displaced by investment in or introduction of another intervention. This may be best measured by the health benefits that could have been achieved had the money been spent on the next best alternative healthcare intervention.
Outcome	The end result of care and treatment and/ or rehabilitation. In other words, the change in health, functional ability, symptoms or situation of a person, which can be used to measure the effectiveness of care/ treatment/ rehabilitation. Researchers should decide what outcomes to measure before a study begins; outcomes are then assessed at the end of the study.
P-value	The probability that an observed difference could have occurred by chance, assuming that there is in fact no underlying difference between the means of the observations. If the probability is less than 1 in 20, the P value is less than 0.05; a result with a P value of less than 0.05 is conventionally considered to be 'statistically significant'.
Paediatric	Pertaining to children and infants
Paraesthesia	Abnormal sensation such as burning or tingling due to a disorder of the sensory nervous system.
Penetrating head injury	Head injury where an object penetrates the scalp and skull and enters the brain or its lining.
Performance bias	Systematic differences in care provided apart from the intervention being evaluated. For example, if study participants know they are in the control group they may be more likely to use other forms of care; people who know they are in the experimental group may experience placebo effects, and care providers may treat patients differently according to what group they are in. Masking (blinding) of both the recipients and providers of care is used to protect against performance bias.
Periorbital haemotoma	Bleeding around or behind the eyes.
Pilot study	A small scale 'test' of the research instrument. For example, testing out (piloting) a new questionnaire with people who are similar to the population of the study, in order to highlight any problems or areas of concern, which can then be addressed before the full scale study begins.
Placebo	Placebos are fake or inactive treatments received by participants allocated to the control group in a clinical trial which are indistinguishable from the active treatments being given in the experimental group. They are used so that participants are ignorant of their treatment allocation in order to be able to quantify the effect of the experimental treatment over and above any placebo effect due to receiving care or attention.

Placebo effect	A beneficial (or adverse) effect produced by a placebo and not due to any property of the placebo itself.
Positive predictive value	The proportion of individuals with a positive test result who actually have the disease.
Post-test probability	For diagnostic tests. The proportion of patients with that particular test result who have the target disorder (post test odds/[1 + post-test odds]).
Power	See Statistical power.
Pre-test probability	For diagnostic tests. The proportion of people with the target disorder in the population at risk at a specific time point or time interval. Prevalence may depend on how a disorder is diagnosed.
Primary outcome	The outcome of greatest importance, usually the one in a study that the power calculation is based on.
Product licence	An authorisation from the MHRA to market a medicinal product.
Prognosis	A probable course or outcome of a disease. Prognostic factors are patient or disease characteristics that influence the course. Good prognosis is associated with low rate of undesirable outcomes; poor prognosis is associated with a high rate of undesirable outcomes.
Primary care	Healthcare delivered to patients outside hospitals. Primary care covers a range of services provided by General Practitioners, nurses and other healthcare professionals, dentists, pharmacists and opticians.
Probability	How likely an event is to occur, for example, how likely a treatment or intervention will alleviate a symptom.
Prognostic factor	Patient or disease characteristics, for example, age or co-morbidity, which influence the course of the disease under study. In a randomised trial to compare two treatments, chance imbalances in variables (prognostic factors) that influence patient outcome are possible, especially if the size of the study is fairly small. In terms of analysis these prognostic factors become confounding factors. See also Prognostic marker.
Prognostic marker	A prognostic factor used to assign patients to categories for a specified purpose – for example, for treatment, or as part of a clinical trial, according to the likely progression of the disease. For example, the purpose of randomisation in a clinical trial is to produce similar treatment groups with respect to important prognostic factors. This can often be achieved more efficiently if randomisation takes place within subgroups defined by the most important prognostic factors. Thus if age was very much related to patient outcome then separate randomisation schemes would be used for different age groups. This process is known as stratified random allocation.
Prospective study	A study in which people are entered into the research and then followed up over a period of time with future events recorded as they happen. This contrasts with studies that are retrospective.

