Head Injury: triage, assessment, investigation and early management of head injury in infants, children and adults (Partial Update)

National Collaborating Centre for Acute Care

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Foreword

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HEAD INJURY UPDATE FULL GUIDELINE: DRAFT FOR CONSULTATION
(FEB 2007)

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Conflict of interests (2003 and 2007)
The Guideline Development Group were asked to declare any possible conflict of interest they might have that could interfere with their work on the guideline. No conflicts of interest were declared.

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Stakeholder involvement

The following stakeholders commented on draft versions of these guidelines (2003):

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British Paediatric Neurology Association
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British Society of Rehabilitation Medicine
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Faculty of Public Health Medicine
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Royal College of Ophthalmologists
Royal College of Paediatrics and Child Health
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Royal College of Psychiatrists
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Victim Support
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Wessex Neurological Centre

Stakeholder Involvement

The following stakeholders registered with NICE and were invited to comment on draft versions of these guidelines (2007):

- 5 Boroughs Partnership NHS Trust
- Acute Care Collaborating Centre
- Addenbrooke's NHS Trust
- Adults Strategy and Commissioning Unit
- Aintree Hospitals NHS Trust
- Association for Spina Bifida & Hydrocephalus (ASBAH)
- Association of British Neurologists
- Association of the British Pharmaceuticals Industry,(ABPI)
- Barnsley Acute Trust
- Barnsley PCT
- Biophausia AB
- Bradford & Airedale Primary Care Trust
- British and Irish Orthoptic Society
- British Association for Counselling and Psychotherapy (BACP)
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• CASPE Research
• Chartered Society of Physiotherapy (CSP)
• Childrens Acute Transport Service
• Chronic Conditions Collaborating Centre
• Clinical Effectiveness Committee
• Clinovia Ltd
• College of Emergency Medicine
• College of Occupational Therapists
• Commission for Social Care Inspection
• Community Practitioners and Health Visitors Association
• Connecting for Health
• Conwy & Denbighshire Acute Trust
• Cornwall Acute Trust
• Cyrenians
• Department for Education and Skills
• Department of Health
• Derbyshire Mental Health Trust
• Dudley Group of Hospitals NHS Trust
• East and North Herts NHS Trust
• Eaton Foundation
• Faculty of Dental Surgery
• Gloucestershire Partnership NHS Trust
• Good Hope Hospitals NHS Trust
• Great Ormond Street Hospital for Children NHS Trust
• Hampshire PCT
• Headway - The Brain Injury Association
• Health and Safety Executive
• Health Commission Wales
• Healthcare Commission
• Heart of England NHS Foundation Trust
• Help the Hospices
• Hertfordshire Partnership NHS Trust
• Huntleigh Healthcare
• Institute of Physics and Engineering in Medicine
• King's College Acute Trust
• Kingston PCT
• Leeds Teaching Hospitals NHS Trust
• Liverpool PCT
• Luton and Dunstable Hospital NHS Trust
• Maidstone and Tunbridge Wells NHS Trust
• Medicines and Healthcare Products Regulatory Agency (MHRA)
• Mental Health Act Commission
• Mental Health Collaborating Centre
• Mental Health Nurses Association
• National Institute for Mental Health in England (NIMHE)
• National Patient Safety Agency
• National Public Health Service - Wales
• National Treatment Agency for Substance Misuse
• NCC for Cancer
• NCCHTA
• NCEPOD
• NHS Direct
• NHS Health and Social Care Information Centre
• NHS Pathways
• NHS Plus
• NHS Quality Improvement Scotland
• North Cumbria Acute Hospitals NHS Trust
• North Staffordshire Combined Healthcare NHS Trust
• Northwest London Hospitals NHS Trust
• Nottingham City PCT
• Novo Nordisk Limited
• Nursing & Supportive Care Collaborating Centre
• Nutricia Ltd (UK)
• Oxfordshire & Buckinghamshire Mental Health Trust
• Patient and Public Involvement Programme for NICE
• PERIGON (formerly The NHS Modernisation Agency)
• Primary Care Collaborating Centre
• Primary Care Neurology Society
• Regional Public Health Group - London
• Royal College of General Practitioners
• Royal College of Nursing
• Royal College of Paediatrics and Child Health
• Royal College of Pathologists
• Royal College of Physicians of London
• Royal College of Radiologists
• Royal College of Speech and Language Therapists
• Royal National Hospital For Rheumatic Diseases
• Royal United Hospital Bath NHS Trust
• Saracen Care Services
• Scottish Intercollegiate Guidelines Network (SIGN)
• Sheffield Children's Hospital Trust
• Sheffield PCT
• Sheffield Teaching Hospitals NHS Foundation Trust
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• St George's Healthcare NHS Trust
• Staffordshire Ambulance HQ
• Staffordshire Ambulance Service NHS Trust
• Staffordshire Moorlands PCT
• Stockport PCT
• Tameside and Glossop Acute Trust
• The Association of the British Pharmaceutical Industry (ABPI)
• The British Psychological Society
• The Chartered Society of Physiotherapy
• The Confidential Enquiry into Maternal & Child Health (CEMACH)
• The David Lewis Centre
• The North West London Hospitals NHS Trust
• The Robert Jones & Agnes Hunt Orthopaedic & District Hospital NHS Trust
• The Royal Society of Medicine
• The Stroke Association
• Tissue Viability Nurses Association
• UK Specialised Services Public Health Network
• University College London Hospitals (UCLH) Acute Trust
• University Hospital Birmingham NHS Trust
• Vitaline Pharmaceuticals UK Ltd
• Walsall PCT
• Walton Centre for Neurology and Neurosurgery NHS Trust
• Welsh Assembly Government
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- Welsh Scientific Advisory Committee (WSAC)
- Wessex Neurological Centre
- Wirral Hospital Acute Trust
- Withybush Hospital
- Women's & Children's Collaborating Centre

The Guideline Review Panel is an independent panel that oversees the development of the guideline and takes responsibility for monitoring its quality. The members of the Guideline Review Panel were as follows:

To be completed after consultation
# Abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Definition</th>
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<tbody>
<tr>
<td>A&amp;E</td>
<td>Accident and emergency</td>
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<tr>
<td>ABC</td>
<td>Airways, breathing, circulation.</td>
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<tr>
<td>ALS</td>
<td>Advanced Life Support</td>
</tr>
<tr>
<td>APLS</td>
<td>Advanced paediatric life support course</td>
</tr>
<tr>
<td>ARR</td>
<td>Absolute risk reduction</td>
</tr>
<tr>
<td>ATLS</td>
<td>Advanced trauma life support</td>
</tr>
<tr>
<td>AVPU</td>
<td>AVPaediatric Unit</td>
</tr>
<tr>
<td>BLS</td>
<td>Basic Life Support</td>
</tr>
<tr>
<td>CT</td>
<td>Computer tomography</td>
</tr>
<tr>
<td>EMD</td>
<td>Emergency Medical Dispatch</td>
</tr>
<tr>
<td>EPLS</td>
<td>European paediatric life support course</td>
</tr>
<tr>
<td>GCS</td>
<td>Glasgow Coma Scale or Score</td>
</tr>
<tr>
<td>GDG</td>
<td>Guideline Development Group</td>
</tr>
<tr>
<td>GOS</td>
<td>Glasgow Outcome Scale</td>
</tr>
<tr>
<td>HTA</td>
<td>Health Technology Assessment</td>
</tr>
<tr>
<td>ICH</td>
<td>Intracranial Haematoma</td>
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<tr>
<td>MRI</td>
<td>Magnetic Resonance Imaging</td>
</tr>
<tr>
<td>NEXUS</td>
<td>National Emergency X-Radiography Utilization Study</td>
</tr>
<tr>
<td>NICE</td>
<td>National Institute for Health and Clinical Excellence</td>
</tr>
<tr>
<td>NAI</td>
<td>Non-accidental injury</td>
</tr>
<tr>
<td>NRPB</td>
<td>National Radiological Protection Board</td>
</tr>
<tr>
<td>QALY</td>
<td>Quality Adjusted Life Year</td>
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### Glossary

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
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<tr>
<td><strong>Absolute risk</strong></td>
<td>Measures the probability of an event or outcome occurring (e.g. 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.</td>
</tr>
<tr>
<td><strong>Absolute Risk Reduction (ARR)</strong></td>
<td>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.</td>
</tr>
<tr>
<td><strong>Acute care centre</strong></td>
<td>Static centre where patients with urgent care needs are taken.</td>
</tr>
<tr>
<td><strong>Acute sector</strong></td>
<td>Hospital-based health services which are provided on an in-patient, day case or out-patient basis.</td>
</tr>
<tr>
<td><strong>Advanced Paediatric Life Support (APLS) system</strong></td>
<td>The Advance Life Support Group is a registered medical education charity. The organisation aims to preserve life by providing training and education for paediatric life saving techniques. (See <a href="http://www.alsg.org/">http://www.alsg.org/</a>)</td>
</tr>
<tr>
<td><strong>Advanced Trauma Life Support (ATLS) system</strong></td>
<td>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 <a href="http://www.rcseng.ac.uk/education/courses">http://www.rcseng.ac.uk/education/courses</a>)</td>
</tr>
<tr>
<td><strong>Algorithm (in guidelines)</strong></td>
<td>A flow chart of the clinical decision pathway described in the guideline, where decision points are represented with boxes, linked with arrows.</td>
</tr>
<tr>
<td><strong>Allocation concealment</strong></td>
<td>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.</td>
</tr>
<tr>
<td><strong>Amnesia</strong></td>
<td>Partial or total loss of memory, usually resulting from shock, psychological disturbance, brain injury, or illness.</td>
</tr>
<tr>
<td><strong>Applicability</strong></td>
<td>The extent to which the results of a study or review can be applied to the target population for a clinical guideline.</td>
</tr>
<tr>
<td><strong>Appraisal of evidence</strong></td>
<td>Formal assessment of the quality of research evidence and its relevance to the clinical question or guideline under consideration, according to predetermined criteria.</td>
</tr>
<tr>
<td><strong>ARR</strong></td>
<td>See Absolute Risk Reduction.</td>
</tr>
<tr>
<td><strong>Basal skull fracture</strong></td>
<td>A fracture involving the base of the cranium.</td>
</tr>
<tr>
<td><strong>Battle's sign</strong></td>
<td>Postauricular (behind the ear) ecchymosis in cases of fracture of the base of the skull (basal skull fracture).</td>
</tr>
<tr>
<td><strong>Best available evidence</strong></td>
<td>The strongest research evidence available to support a particular guideline recommendation.</td>
</tr>
<tr>
<td><strong>Bias</strong></td>
<td>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, e.g. in the collection, analysis, interpretation, publication or review of research data. For examples see Selection bias, Performance bias, Information bias, Confounding, Publication bias.</td>
</tr>
<tr>
<td><strong>Blinding or masking</strong></td>
<td>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).</td>
</tr>
</tbody>
</table>
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<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
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<tbody>
<tr>
<td>Purpose of ‘blinding’ or ‘masking’</td>
<td>To protect against bias. See also Double blind study, Single blind study, Triple blind study.</td>
</tr>
<tr>
<td>C-spine</td>
<td>Cervical spine</td>
</tr>
<tr>
<td>Case-control study</td>
<td>A study that starts with the identification of a group of individuals sharing the same characteristics (e.g. people with a particular disease) and a suitable comparison (control) group (e.g. people without the disease). All subjects are then assessed with respect to things that happened to them in the past, e.g. 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.</td>
</tr>
<tr>
<td>Case report (or case study)</td>
<td>Detailed report on one patient (or case), usually covering the course of that person’s disease and their response to treatment.</td>
</tr>
<tr>
<td>Case series</td>
<td>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.</td>
</tr>
<tr>
<td>Causal relationship</td>
<td>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 (e.g. environmental factors) had been ruled out.</td>
</tr>
<tr>
<td>Cerebrospinal fluid otorrhea</td>
<td>Discharge from the external ear of a watery fluid, continuously being produced and absorbed, which flows in the ventricles (cavities) within the brain and around the surface of the brain and spinal cord.</td>
</tr>
<tr>
<td>Cervical spine</td>
<td>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, referred to by ‘C’, appended with an identifying number. The number indicates the level of the spine in which the particular vertebra is located.</td>
</tr>
<tr>
<td>Cervico-dorsal junction</td>
<td>The junction between the bottom of the cervical spine and the top of the dorsal spine.</td>
</tr>
<tr>
<td>Clinical audit</td>
<td>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.</td>
</tr>
<tr>
<td>Clinical decision rule</td>
<td>A clinical decision rule/clinical prediction rule is generated by initially examining, and ultimately combining, a number of variables to predict the likelihood of a current diagnosis of a future event. Sometimes, if the likelihood is sufficiently high or low, the rule generates a suggested course of action.</td>
</tr>
<tr>
<td>Clinical effectiveness</td>
<td>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.</td>
</tr>
<tr>
<td>Clinical impact</td>
<td>The effect that a guideline recommendation is likely to have on the treatment, or treatment outcomes, of the target population.</td>
</tr>
<tr>
<td>Clinical question</td>
<td>This term is sometimes used in guideline development work to refer to the...</td>
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</table>
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 health care professional providing patient care, e.g. doctor, nurse, physiotherapist.

**Closed head injury**
A bouncing motion of the brain that results from a blow to the head or severe shaking that does not penetrate the skull or brain tissue. This bouncing motion can cause tearing, shearing or stretching of the nerves at the base of the brain, blood clots, edema (swelling) and even death.

**Cluster randomisation**
A study in which groups of individuals (e.g. patients in a GP 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 GP 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 (e.g. 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, e.g. 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. May be caused by hyperglycaemia (high blood glucose) or hypoglycaemia (low blood glucose) in people with diabetes.

**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, paramedics, NHS walk-in centres and dental practitioners.

**Concussion**
The common result of a blow to the head or sudden deceleration usually causing an altered mental state, either temporary or prolonged. Physiologic and/or anatomic 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.

**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 health care treatment are measured in the same monetary units. If benefits exceed costs, the evaluation would recommend providing the treatment.

**Cost effectiveness**

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 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 or superior end of the body.

**Craniocervical junction**

The junction between the base of the skull and the top of the cervical spine.

**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...
<table>
<thead>
<tr>
<th>Concept</th>
<th>Definition</th>
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<tbody>
<tr>
<td>Cross-sectional study</td>
<td>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.)</td>
</tr>
<tr>
<td>Data set</td>
<td>A list of required information relating to a specific disease.</td>
</tr>
<tr>
<td>Decision analysis</td>
<td>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.</td>
</tr>
<tr>
<td>Diagnostic study</td>
<td>A study to assess the effectiveness of a test or measurement in terms of its ability to accurately detect or exclude a specific disease.</td>
</tr>
<tr>
<td>Double blind study</td>
<td>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.</td>
</tr>
<tr>
<td>Drowsiness</td>
<td>A state of impaired awareness associated with a desire or inclination to sleep.</td>
</tr>
<tr>
<td>Economic evaluation</td>
<td>Comparative analysis of alternative courses of action in terms of both their costs and consequences.</td>
</tr>
<tr>
<td>Effectiveness</td>
<td>See Clinical effectiveness.</td>
</tr>
<tr>
<td>Efficacy</td>
<td>The extent to which a specific treatment or intervention, under ideally controlled conditions (e.g. in a laboratory), has a beneficial effect on the course or outcome of disease compared to no treatment or other routine care.</td>
</tr>
<tr>
<td>Elective</td>
<td>Name for clinical procedures that are regarded as advantageous to the patient but not urgent.</td>
</tr>
<tr>
<td>Empirical</td>
<td>Based directly on experience (observation or experiment) rather than on reasoning alone.</td>
</tr>
<tr>
<td>Epidemiology</td>
<td>Study of diseases within a population, covering the causes and means of prevention.</td>
</tr>
<tr>
<td>European paediatric life support course (EPLS)</td>
<td>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 <a href="http://www.resus.org.uk/">http://www.resus.org.uk/</a>)</td>
</tr>
<tr>
<td>Event rate</td>
<td>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.</td>
</tr>
<tr>
<td>Evidence based clinical practice</td>
<td>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.</td>
</tr>
<tr>
<td>Evidence table</td>
<td>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.</td>
</tr>
<tr>
<td>Exclusion criteria</td>
<td>See Selection criteria.</td>
</tr>
<tr>
<td>Experimental study</td>
<td>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.</td>
</tr>
<tr>
<td>Experimental treatment</td>
<td>A treatment or intervention (e.g. a new drug) being studied to see if it has an effect on the course or outcome of a condition or disease.</td>
</tr>
<tr>
<td>Term</td>
<td>Definition</td>
</tr>
<tr>
<td>----------------------</td>
<td>---------------------------------------------------------------------------</td>
</tr>
<tr>
<td>External validity</td>
<td>The degree to which the results of a study hold true in non-study situations, e.g. in routine clinical practice. May also be referred to as the generalisability of study results to non-study patients or populations.</td>
</tr>
<tr>
<td>Extradural space</td>
<td>The space on the outer side of the dura mater.</td>
</tr>
<tr>
<td>Extrapolation</td>
<td>The application of research evidence based on studies of a specific population to another population with similar characteristics.</td>
</tr>
<tr>
<td>Focal Neurological Deficit</td>
<td>A neurological deficit restricted to a particular part of the body or a particular activity</td>
</tr>
<tr>
<td>Forest plot</td>
<td>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.</td>
</tr>
<tr>
<td>Funnel plot</td>
<td>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.</td>
</tr>
<tr>
<td>Generalisability</td>
<td>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.</td>
</tr>
<tr>
<td>Glasgow Coma Scale</td>
<td>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.</td>
</tr>
<tr>
<td>Gold standard</td>
<td>A method, procedure or measurement that is widely accepted as being the best available.</td>
</tr>
<tr>
<td>Haematoma</td>
<td>An accumulation of blood under the tissues to produce a solid swelling.</td>
</tr>
<tr>
<td>Haemotympanum</td>
<td>A collection of blood in the middle ear space</td>
</tr>
<tr>
<td>Health economics</td>
<td>A field of conventional economics which examines the benefits of health care interventions (e.g. medicines) compared with their financial costs.</td>
</tr>
<tr>
<td>Heterogeneity</td>
<td>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.</td>
</tr>
<tr>
<td>Hierarchy of evidence</td>
<td>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.</td>
</tr>
<tr>
<td>Homogeneity</td>
<td>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.</td>
</tr>
<tr>
<td>Hyperventilation</td>
<td>Abnormally rapid breathing usually accompanied by air swallowing. Hyperventilation results in excessive intake of oxygen and increased elimination of carbon dioxide, which may eventually lead to a disturbance in the body's acid-base balance.</td>
</tr>
<tr>
<td>Hypoglycaemia</td>
<td>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.</td>
</tr>
<tr>
<td><strong>Inclusion criteria</strong></td>
<td>See Selection criteria.</td>
</tr>
<tr>
<td>-----------------------</td>
<td>-------------------------</td>
</tr>
<tr>
<td><strong>Infant</strong></td>
<td>Aged less than 1 year.</td>
</tr>
<tr>
<td><strong>Intention to treat analysis</strong></td>
<td>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.</td>
</tr>
<tr>
<td><strong>Internal validity</strong></td>
<td>Refers to the integrity of the study design.</td>
</tr>
<tr>
<td><strong>Intervention</strong></td>
<td>Healthcare action intended to benefit the patient, e.g. drug treatment, surgical procedure, psychological therapy, etc.</td>
</tr>
<tr>
<td><strong>Interventional procedure</strong></td>
<td>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 Clinical Excellence (NICE) has the task of producing guidance about whether specific interventional procedures are safe enough and work well enough for routine use.</td>
</tr>
<tr>
<td><strong>Intracranial</strong></td>
<td>Originating within the cranial (brain) cavity.</td>
</tr>
<tr>
<td><strong>Intracranial haematoma</strong></td>
<td>Rupture of a blood vessel that causes blood to leak and form a blood clot (hematoma) that compresses brain tissue.</td>
</tr>
<tr>
<td><strong>Intracranial haemorrhage</strong></td>
<td>A bleed inside the skull.</td>
</tr>
<tr>
<td><strong>Intracranial lesion</strong></td>
<td>A lesion of the brain.</td>
</tr>
<tr>
<td><strong>Literature review</strong></td>
<td>A process of collecting, reading and assessing the quality of published (and unpublished) articles on a given topic.</td>
</tr>
<tr>
<td><strong>Longitudinal study</strong></td>
<td>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.)</td>
</tr>
<tr>
<td><strong>Mandible</strong></td>
<td>The lower jaw as a functional unit, regardless of which bones or cartilage make up the lower jaw in a particular organism.</td>
</tr>
<tr>
<td><strong>Meningism</strong></td>
<td>Symptoms that mimic those of meningitis but without inflammation of the meninges</td>
</tr>
<tr>
<td><strong>Meta analysis</strong></td>
<td>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 e.g. 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 &amp; Heterogeneity.</td>
</tr>
<tr>
<td><strong>Methodology</strong></td>
<td>The overall approach of a research project, e.g. the study will be a randomised controlled trial, of 200 people, over one year.</td>
</tr>
<tr>
<td><strong>Methodological quality</strong></td>
<td>The extent to which a study has conformed to recognised good practice in the design and execution of its research methods.</td>
</tr>
<tr>
<td><strong>Motor response</strong></td>
<td>Movement in reply to an external stimulus</td>
</tr>
<tr>
<td><strong>Multicentre study</strong></td>
<td>A study where subjects were selected from different locations or populations, e.g. a co-operative study between different hospitals; an international collaboration involving patients from more than one country.</td>
</tr>
<tr>
<td><strong>Neurorehabilitation services</strong></td>
<td>A program of clinical and vocational services with the goal of returning employees to a satisfying occupation, if possible, after injury to the nervous system.</td>
</tr>
<tr>
<td><strong>Neurosurgery</strong></td>
<td>A surgical specialty for the treatment of diseases and disorders of the brain, spinal cord, and peripheral and autonomic nervous system.</td>
</tr>
<tr>
<td><strong>Non-experimental study</strong></td>
<td>A study based on subjects selected on the basis of their availability, with no attempt having been made to avoid problems of bias.</td>
</tr>
<tr>
<td><strong>Non-systematic review</strong></td>
<td>See Review.</td>
</tr>
<tr>
<td><strong>Objective measure</strong></td>
<td>A measurement that follows a standardised procedure which is less open to subjective interpretation by potentially biased observers and study participants.</td>
</tr>
</tbody>
</table>
| **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 (e.g. whether or not people received a specific treatment or intervention) are studied.
in relation to changes or differences in other(s) (e.g. whether or not they died), without the intervention of the investigator. There is a greater risk of selection bias than in experimental studies.