Publication bias	Studies with statistically significant results are more likely to get published than those with non-significant results. Meta-analyses that are exclusively based on published literature may therefore produce biased results. This type of bias can be assessed by a funnel plot.
P value	If a study is done to compare two treatments then the P value is the probability of obtaining the results of that study, or something more extreme, if there really was no difference between treatments. (The assumption that there really is no difference between treatments is called the 'null hypothesis'.) Suppose the P-value was P=0.03. What this means is that if there really was no difference between treatments then there would only be a 3% chance of getting the kind of results obtained. Since this chance seems quite low we should question the validity of the assumption that there really is no difference between treatments. We would conclude that there probably is a difference between treatments. By convention, where the value of P is below 0.05 (that is, less than 5%) the result is seen as statistically significant. Where the value of P is 0.001 or less, the result is seen as highly significant. P values just tell us whether an effect can be regarded as statistically significant or not. In no way do they relate to how big the effect might be, for which we need the confidence interval.
Qualitative research	Qualitative research is used to explore and understand people's beliefs, experiences, attitudes, behaviour and interactions. It generates non-numerical data, for example, a patient's description of their pain rather than a measure of pain. In healthcare, qualitative techniques have been commonly used in research documenting the experience of chronic illness and in studies about the functioning of organisations. Qualitative research techniques such as focus groups and in depth interviews have been used in one-off projects commissioned by guideline development groups to find out more about the views and experiences of patients and carers.
Quality adjusted life years (QALYS)	A measure of health outcome. QALYS are calculated by estimating the total life-years gained from a treatment and weighting each year with a quality of life score.
Quality of life	See 'Health-related quality of life'.
Quantitative research	Research that generates numerical data or data that can be converted into numbers, for example clinical trials or the national Census which counts people and households.
Quasi experimental study	A study designed to test if a treatment or intervention has an effect on the course or outcome of disease. It differs from a controlled clinical trial and a randomised controlled trial in that: a) the assignment of patients to treatment and comparison groups is not done randomly, or patients are not given equal probabilities of selection, or b) the investigator does not have full control over the allocation and/or timing of the intervention, but nonetheless conducts the study as if it were an experiment, allocating subjects to treatment and comparison groups.

Random allocation or Randomisation	A method that uses the play of chance to assign participants to comparison groups in a research study, for example, by using a random numbers table or a computer-generated random sequence. Random allocation implies that each individual (or each unit in the case of cluster randomisation) being entered into a study has the same chance of receiving each of the possible interventions.
Randomised controlled trial	A study to test a specific drug or other treatment in which people are randomly assigned to two (or more) groups: one (the experimental group) receiving the treatment that is being tested, and the other (the comparison or control group) receiving an alternative treatment, a placebo (dummy treatment) or no treatment. The two groups are followed up to compare differences in outcomes to see how effective the experimental treatment was. (Through randomisation, the groups should be similar in all aspects apart from the treatment they receive during the study.)
Receiver operated characteristic (ROC) curve	A graphical method of assessing the accuracy of a diagnostic test. Sensitivity Is plotted against 1-specificity. A perfect test will have a positive, vertical linear slope starting at the origin. A good test will be somewhere close to this ideal.
Reference standard	The test that is considered to be the best available method to establish the presence or absence of the outcome – this may not be the one that is routinely used in practice.
Rehabilitation services	A programme of clinical and vocational services with the goal of returning patients to a satisfying occupation.
Relative risk	A summary measure which represents the ratio of the risk of a given event or outcome (for example, an adverse reaction to the drug being tested) in one group of subjects compared to another group. When the 'risk' of the event is the same in the two groups the relative risk is 1. In a study comparing two treatments, a relative risk of 2 would indicate that patients receiving one of the treatments had twice the risk of an undesirable outcome than those receiving the other treatment. Relative risk is sometimes used as a synonym for risk ratio.
Reliability	Reliability refers to a method of measurement that consistently gives the same results. For example someone who has a high score on one occasion tends to have a high score if measured on another occasion very soon afterwards. With physical assessments it is possible for different clinicians to make independent assessments in quick succession – and if their assessments tend to agree then the method of assessment is said to be reliable.
Reporting bias	See publication bias.
Resource implication	The likely impact in terms of finance, workforce or other NHS resources.
Retrospective study	A retrospective study deals with the present/ past and does not involve studying future events. This contrasts with studies that are prospective.