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Occipital condyle</td>
<td>The articulation point between the skull and the first vertebra. It positioning on the skull helps determine whether the individual walked upright or not.</td>
</tr>
<tr>
<td>Odds ratio</td>
<td>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.</td>
</tr>
<tr>
<td>Outcome</td>
<td>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.</td>
</tr>
<tr>
<td>Paediatric</td>
<td>Pertaining to children and infants</td>
</tr>
<tr>
<td>Paraesthesia</td>
<td>Abnormal sensation such as burning or tingling due to a disorder of the sensory nervous system.</td>
</tr>
<tr>
<td>Penetrating head injury</td>
<td>Entering the interior of an organ or cavity, trauma to the head that does penetrate or fracture the skull.</td>
</tr>
<tr>
<td>Performance bias</td>
<td>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.</td>
</tr>
<tr>
<td>Periorbital haemotoma</td>
<td>A blood clot around or behind the eyes.</td>
</tr>
<tr>
<td>Pilot study</td>
<td>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.</td>
</tr>
<tr>
<td>Placebo</td>
<td>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.</td>
</tr>
<tr>
<td>Placebo effect</td>
<td>A beneficial (or adverse) effect produced by a placebo and not due to any property of the placebo itself.</td>
</tr>
<tr>
<td>Power</td>
<td>See Statistical power.</td>
</tr>
<tr>
<td>Primary care</td>
<td>Healthcare delivered to patients outside hospitals. Primary care covers a range of services provided by GPs, nurses and other health care professionals, dentists, pharmacists and opticians.</td>
</tr>
<tr>
<td>Probability</td>
<td>How likely an event is to occur, e.g. how likely a treatment or intervention will alleviate a symptom.</td>
</tr>
<tr>
<td>Prognostic factor</td>
<td>Patient or disease characteristics, e.g. 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.</td>
</tr>
</tbody>
</table>
| Prognostic marker     | A prognostic factor used to assign patients to categories for a specified purpose – e.g. 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
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 (i.e. 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, e.g. a patient’s description of their pain rather than a measure of pain. In health care, 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.

**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.)

<table>
<thead>
<tr>
<th><strong>Rehabilitation services</strong></th>
<th>A program of clinical and vocational services with the goal of returning employees to a satisfying occupation, if possible, after injury.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Relative risk</strong></td>
<td>A summary measure which represents the ratio of the risk of a given event or outcome (e.g. 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.</td>
</tr>
<tr>
<td><strong>Reliability</strong></td>
<td>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.</td>
</tr>
<tr>
<td><strong>Retrospective study</strong></td>
<td>A retrospective study deals with the present/past and does not involve studying future events. This contrasts with studies that are prospective.</td>
</tr>
<tr>
<td><strong>Review</strong></td>
<td>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.</td>
</tr>
<tr>
<td><strong>Risk ratio</strong></td>
<td>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.</td>
</tr>
<tr>
<td><strong>Sample</strong></td>
<td>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.</td>
</tr>
<tr>
<td><strong>Sampling</strong></td>
<td>Refers to the way participants are selected for inclusion in a study.</td>
</tr>
<tr>
<td><strong>Secondary care</strong></td>
<td>Care provided in hospitals.</td>
</tr>
<tr>
<td><strong>Seizure</strong></td>
<td>An uncontrolled discharge of nerve cells which may spread to other cells nearby or throughout the entire brain. It usually lasts only a few minutes. It may be associated with loss of consciousness, loss of bowel and bladder control and tremors. May also cause aggression or other behavioral change.</td>
</tr>
<tr>
<td><strong>Selection bias</strong></td>
<td>Selection bias has occurred if: a) the characteristics of the sample differ from those of the wider population from which the sample has been drawn OR b) there are systematic differences between comparison groups of patients in a study in terms of prognosis or responsiveness to treatment.</td>
</tr>
<tr>
<td><strong>Selection criteria</strong></td>
<td>Explicit standards used by guideline development groups to decide which studies should be included and excluded from consideration as potential sources of evidence.</td>
</tr>
<tr>
<td><strong>Semi-structured interview</strong></td>
<td>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.</td>
</tr>
</tbody>
</table>
| **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
<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head trauma</td>
<td>Injury to the head or brain, often caused by a blow, jolt, or shake to the head.</td>
</tr>
<tr>
<td>Head injury</td>
<td>Damage to the brain caused by an external force, often due to a blow to the head.</td>
</tr>
<tr>
<td>Headache</td>
<td>Persistent or recurrent pain or discomfort perceived as originating in the head.</td>
</tr>
<tr>
<td>Sequelea</td>
<td>Plural of sequela, which is any abnormal condition that occurs subsequent to and/or is caused by disease, injury, or treatment.</td>
</tr>
<tr>
<td>Single blind study</td>
<td>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.</td>
</tr>
<tr>
<td>Specific indication</td>
<td>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.</td>
</tr>
<tr>
<td>Specificity</td>
<td>In diagnostic testing, it refers to the chance of having a negative test result given that the disease is not the same the 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.</td>
</tr>
<tr>
<td>Standard deviation</td>
<td>A measure of the spread, scatter or variability of a set of measurements. Usually used with the mean (average) to describe numerical data.</td>
</tr>
<tr>
<td>Statistical power</td>
<td>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 (i.e. a statistically significant treatment effect) if there really was an important difference (e.g. 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.</td>
</tr>
<tr>
<td>Structured interview</td>
<td>A research technique where the interviewer controls the interview by adhering strictly to a questionnaire or interview schedule with pre-set questions.</td>
</tr>
<tr>
<td>Study checklist</td>
<td>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.</td>
</tr>
<tr>
<td>Study population</td>
<td>People who have been identified as the subjects of a study.</td>
</tr>
<tr>
<td>Study quality</td>
<td>See Methodological quality.</td>
</tr>
<tr>
<td>Study type</td>
<td>The kind of design used for a study. Randomised controlled trial, case-control study, cohort study are all examples of study types.</td>
</tr>
<tr>
<td>Sub-group analysis</td>
<td>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.</td>
</tr>
<tr>
<td>Subdural space</td>
<td>The space located between the innermost layer of the dura mater and the arachnoid mater. This is often the area of rupture of delicate thin-walled veins following head injuries.</td>
</tr>
<tr>
<td>Subdural haematoma</td>
<td>A subdural hematoma, also called a subdural hemorrhage, is a collection of blood between the dura (the outer protective covering of the brain) and the arachnoid (the middle layer of the meninges). Such bleeding often separates these two meningeal layers. Injury to the brain may then result from local pressure, increased intracranial pressure, or related insults.</td>
</tr>
<tr>
<td>Subject</td>
<td>A person who takes part in an experiment or research study.</td>
</tr>
<tr>
<td>Subluxation</td>
<td>A partial dislocation of a joint in which the bones become out of alignment, but the joint itself is still intact.</td>
</tr>
<tr>
<td>Survey</td>
<td>A study in which information is systematically collected from people (usually from a sample within a defined population).</td>
</tr>
<tr>
<td>Systematic</td>
<td>Methodical, according to plan; not random.</td>
</tr>
<tr>
<td>Systematic error</td>
<td>Refers to the various errors or biases inherent in a study. See also Bias.</td>
</tr>
<tr>
<td>Systematic review</td>
<td>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.</td>
</tr>
<tr>
<td><strong>Systemic</strong></td>
<td>Involving the whole body.</td>
</tr>
<tr>
<td><strong>Target population</strong></td>
<td>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 – e.g. in terms of age, disease state, social background.</td>
</tr>
<tr>
<td><strong>Tertiary centre</strong></td>
<td>A major 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.</td>
</tr>
<tr>
<td><strong>Torticollis</strong></td>
<td>Involuntary spasms of the musculature of the spine in the neck.</td>
</tr>
<tr>
<td><strong>Triangulation</strong></td>
<td>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.</td>
</tr>
<tr>
<td><strong>Triple blind study</strong></td>
<td>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.</td>
</tr>
<tr>
<td><strong>Unconsciousness</strong></td>
<td>A temporary or prolonged loss of awareness of self and of surroundings</td>
</tr>
<tr>
<td><strong>Validity</strong></td>
<td>Assessment of how well a tool or instrument measures what it is intended to measure. See also External validity, Internal validity.</td>
</tr>
<tr>
<td><strong>Variable</strong></td>
<td>A measurement that can vary within a study, e.g. 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.</td>
</tr>
</tbody>
</table>
Background and scope

1.1 Introduction

This guideline was first published in June 2003 and the present guideline is a partial update of only some areas where new evidence has been published since the original published guideline. There is only one guideline incorporating both the original and the updates sections. All updated sections of the guideline are not highlighted in grey for the readers ease. All non highlighted section have been updated.

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.\textsuperscript{75,76} 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 Accident and Emergency (A&E) Departments. A figure of one million A&E attenders for the United Kingdom as a whole is often quoted but this is based on figures from the late 1970s.\textsuperscript{150} It is estimated that head injury admissions represent around 20% of all head injury attenders,\textsuperscript{157} which would imply around 600,000 patients per annum attending A&E in England and Wales with a head injury. The true A&E 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 A&E dataset increases.

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\textsuperscript{294} 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). 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). As few as 0.2% of all patients attending A&E with a head injury will die as a result of this injury. 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. Therefore A&E 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.

1.2 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. They were used in the UK for over fifteen years and relied on various clinical factors, particularly the level of consciousness, to triage patients with a head injury into different risk categories. The main investigation incorporated into these guidelines was skull radiography, reflecting the perceived 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. The triage and imaging of patients who have sustained a head injury is also addressed by guidelines from the Royal College of Radiologists.
The recent recommendations of the Scottish Intercollegiate Guidelines Network centre around the identification of patients with a high (e.g. 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, but the value of this in terms of sensitivity and specificity in the detection of haematomas was not determined.

1.3 **Role of CT imaging**

There is evidence of an increased desire to perform CT scanning in the UK. UK Hospitals have seen a marked increase in the number of CT scans being requested and over the last five years the number of CT scans being requested for head injury has doubled in District General Hospitals (Yates DW, personal communication, 2002). This change was advocated by Neurosurgeons in 1990 and 1998, 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. The move to CT reflects a general consensus that earlier definitive imaging is associated with improved outcomes.

1.4 **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 triage tools, with observation for patients with 'medium-risk' and CT for the highest risk groups. In the USA, CT scanning is performed in between 75% to 100% of all patients with normal GCS and some previous loss of consciousness following a head injury. This is in marked contrast to CT scan rates in the UK that are in the order of 32% of all patients attending the A&E Department with a head injury. In the UK, controversy over guidelines for head injury centres 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.\textsuperscript{135,249,304}

### 1.5 The skull radiograph

Historically, in the absence of readily available CT scanning resources, skull X-ray was used to triage patients with minor/mild head injuries into high and low risk groups. Previously in the UK up to 74\% of all patients attending A&E with a head injury receive a skull X-ray, even though the image may reveal a fracture in only 2\% of cases.\textsuperscript{71,104}

An elevation of risk following positive skull X-ray is widely acknowledged and supported by UK evidence.\textsuperscript{197} 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.\textsuperscript{135} 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 A&E clinicians will miss between 13\% and 23\% of all skull fractures that are detected when radiographs are subsequently reviewed by a radiologist.\textsuperscript{104,181,317}

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 (e.g. multisection helical CT), 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 other uncooperative patients. Nevertheless, anaesthesia and ventilation may still be necessary in restless patients and young children.

1.6 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. 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.

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 six hours and 14 days after the head injury, with a median delay of 18 hours.

This is not a problem unique to the UK as 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. 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, but it is unclear whether this has resulted in an increased proportion of patients with head injury being observed in A&amp;E Department wards.

1.7 Morbidity

The incidence of morbidity after head injury is higher than had been previously appreciated 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 (i.e. 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. They saw 639 patients who had originally had a minor head injury. Fifty-six per cent were not back to work at two weeks, and 12% had not returned to work at 6 weeks. In addition at six weeks many had persisting symptoms including headache (13%), memory loss (15%) and concentration problems (14%). This data has been reproduced in other countries.

1.8 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.\textsuperscript{75,76,150,157,309}

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.\textsuperscript{1,126,156,161,178,210}

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. This is comparable with UK estimates. However, the Canadian study found that 43% had been in some form of road traffic accidents, which is 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%).\textsuperscript{304} The Guideline Development Group is also of the opinion that a head injury episode is more likely to have alcohol involvement in the UK than in Canada.
1.9 **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. Compared to North America however, different protocols are still being followed in 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 this data is confounded by case mix issues, especially the older age profile of patients with head injury in England and Wales. 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. This shortfall can lead to delays in patient transfer, and is symptomatic of larger resource and workload issues for neurosurgery in the UK. 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.

1.10 Scope

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 provides advice on effective care using the best possible research evidence. The project 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 A&E staff on the management of patients who re-present with suspicious symptoms;

guidance on appropriate handover arrangements;

information for patients and carers.

1.11 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 been unaware that they had sustained a head injury because of intoxication or other causes. The guideline does not provide advice on the management of patients with other traumatic injury to the head (e.g. 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.

1.12 Health care setting

The guideline covers the care received from NHS advice sources (e.g. NHS Direct, A&E 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 A&E 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.

### 1.13 The need for this update guideline

Up to 2 years after publication of all NICE guidelines any new evidence is considered for relevance and importance. The original guideline was produced in June 2003 and this current version is the 2 year partial update of the previous guideline. There was sufficient new evidence to prompt an update to be carried out. This update affects only a few recommendations within the original guideline.

New evidence has been incorporated using the latest version of the NICE technical manual (April 2006). The original guideline was produced using methodology used between 2001-03, prior to the first version of the NICE technical manual. In this update we have not sought to revisit previously reviewed literature and recommendations except in the areas that we are updating. The write up of sections that we have not updated has not been amended and we have added sections only where an update was needed. A full update will be considered 2 years after publication of this version.

### 1.14 What are clinical practice guidelines?

Our clinical guidelines are recommendations for the care of individuals in specific clinical conditions or circumstances within the NHS – from prevention and self-care though 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 clinical questions.
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 to 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 Collaborating Centre for Acute Care
  - The National Collaborating Centre for Acute Care establish 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 National Collaborating Centre for Acute Care and NICE produce a number of versions of this guideline:
HEAD INJURY UPDATE FULL GUIDELINE: DRAFT FOR CONSULTATION (FEB 2007)

- the full guideline contains all the recommendations, plus details of the methods used and the underpinning evidence
- the NICE guideline presents the recommendations from the full version in a format suited to implementation by health professionals and NHS bodies
- the quick reference guide presents recommendations in a suitable format for health professionals
- information for the public is written using suitable language for people without specialist medical knowledge.

This version is the full version. The other versions can be downloaded from our website at www.rcseng.ac.uk/surgical_research_units/nccac/ or are available from NICE www.NICE.org.uk.