Review	Summary of the main points and trends in the research literature on a specified topic. A review is considered non-systematic unless an extensive literature search has been carried out to ensure that all aspects of the topic are covered and an objective appraisal made of the quality of the studies.
Risk ratio	Ratio of the risk of an undesirable event or outcome occurring in a group of patients receiving experimental treatment compared with a comparison (control) group. The term relative risk is sometimes used as a synonym of risk ratio.
Sample	A part of the study's target population from which the subjects of the study will be recruited. If subjects are drawn in an unbiased way from a particular population, the results can be generalised from the sample to the population as a whole.
Sampling	Refers to the way participants are selected for inclusion in a study.
Sampling frame	A list or register of names which is used to recruit participants to a study.
Secondary care	Care provided in hospitals.
Secondary outcome	An outcome used to evaluate additional effects of the intervention deemed a priori as being less important than the primary outcomes.
Seizure	An uncontrolled discharge of nerve impulses which may spread throughout the brain. It usually lasts only a few minutes. It may be associated with loss of consciousness or loss of bowel and bladder control.
Selection bias	Selection bias has occurred if: the characteristics of the sample differ from those of the wider population from which the sample has been drawn OR there are systematic differences between comparison groups of patients in a study in terms of prognosis or responsiveness to treatment.
Selection criteria	Explicit standards used by guideline development groups to decide which studies should be included and excluded from consideration as potential sources of evidence.
Semi-structured interview	Structured interviews involve asking people pre-set questions. A semi-structured interview allows more flexibility than a structured interview. The interviewer asks a number of open-ended questions, following up areas of interest in response to the information given by the respondent.
Sensitivity analysis	A means of representing uncertainty in the results of economic evaluations. Uncertainty may arise from missing data, imprecise estimates or methodological controversy. Sensitivity analysis also allows for exploring the generalisability of results to other settings. The analysis is repeated using different assumptions to examine the effect on the results.

	One-way simple sensitivity analysis (univariate analysis): each parameter is varied individually in order to isolate the consequences of each parameter on the results of the study. Multi-way simple sensitivity analysis (scenario analysis): two or more parameters are varied at the same time and the overall effect on the results is evaluated. Threshold sensitivity analysis: the critical value of parameters above or below which the conclusions of the study will change are identified. Probabilistic sensitivity analysis: probability distributions are assigned to the uncertain parameters and are incorporated into evaluation models based on decision analytical techniques (For example, Monte Carlo simulation).
Sensitivity	In diagnostic testing, it refers to the chance of having a positive test result given that you have the disease. 100% sensitivity means that all those with the disease will test positive, but this is not the same the other way around. A patient could have a positive test result but not have the disease – this is called a 'false positive'. The sensitivity of a test is also related to its 'negative predictive value' (true negatives) – a test with a sensitivity of 100% means that all those who get a negative test result do not have the disease. To fully judge the accuracy of a test, its Specificity must also be considered.
Sequelae	Plural of sequela, which is any abnormal condition that occurs subsequent to and/or is caused by disease, injury, or treatment.
Significance (statistical)	A result is deemed statistically significant if the probability of the result occurring by chance is less than 1 in 20 ($p < 0.05$).
Single blind study	A study in which either the subject (patient/participant) or the observer (clinician/investigator) is not aware of which treatment or intervention the subject is receiving.
Specific indication	When a drug or a device has a specific remit to treat a specific condition and is not licensed for use in treating other conditions or diseases.
Specificity	In diagnostic testing, it refers to the chance of having a negative test result given that you do not have the disease. 100% specificity means that all those without the disease will test negative, but this is not the same the other way around. A patient could have a negative test result yet still have the disease – this is called a 'false negative'. The specificity of a test is also related to its 'positive predictive value' (true positives) – a test with a specificity of 100% means that all those who get a positive test result definitely have the disease. To fully judge the accuracy of a test, its Sensitivity must also be considered.
Stakeholder	Those with an interest in the use of the guideline. Stakeholders include manufacturers, sponsors, healthcare professionals, and patient and carer groups.
Standard deviation	A measure of the spread, scatter or variability of a set of measurements. Usually used with the mean (average) to describe