1.15 The National Collaborating Centre for Acute Care
This guideline was commissioned by NICE and developed by the National Collaborating Centre for Acute Care. The centre is one of seven national collaborating centres funded by NICE and comprises a partnership between a variety of academic, professional and patient-based organisations. As a multidisciplinary centre we draw upon the expertise of the healthcare professions and academics and ensure the involvement of patients in our work. Further information on the centre and our partner organisations can be found at our website. (www.rcseng.ac.uk/surgical_research_units/nccac/)

1.16 Remit of the Guideline
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.

1.17 What the update guideline covers
The guideline covers best practice advice on the care of adults and children aged 1-15 years (including infants aged less than 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 acute care centre.
- The benefits of secondary transfer of patients.
- The best imaging tool for identifying patient for 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.
- Tool for identifying the patients who should be referred to rehabilitation services following the initial management of a head injury

Only the 8 clinical questions See Appendix C are covered within this partial update and all other criteria set in the scope (Appendix A) were adhered to in this update. All updates sections are not shaded in grey for reader ease.

1.18 What the guideline does not cover

The guideline does not provide advice on the management of patients with other traumatic injury to the head (e.g. 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 and all other criteria set in the scope (Appendix A) were adhered to in the update.
There are few really good high grade studies of head injury care. The Corticosteroid Randomisation after Significant Head Injury (CRASH) trial\textsuperscript{89}, which looked at the perceived value of steroids, in head injured patients. The results of the trial were published after the first version of this guideline. This update guideline will not be addressing any other treatment such as mannitol or hyperventilation as it is not within the remit/scope of the update. However, the GDG agree that it is essential that we advise readers that the use of steroids in the acute management of head injured patients has never been recommended.

1.19 **Who developed this guideline?**

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 Clinical Excellence funds the National Collaborating Centre for Acute Care (NCC-AC) and thus supported the development of this guideline. The GDG was convened by the NCC-AC and chaired by Professor David Yates in accordance with guidance from the National Institute for Health and Clinical Excellence (NICE).

The group met every 6-8 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 are either required to withdraw completely or for part of the discussion if their declared interest makes it appropriate, however this was not deemed necessary for any group members on this guideline.

Staff from the NCC-AC provided methodological support and guidance for the development process. They undertook systematic searches, retrieval and appraisal of the evidence and drafted the guideline. The glossary to the guideline contains definitions of terms used by staff and the GDG.
2 Methods

2.1 Guideline development group

A Guideline Development Group 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.

2.2 Working principles

It was decided by the Guideline Development Group to focus the full systematic reviewing methods used in these guidelines on the selection of patients who have sustained a head injury 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 less than 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’ (i.e. aged less than 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.

2.3 Systematic reviews

The systematic reviews performed for these guidelines were designed to identify different types of clinical decision rule. The studies reviewed included derivation designs (usually cohort studies where the predictive power of a
number of prognostic variables were explored) and validation designs (where the sensitivity and specificity of previously defined rules were examined). Data collection may have been prospective or retrospective. The follow-up rate for important outcomes was also recorded: a standard of at least 80% follow-up is often stated for studies on the development of clinical decision rules. The use of multivariate statistics to identify the independent contribution of each variable to the rules was also an important determinant of study quality. Systematic reviews of studies on the development of clinical decision studies and/or prognostic variables in head injury were also sought.

The Guideline Development Group agreed to use classifications adapted from the Oxford Centre for Evidence-based Medicine Levels of Evidence (May 2001), to summarise the evidence levels for reviewed studies. These differ from the levels of evidence normally used by NICE, as the NICE classification is not suitable for certain study designs.

The levels of evidence used for studies on the development of clinical decision rules were as follows:

1. Cohort study with consecutive patients and good reference standards, used to validate clinical decision rules;
2. Cohort study with consecutive patients and good reference standards used to derive clinical decision rules (or validated on split samples only);
3. Non-consecutive study or without consistently applied reference standards;
4. Case-control study, poor or non-independent reference standard;
5. Expert opinion without explicit critical appraisal, or based on physiology, bench research or "first principles".

The levels of evidence used for systematic reviews were as follows:

1. Systematic review (with homogeneity) of mostly Level 1 studies
2. Systematic review (with homogeneity) of mostly Level 2 studies
3. Systematic review (with homogeneity) of mostly Level 3 studies

It was also agreed to adopt the Oxford Centre for Evidence-based Medicine classification for grade of recommendations (May 2001). This was used so that consistency with the levels of evidence classification could be achieved.

The grades of recommendation used in this guideline are as follows:

A. Consistent level 1 studies
B. Consistent level 2 or 3 studies or extrapolations from level 1 studies
C. Level 4 studies or extrapolations from level 2 or 3 studies
D. Level 5 evidence or troublingly inconsistent or inconclusive studies of any level

2.4 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)
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 (i.e. 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.

2.5 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 Guideline Development Group members to the final guidelines. An initial set of recommendations was circulated in questionnaire
format, and Guideline Development Group 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 Guideline Development Group responses to the questionnaire. A revised set of recommendations was drawn up following the meeting and again circulated to Guideline Development Group 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.

### 2.6 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 (e.g. 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 (e.g. 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.

### 2.7 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 (e.g. 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.

2.8 **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.

2.9 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.

2.10 Guideline methodology

The guideline was commissioned by NICE and developed in accordance with the guideline development process outlined in 'The guidelines manual' updated in April 2006. Development prior to this stage (e.g. development of the scope, early reviewing) was carried out using the methodology outlined in the previous version of the manual (March 2005).
2.11 Developing the clinical questions

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

The clinical questions were initially drafted by the review team and were refined and validated by the guideline development group. The questions were based on the scope (Appendix A).

2.12 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 1. 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)
2.13 Hierarchy of clinical evidence

There are many different methods of ranking the evidence and there has been considerable debate about which system is best. We used the system, developed by the Scottish Intercollegiate Guidelines Network (SIGN), shown in Table 1.
### Table 1: Levels of evidence for intervention studies

(Reproduced with permission of the Scottish Intercollegiate Guidelines Network)

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

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.

#### 2.14 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 guideline development group also suggested further references and we assessed these 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.²¹¹
2.15  **Health economics methods**

See chapter 11 for more details.

2.16  **Grading of recommendations**

Following a public consultation in April 2006 NICE is no longer publishing grades alongside recommendations contained within its guidance. Only this full version will contained the recommendation grading in the original portions that are not being updated.

2.17  **Research recommendations**

When areas were identified for which good evidence was lacking, the guideline development group 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.

2.18  **Prioritisation of recommendations for implementation**

To assist users of the guideline in deciding the order in which to implement the recommendations, the guideline development group identified nine key priorities for implementation. The decision was made after discussion and voting by the GDG. They selected recommendations that would:

- Have a high impact on patient outcomes, including mortality and morbidity
- Have a high impact on reducing variation
- Lead to a more efficient use of NHS resources
- Mean patients reach critical points in the care pathways more quickly

2.19  **Validation of the guideline**

Registered stakeholders were given the opportunity to comment on the draft guideline, which was posted on the NICE website. A Guideline Review Panel
also reviewed the guideline and checked that stakeholders’ comments had been addressed.

2.20 Updating the guideline

NICE clinical guidelines are updated as needed so that recommendations take into account important new information. We check for new evidence 2 and 4 years after publication, to decide whether all or part of the guideline should be updated. If important new evidence is published at other times, we may decide to do a more rapid update of some recommendations.
3  Summary of recommendations

Below are the recommendations that the GDG selected as the key priorities for implementation followed by the full list of recommendations.

3.1  Key Priorities for Implementation

3.1.1  Training in risk assessment

It is recommended that GPs, nurse practitioners, dentists and paramedics should all be capable of assessing the presence or absence of the risk factors listed in section 3.3.2. Training should be available as required to ensure head injury triage accuracy in paramedics, GPs, nurse practitioners and dentists. [Recommendation 3.2.3.1]

3.1.2  Pre-hospital management

Patients who have sustained a head injury should be transported directly to a facility that has been identified as having the resources necessary to expeditiously assess and intervene to optimise outcome. These are defined in the chapter 6 of the full guideline. It is expected that all acute hospitals accepting patients who have sustained a head injury should have these resources, and that these resources should be appropriate for the patient’s age. [3.4.2.5]

3.1.3  Initial transport to a neurosciences centre

Isolated severely head injured patients (GCS 8 or less) should ideally be transferred directly to a neurosciences unit to receive treatment irrespective of any need for a neurosurgical operation instead of receiving treatment at an acute care centre for initial assessment. [3.6.3.1]

3.1.4  Initial assessment in the emergency department

All patients presenting to A&E with a head injury should be assessed by triage by a trained member of staff 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, using
the guidance on patient selection and urgency for imaging (head and neck cervical spine – see later recommendations). [3.5.1.6]

3.1.5 Clinical management

Patients who have sustained a head injury should initially be assessed and managed according to clear principles and standard practice as embodied in the Advanced Trauma Life Support (ATLS) course and for children the principles as outlined in the Advanced Paediatric Life Support (APLS)/European Paediatric Life Support (EPLS) course materials. [3.4.2.1]

3.1.6 Selecting patients for CT imaging of the head

Adult patients who have sustained a head injury and present with any one of the following risk factors should have CT scanning of the head immediately requested.

− GCS less than 13 on initial assessment in the emergency department.
− GCS equal to 13 or 14 at two 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 otorrhoea, Battle’s sign)
− Post-traumatic seizure
− Focal neurological deficit
− More than one episode of vomiting.
− Amnesia for greater than 30 minutes of events before impact. [3.5.3.1]

Children who have sustained a head injury and present with any one of the following risk factors should have an immediate CT request of the head:

− History
  ◊ Witnessed loss of consciousness of >5 min duration
  ◊ History of amnesia (either antegrade or retrograde) of >5 min duration
  ◊ Abnormal drowsiness (defined as drowsiness in excess of that expected by the examining clinician)
  ◊ 3 vomits after head injury (a vomit is defined as a single discrete episode of vomiting)
◊ Suspicion of non-accidental injury (NAI, defined as any suspicion of NAI by the examining clinician)
◊ Seizure after head injury in a patient who has no history of epilepsy

− Examination
◊ Glasgow Coma Score (GCS)<14, or GCS<15 if <1 year old on assessment in the emergency department.
◊ Suspicion of penetrating or depressed skull injury or tense fontanelle
◊ Signs of a basal skull fracture (defined as evidence of blood or cerebrospinal fluid from ear or nose, panda eyes, Battles sign, haemotympanum, facial crepitus or serious facial injury)
◊ Positive focal neurology (defined as any focal neurology, including motor, sensory, coordination or reflex abnormality)
◊ Presence of bruise, swelling or laceration >5 cm if <1 year old

− Mechanism
◊ High-speed road traffic accident either as pedestrian, cyclist or occupant (defined as accident with speed >40 m/h)
◊ Fall of >3 m in height
◊ High-speed injury from a projectile or an object

If none of the above variables are present, the patient is at low risk of intracranial pathology. [NEW] [3.5.3.3]

3.1.7 Selecting patients for CT imaging of cervical spine

The current initial investigation of choice for the detection of injuries to the cervical spine is three view plain radiographs of good technical quality. However, CT imaging is indicated in the following situations:

- in patients with GCS < 8
- if the plain film series is technically inadequate (for example, desired view unavailable), suspicious or definitely abnormal
- if there is continued clinical suspicion of injury despite a normal X ray
- if other body areas are to be scanned
- if a definitive diagnosis of cervical spine injury is required urgently [3.5.6.4]
Children aged 10 years or more can be treated as adults for the purposes of cervical spine imaging. [3.5.6.3]

In children under 10 years, because of the increased risks associated with irradiation, particularly to the thyroid gland, and the generally lower risk of significant spinal injury, CT of the cervical spine should only be used in exceptional circumstances for example, cases where patients have a severe head injury (GCS ≤ 8), or where there is a strong suspicion of injury despite normal plain films, or cases where there is a strong suspicion of injury and plain films are inadequate). [NEW] [3.5.6.4]

3.1.8 Organisation of transfer of patients between receiving hospital and neuroscience unit
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. These should be consistent with established national guidelines. Details of the transfer of the responsibility for patient care should also be agreed. [3.6.1.1]

3.1.9 Good practice in observation of patients with head injury
It is recommended that in-hospital observation of patients with a head injury, including all A&E observations, should only be conducted by professionals competent in the assessment of head injury. [3.5.11.5 and 3.5.1.11]

3.1.10 Advice about long-term problems and support services
All patients and their carers should be made aware of the possibility of long-term symptoms and disabilities following head injury and should be made aware of the existence of the services that they could contact should they experience long-term problems. Details of support services should be included on patient discharge advice cards. Patients should also be advised to contact their doctor about these problems. [3.8.10.1]
3.2 The complete list of clinical practice recommendations

3.2.1 Glasgow Coma Scale

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. Recommended versions are shown in appendices M and N. Good practice in the use of the Glasgow Coma Scale and Score should be adhered to at all times, following the principles below.

3.2.1.1 Monitoring and exchange of information about individual patients should be based 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). (D)

3.2.1.2. If a total score is recorded or communicated, it should be based on a sum of 15, and to avoid confusion this denominator should be specified (for example, 13/15). (D)

3.2.1.3 The individual components of the GCS should be described in all communications and every note and should always accompany the total score. (D)

3.2.1.4 The paediatric version of the GCS should include a ‘grimace’ alternative to the verbal score to facilitate scoring in pre-verbal or intubated patients. (D)

3.2.1.5 Best practice in paediatric coma observation and recording as detailed by the National Paediatric Neuroscience Benchmarking Group should be followed at all times (these principles are detailed in Appendix N. (D)

3.2.2 Public health literature

3.2.2.1 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. (D)

3.2.3 Training in risk assessment

3.2.3.1 It is recommended that GPs, nurse practitioners, dentists and paramedics should all be capable of assessing the presence or absence of the risk factors listed in 3.3.2. Training should be available as required to ensure head injury triage accuracy in paramedics, GPs, nurse practitioners and dentists (D).

3.2.4 Support for families and carers

3.2.4.1 There should be a protocol for all staff to introduce themselves to family members or carers and briefly explain what they are doing. In addition a photographic board with the names and titles of personnel in the hospital departments caring for patients with head injury can be helpful. (D)

3.2.4.2 Information sheets detailing the nature of head injury and any investigations likely to be used should be available in the A&E Department. The patient version of these NICE guidelines may be helpful. (D)

3.2.4.3 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. (D)

3.2.4.4 Health care professionals should encourage carers and relatives 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 many hours at the bedside, and if they are, healthcare professionals should encourage them to take a break. (D)

3.2.4.5 There should be a board or area displaying leaflets or contact details for patient support organisations either locally or nationally to enable family members to gather further information. (D)
3.3  **Presentation and referral**

A person with a head injury may present via a telephone advice service or to a community health service or minor injury clinic. The following recommendations apply in these settings.

3.3.1  **Telephone advice services**

3.3.1.1 Telephone advice services (for example, NHS Direct, A&E helplines) should refer people who have sustained a head injury to the emergency ambulance services (that is 999) for emergency transport to A&E if they have experienced any of the following (alternative terms to facilitate communication are in parentheses).

- Unconsciousness, or lack of full consciousness (for example, problems keeping eyes open).
- 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).
- Any suspicion of a skull fracture or penetrating head 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).
- Any seizure (‘convulsion’ or ‘fit’) since the injury.
- A 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 metre or more than five stairs, diving accident, high-speed motor vehicle collision, rollover motor accident, accident involving motorised recreational vehicles, bicycle collision, or any other potentially high energy mechanism). A lower threshold for height of falls should be used.
when dealing with infants and young children (that is, aged less than 5 years).

- The injured person or their carer is incapable of transporting the injured person safely to the hospital A&E Department without the use of ambulance services (providing any other risk factors indicating A&E referral are present). (D)

3.3.1.2 Telephone advice services (for example, NHS Direct, A&E helplines) should refer people who have sustained a head injury to a hospital A&E department if the history related indicates the presence of any of the following risk factors (alternative terms to facilitate communication are in parentheses).

- Any previous loss of consciousness ('knocked out') as a result of the injury, from which the injured person has now recovered.
- Amnesia for events before or after the injury ('problems with memory'). The assessment of amnesia will not be possible in pre-verbal children and is unlikely to be possible in any child aged less than 5 years.
- Persistent headache since the injury.
- Any vomiting episodes since the injury.
- Any previous cranial neurosurgical interventions ('brain surgery').
- History of bleeding or clotting disorder.
- Current anticoagulant therapy such as warfarin.
- Current drug or alcohol intoxication.
- Age greater than or equal to 65 years.
- Suspicion of non-accidental injury.
- Irritability or altered behaviour (‘easily distracted’ ‘not themselves’ ‘no concentration’ ‘no interest in things around them’) particularly in infants and young children (that is, aged less than 5 years).
- Continuing concern by the helpline personnel about the diagnosis. (D)
3.3.1.3 In the absence of any of the factors listed in 3.3.1.2, the helpline should advise the injured person to seek medical advice from community services (for example, general practice) if any of the following factors are present.

- Adverse social factors (for example, no-one able to supervise the injured person at home).
- Continuing concern by the injured person or their carer about the diagnosis. (D)

### 3.3.2 Community health services and NHS minor injury clinics

3.3.2.1 Community health services (general practice, paramedics, NHS walk-in centres, dental practitioners) and NHS minor injury clinics should refer patients who have sustained a head injury to a hospital A&E department, using the ambulance service if deemed necessary, if any of the following is present.

- GCS less than 15 on initial assessment.
- Any loss of consciousness as a result of the injury.
- Any focal neurological deficit since the injury (examples include problems understanding, speaking, reading or writing; decreased sensation; loss of balance; general weakness; visual changes; abnormal reflexes; and problems walking).
- Any suspicion of a skull fracture or penetrating head injury since the injury (for example, clear fluid running from the ears or nose, black eye with no associated damage around the eyes, 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 of concern to the professional).
- Amnesia for events before or after the injury. The assessment of amnesia will not be possible in pre-verbal children and is unlikely to be possible in any child aged under 5 years.
- Persistent headache since the injury.
• Any vomiting episodes since the injury (clinical judgement should be used regarding the cause of vomiting in those aged less than or equal to 12 years, and whether referral is necessary).
• Any seizure since the injury.
• Any previous cranial neurosurgical interventions.
• A 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 metre or more than five stairs, diving accident, high-speed motor vehicle collision, rollover motor accident, accident involving motorised recreational vehicles, bicycle collision, or any other potentially high energy mechanism). A lower threshold for height of falls should be used when dealing with infants and young children (that is, aged less than 5 years).
• History of bleeding or clotting disorder.
• Current anticoagulant therapy such as warfarin.
• Current drug or alcohol intoxication.
• Age greater than or equal to 65 years.
• Suspicion of non-accidental injury.
• Continuing concern by the professional about the diagnosis. (D)

3.3.2.2 In the absence of any the factors listed in 3.3.2.1, the professional should consider referral to A&E if any of the following factors are present depending on their own judgement of severity.