	numerical data.
Stand by call	Contact between a paramedic or other healthcare worker and an emergency department, by telephone or radio, to alert the department to the impending arrival of a seriously ill or injured patient who will require immediate resuscitation.
Statistical power	The ability of a study to demonstrate an association or causal relationship between two variables, given that an association exists. For example, 80% power in a clinical trial means that the study has a 80% chance of ending up with a P value of less than 5% in a statistical test (that is, a statistically significant treatment effect) if there really was an important difference (for example, 10% versus 5% mortality) between treatments. If the statistical power of a study is low, the study results will be questionable (the study might have been too small to detect any differences). By convention, 80% is an acceptable level of power. See also P value.
Structured interview	A research technique where the interviewer controls the interview by adhering strictly to a questionnaire or interview schedule with pre-set questions.
Study checklist	A list of questions addressing the key aspects of the research methodology that must be in place if a study is to be accepted as valid. A different checklist is required for each study type. These checklists are used to ensure a degree of consistency in the way that studies are evaluated.
Study population	People who have been identified as the subjects of a study.
Study quality	See Methodological quality.
Study type	The kind of design used for a study. Randomised controlled trial, case-control study, cohort study are all examples of study types.
Suspicion of skull fracture or penetrating injury	For example, clear fluid running from the ears or nose, black eye with no associated damage around the eye, bleeding from one or both ears, new deafness in one or both ears, bruising behind one or both ears, penetrating injury signs, visible trauma to the scalp or skull.
Sub-group analysis	An analysis in which the intervention effect is evaluated in a defined subset of the participants in the trial, or in complementary subsets, such as by sex or in age categories.
Subdural space	The space beneath the dura mater, between it and the much thinner arachnoid mater. This is often the area of rupture of delicate thin-walled veins following head injuries.
Subdural haematoma (or haemorrhage)	A collection of blood between the dura mater and the arachnoid mater caused by traumatic damage to the associated brain and blood vessels. The rise in pressure caused by such bleeding can cause further significant damage
Subject	A person who takes part in an experiment or research study.
Subluxation	A partial dislocation of a joint in which the joint surfaces remain in contact, albeit out of alignment.

Survey	A study in which information is systematically collected from people (usually from a sample within a defined population).
Systematic	Methodical, according to plan; not random.
Systematic error	Refers to the various errors or biases inherent in a study. See also Bias.
Systematic review	A review in which evidence from scientific studies has been identified, appraised and synthesised in a methodical way according to predetermined criteria. May or may not include a meta-analysis.
Systemic	Involving the whole body.
Target population	The people to whom guideline recommendations are intended to apply. Recommendations may be less valid if applied to a population with different characteristics from the participants in the research study – for example, in terms of age, disease state, social background.
Tertiary centre	A specialist medical centre providing complex treatments which receives referrals from both primary and secondary care. Sometimes called a tertiary referral centre. See also Primary care and Secondary care.
Time horizon	The time span over which costs and health outcomes are considered in a decision analysis or economic evaluation.
Treatment allocation	Assigning a participant to a particular arm of the trial.
Torticollis	Involuntary spasms of the musculature in the neck.
Triangulation	Use of three or more different research methods in combination; principally used as a check of validity. The more the different methods produce similar results, the more valid the findings.
Triple blind study	A study in which the statistical analysis is carried out without knowing which treatment patients received, in addition to the patients and investigators/clinicians being unaware which treatment patients were getting.
Unconsciousness	A temporary or prolonged loss of awareness of self and of surroundings
Univariate	Analysis which separately explores each variable in a data set.
Utility	A measure of the strength of an individual's preference for a specific health state in relation to alternative health states. The utility scale assigns numerical values on a scale from 0 (death) to 1 (optimal or 'perfect' health). Health states can be considered worse than death and thus have a negative value.
Validation study	A study that tests a proposed clinical decision rule (see derivation study and clinical decision rule) to establish the diagnostic performance characteristics of the rule within a relevant population.
Validity	Assessment of how well a tool or instrument measures what it is intended to measure. See also External validity, Internal validity.
Variable	A measurement that can vary within a study, for example, the age of

	participants. Variability is present when differences can be seen between different people or within the same person over time, with respect to any characteristic or feature which can be assessed or measured.
X-ray	A radiograph made by projecting X-rays through organs or structures of the body onto a photographic film. Structures that are relatively radiopaque (allow few X-rays to pass through), such as bones and cavities filled with a radiopaque contrast medium, cast a shadow on the film. Also called X-ray film.

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