• Irritability or altered behaviour, particularly in infants and young children (that is, aged under 5 years).
• Visible trauma to the head not covered above but still of concern to the professional.
• Adverse social factors (for example, no one able to supervise the injured person at home).
• Continuing concern by the injured person or their carer about the diagnosis. (D)

3.4  **Transport from community health services and NHS minor injury clinics and pre-hospital management**

3.4.1  **Transport to A&E**

3.4.1.1 Patients referred from community health services and NHS minor injury clinics should be accompanied by a competent adult during transport to A&E. (D)

3.4.1.2 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. (D)

3.4.1.3 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. (D)

3.4.2  **Pre-hospital management**

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

3.4.2.1 Patients who have sustained a head injury should initially be assessed and managed according to clear principles and standard practice as embodied in the Advanced Trauma Life Support (ATLS) course and for children the principles as outlined in the Advanced Paediatric Life Support (APLS)/European Paediatric Life Support (EPLS) course materials. (D) [NEW] [Replaces recommendation 1.3.2.1 in the original NICE guideline 2003]

3.4.2.2 Paramedics should be fully trained in the use of the adult and paediatric versions of the GCS and its derived score. (D)
3.4.2.3 Paramedics should have some training in the detection of non-accidental injury and should pass this information to A&E personnel when the relevant signs and symptoms arise. (D)

3.4.2.4 The first priority for those administering immediate care is to treat first the greatest threat to life and avoid further harm. (D)

3.4.2.5 Patients who have sustained a head injury should be transported directly to a facility that has been identified as having the resources necessary to expeditiously assess and intervene to optimise outcome. These are defined in chapter 6 of the full guideline. It is expected that all acute hospitals accepting patients who have sustained a head injury should have these resources, and that these resources should be appropriate for the patient's age. (D)

3.4.2.6 Patients who have sustained a head injury and present with any of the following risk factors should have full cervical spine immobilisation attempted unless other factors prevent this:

- GCS less than 15 on initial assessment in the emergency department
- neck pain or tenderness
- focal neurological deficit
- paraesthesia in the extremities
- any other clinical suspicion of cervical spine injury (D)

3.4.2.7 Cervical spine immobilisation should be maintained until full risk assessment including clinical assessment (and imaging if deemed necessary) indicates it is safe to remove the immobilisation device. (D)

3.4.2.8 Standby calls to the destination A&E department should be made for all patients with a GCS less than or equal to 8, to ensure appropriately experienced professionals are available for their treatment and to prepare for imaging. (D)
3.4.2.9 An alerting call to the destination A&E department should be made for all patients with a GCS less than 15. (D)

3.5 **Assessment and investigation in A&E**

The main focus of A&E 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, 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 of life-threatening complications and is associated with better outcomes.

3.5.1 **A&E assessment**

3.5.1.1 The priority for all A&E patients is the stabilisation of airway, breathing and circulation (ABC) before attention to other injuries. (D)

3.5.1.2 Depressed conscious level should be ascribed to intoxication only after a significant brain injury has been excluded. (D)

3.5.1.3 All A&E clinicians involved in the assessment of patients with a head injury should be capable of assessing the presence or absence of the risk factors in the guidance on patient selection and urgency for imaging (head and neck cervical spine – see later recommendations). Training should be available as required to ensure that this is the case. (D)

3.5.1.4 Patients presenting to A&E with impaired consciousness (GCS less than 15) should be assessed immediately by a trained member of staff (for example, triage nurse). (D)

3.5.1.5 In patients with a GCS less than or equal to 8 there should be early involvement of an anaesthetist or critical care physician to provide appropriate airway management, as described in section 3.6, and to assist with resuscitation. (D)
3.5.1.6 All patients presenting to A&E with a head injury should be assessed by triage by a trained member of staff 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, using the guidance on patient selection and urgency for imaging (head and neck cervical spine – see later recommendations). (D)

3.5.1.7 Patients found to be high risk on triage for clinically important brain injury and/or cervical spine injury should be assessed within 10 minutes of triage by an A&E clinician. Part of this assessment should fully establish the need to request CT imaging of the head and/or imaging of the cervical spine. The guidance on patient selection and urgency for imaging (head and cervical spine) should form the basis for the final decision on imaging after discussion with the radiology department. For recommendations on selection for and urgency of CT imaging of the head see recommendations 3.5.3.1 to 3.5.4.2. For recommendations on imaging of the cervical spine see recommendations 3.5.6.1 to 3.5.7.2.

3.5.1.8 Patients with head injury who are discovered to be at low risk for clinically important brain injury and/or cervical spine injury on initial triage should be assessed within a further hour by an A&E clinician. Part of this assessment should fully establish the need to request CT imaging of the head and/or imaging of the cervical spine. The guidance on patient selection and urgency for imaging (head and cervical spine) should again form the basis for the final decision on imaging after discussion with the radiology department. See recommendations 3.5.3.1 to 3.5.4.2 (imaging of the head) and 3.5.6.1 to 3.5.7.2 (imaging of the cervical spine). (D)

3.5.1.9 Pain management is important. Indeed, pain can lead to a rise in intracranial pressure. Reassurance and splintage of limb fractures is helpful; catheterisation of a full bladder will reduce irritability. Significant pain should be treated with small doses of intravenous opiates titrated against clinical response and baseline cardiorespiratory measurements. [NEW] [Replaces recommendation 1.4.1.9 in the original NICE clinical guideline 4.]
3.5.1.10 Throughout the hospital episode, all care professionals should use a standard head injury proforma in their documentation when assessing and observing patients with head injury. A separate proforma for those under 16 years should be used. (Excellent proformas have been produced in previous guidelines from the Scottish Intercollegiate Guidelines Network and the Royal College of Surgeons of England. Areas to allow extra documentation should be included [for example, in cases of non-accidental injury]. Examples of the proformas that should be used in patients with head injury are shown in Appendices J and K. (D)

3.5.1.11 It is recommended that in-hospital observation of patients with a head injury, including all A&E observations, should only be conducted by professionals competent in the assessment of head injury. (D)

3.5.1.12 Patients who have returned to an A&E 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. (B)

3.5.2 Investigations for clinically important brain injuries

3.5.2.1 The current primary investigation of choice for the detection of acute clinically important brain injuries is CT imaging of the head. (A)

3.5.2.2 For safety, logistic and resource reasons, MRI scanning is not currently indicated 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. (D)

3.5.2.3 MRI is contraindicated in both head and cervical spine investigations unless there is absolute certainty that the patient does not harbour an incompatible device, implant or foreign body. (D)

3.5.2.4 There should be appropriate equipment for maintaining and monitoring the patient within the MRI environment and all staff involved should be aware
of the dangers and necessary precautions for working near an MRI scanner. (D)

3.5.2.5 Plain X-rays of the skull have no role in the diagnosis of significant brain injury. However, they are useful as part of the skeletal survey in children presenting with suspected non-accidental injury. [NEW]

3.5.2.6 For patients over 65 presenting out of hours it is safe to admit for effective over-night observation instead of initiating an immediate CT unless GCS< 15. [NEW]

[Replaces recommendation 1.4.2.5 in original NICE clinical guideline 4]

3.5.2.7 Skull X-rays in conjunction with high-quality in-patient observation also have a role where CT scanning resources are unavailable. (D)

3.5.3 Selection of patients for CT imaging of the head

For adults

3.5.3.1 Adult patients who have sustained a head injury and present with any one of the following risk factors should have CT scanning of the head immediately requested.

- GCS less than 13 on initial assessment in the emergency department.
- GCS equal to 13 or 14 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 otorrhoea, Battle’s sign).
- Post-traumatic seizure.
- Focal neurological deficit.
- More than one episode of vomiting.
- Amnesia for greater than 30 minutes of events before impact. (B)
3.5.3.2 CT should also be immediately requested in patients with any of the following risk factors, provided they have experienced some loss of consciousness or amnesia since the injury:

- Age greater than or equal to 65 years.
- Coagulopathy (history of bleeding, clotting disorder, current treatment with warfarin).
- Dangerous mechanism of injury (a pedestrian struck by a motor vehicle, an occupant ejected from a motor vehicle or a fall from a height of greater than 1 metre or five stairs). (B)

For children

3.5.3.3 Children who have sustained a head injury and present with any one of the following risk factors should have an immediate CT request of the head:

- History
  - Witnessed loss of consciousness of >5 min duration
  - History of amnesia (either antegrade or retrograde) of >5 min duration
  - Abnormal drowsiness (defined as drowsiness in excess of that expected by the examining clinician)
  - 3 vomits after head injury (a vomit is defined as a single discrete episode of vomiting)
  - Suspicion of non-accidental injury (NAI, defined as any suspicion of NAI by the examining clinician)
  - Seizure after head injury in a patient who has no history of epilepsy
- Examination
  - Glasgow Coma Score (GCS)<14, or GCS<15 if <1 year old on assessment in the emergency department.
  - Suspicion of penetrating or depressed skull injury or tense fontanelle
Signs of a basal skull fracture (defined as evidence of blood or cerebrospinal fluid from ear or nose, panda eyes, Battles sign, haemotympanum, facial crepitus or serious facial injury)
- Positive focal neurology (defined as any focal neurology, including motor, sensory, coordination or reflex abnormality)
- Presence of bruise, swelling or laceration >5 cm if <1 year old

Mechanism
- High-speed road traffic accident either as pedestrian, cyclist or occupant (defined as accident with speed >40 m/h)
- Fall of >3 m in height
- High-speed injury from a projectile or an object

If none of the above variables are present, the patient is at low risk of intracranial pathology. [NEW]

[Replaces recommendation 1.4.2.9 in the original NICE clinical guideline 4]

3.5.4 Urgency in performing CT imaging of the head

3.5.4.1 CT imaging of the head should be performed (that is, imaging carried out and results analysed) within one hour of the request having been received by the radiology department in those patients where imaging is requested because of any of the following risk factors.

- GCS less than 13 on initial assessment in the emergency department.
- GCS equal to 13 or 14 at two hours after the injury.
- Suspected open or depressed skull fracture.
- Any sign of basal skull fracture (haemotympanum, ‘panda’ eyes, cerebrospinal fluid otorrhoea, Battle’s sign).
- More than one episode of vomiting in adults. In children more than 3 vomiting episodes (clinical judgement should be used regarding the cause of vomiting in those aged less than or equal to 12 years, and whether imaging is necessary).
- Age greater than or equal to 65 years, providing that some loss of consciousness or amnesia has been experienced.
• Post-traumatic seizure.
• Coagulopathy (history of bleeding, clotting disorder, current treatment with warfarin) providing that some loss of consciousness or amnesia has been experienced.
• Focal neurological deficit. (B)

3.5.4.2 Patients who have any of the following risk factors and none of the risk factors in 3.5.4.1 should have their CT imaging performed within 8 hours of the injury (imaging should be performed immediately in these patients if they present 8 hours or more after their injury).

• Amnesia for greater than 30 minutes of events before impact (the assessment of amnesia will not be possible in pre-verbal children and is unlikely to be possible in any child aged less than 5 years).
• Dangerous mechanism of injury (a pedestrian struck by a motor vehicle, an occupant ejected from a motor vehicle or a fall from a height of greater than 1 metre or five stairs) providing that some loss of consciousness or amnesia has been experienced. A lower threshold for height of falls should be used when dealing with infants and young children (that is, aged less than 5 years). (B)

3.5.5 Investigation for injuries to the cervical spine

3.5.5.1 The current investigations of choice for the detection of injuries to the cervical spine are three view plain radiographs of good technical quality. (B)

3.5.5.2 Where it is not possible to achieve the cervical spine views desired with X-ray, CT imaging is indicated. (B)

3.5.5.3 CT is also indicated in patients with severe head injury (GCS ≤8), if the plain film series is technically inadequate (for example, desired view unavailable), suspicious or definitely abnormal or if there is continued clinical suspicion of injury despite a normal X ray. [NEW]

[Replaces recommendation 1.4.3.3 in the original NICE clinical guideline 4]
3.5.5.4 CT imaging of the cervical spine should be considered if the patient is having other body areas scanned for head injury/multi-region trauma, and a definitive diagnosis of cervical spine injury is required urgently. (B)

3.5.5.5 As a minimum, CT should cover any areas of concern or uncertainty on plain film or clinical grounds. (B)

3.5.5.6 With modern multislice scanners the whole cervical spine can be scanned at high resolution with ease and multiplanar reformatted images generated rapidly. Facilities for multiplanar reformatting and interactive viewing should be available. (B)

3.5.5.7 MRI is indicated in the presence of neurological signs and symptoms referable to the cervical spine and if there is suspicion of vascular injury (for example, subluxation or displacement of the spinal column, fracture through foramen transversarium or lateral processes, posterior circulation syndromes). (B)

3.5.5.8 MRI may add important information about soft tissue injuries associated with bony injuries demonstrated by plain films and/or CT. (B)

3.5.5.9 MRI has a role in the assessment of ligamentous and disc injuries suggested by plain films, CT or clinical findings. (B)

3.5.5.10 In CT, the occipital condyle region should be routinely reviewed on 'bone windows' 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. (B)

3.5.5.11 In patients who have sustained high energy trauma or are showing signs of lower cranial nerve palsy, the results of initial imaging should be considered and particular attention should be paid to the region of the foramen magnum. If necessary, additional high resolution imaging for coronal and sagittal reformatting should be performed while the patient is on the scanner table. (B)
3.5.6 Selection of patients for imaging of the cervical spine

3.5.6.1 Adult patients with any one of the following risk factors should have three view radiograph imaging of the cervical spine immediately requested.

- GCS less than 15 on initial assessment in the emergency department.
- Paraesthesia in the extremities
- Focal neurological deficit
- Not possible to test for range of motion in the neck (safe assessment of range of motion can be performed with the following: simple rear-end motor vehicle collision, sitting position in A&E, ambulatory at any time since injury, delayed onset of neck pain, absence of midline cervical spine tenderness).
- Patient not able to actively rotate neck to 45 degrees to the left and right (if assessment is possible). (A)

3.5.6.2 Cervical spine imaging should also be immediately requested in the patients with the following risk factors provided they have some neck pain or tenderness.

- Age greater than or equal to 65 years
- Dangerous mechanism of injury (fall from greater than 1 metre or five stairs; axial load to head for example, diving; high-speed motor vehicle collision greater than 65 miles per hour; rollover motor accident; ejection from a motor vehicle; accident involving motorised recreational vehicles; bicycle collision). A lower threshold for height of falls should be used when dealing with infants and young children (that is, aged less than 5 years). (A)

3.5.6.3 Children aged 10 years or more can be treated as adults for the purposes of cervical spine imaging. (D)

3.5.6.4 In children under 10 years, because of the increased risks associated with irradiation, particularly to the thyroid gland, and the generally lower risk of significant spinal injury, CT of the cervical spine should only be used in
exceptional circumstances for example, cases where patients have a severe head injury (GCS ≤ 8), or where there is a strong suspicion of injury despite normal plain films, or cases where there is a strong suspicion of injury and plain films are inadequate). [NEW]

[Replaces recommendations 1.4.3.15 and 1.4.3.19 in the original NICE clinical guideline 4]

3.5.6.5 Children under 10 years should receive anterior/posterior and lateral views without an anterior/posterior peg view. (D)

3.5.6.6 Abnormalities or uncertainties in those under 10 years should be clarified by CT imaging. When minor trauma is associated with subsequent torticollis the plain films are almost uninterpretable; CT is very helpful in this situation. (D)

3.5.7 Urgency in performing cervical spine imaging

3.5.7.1 Imaging of the cervical spine should be performed within 1 hour of a request having been received by the radiology department. Where a request for urgent head CT (that is, within 1 hour) has also been received, the cervical spine imaging should also be carried out within 1 hour. (D)

3.5.7.2 Children less than 10 years old who have a GCS of 8 or less should have a CT of the cervical spine within 1 hour of presentation. CT should also be undertaken when the GCS is between 14 and 9 if there is high clinical concern (for example, focal neurological deficit or paraesthesia in the extremities). Finally, CT should be undertaken in any child when an x ray is found to be inadequate or there is continuing clinical concern. [NEW]

3.5.8 Investigations of non-accidental injury in children

3.5.8.1 Owing to the distinct pattern of injuries involved, skull X-ray as part of a series of plain x-rays (skeletal survey), along with other well-established examinations (for example, ophthalmoscopic examination for retinal haemorrhage; examination for pallor, anaemia, tense fontanelle) and investigations (for example, CT, MRI), has a role in detecting non-accidental
head injuries in children (that is, aged less than 12 years). A clinician with expertise in non accidental injury must be involved in any suspected case of non-accidental injury. [NEW]

3.5.9 Radiation exposure management

3.5.9.1 In line with good radiation exposure practice every effort should be made 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. (D)

3.5.9.2 Emerging evidence suggests that plain x rays of the cervical spine may fail to identify clinically important injury. CT is therefore recommended in those most at risk. In children this risk is less and the potential damage from radiation greater. The guidelines reflect this concern by restricting the recommendations for CT in children to those who have indicators of more serious injury. [NEW]

3.5.10 Involving the neurosurgeon

3.5.10.1 The care of all patients with new, surgically significant abnormalities on imaging should be discussed with a neurosurgeon. The definition of ‘surgically significant’ should be developed by local neurosurgical centres and agreed with referring hospitals. An example of a neurosurgical referral letter is provided in Appendix L. (D)

3.5.10.2 Regardless of imaging, other reasons for discussing a patient’s care plan with a neurosurgeon include:

- persisting coma (GCS less than or equal to 8) 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. (D)

3.5.11 Admission

3.5.11.1 The following patients meet the criteria for admission to hospital following a head injury.

• Patients with new, clinically significant abnormalities on imaging.
• Patients who have not returned to GCS equal to 15 after imaging, regardless of the imaging results.
• When a patient fulfils the criteria 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 co-operative 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). (D)

3.5.11.2 Some patients may require an extended period in a recovery setting due to the use of sedation or general anaesthetic during CT imaging. These patients should not normally require admission. (D)

3.5.11.3 Patients with multiple injuries should be admitted under the care of the team that is trained to deal with their most severe and urgent problem. (D)

3.5.11.4 In circumstances where a patient with a head injury requires hospital admission, it is recommended that the patient only be admitted under the care of a consultant who has been trained in the management of this condition during his/her higher specialist training. (D)
3.5.11.5 It is recommended that in-hospital observation of patients with a head injury should only be conducted by professionals competent in the assessment of head injury. (D)

3.6 **Transfer from secondary settings to a neuroscience unit**

3.6.1 **Transfer of adults**

3.6.1.1 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. These should be consistent with established national guidelines. Details of the transfer of the responsibility for patient care should also be agreed. (D)

3.6.1.2 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. (D)

3.6.1.3 Patients with head injuries 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 must have a dedicated and adequately trained assistant. They should be provided with appropriate clothing for the transfer, medical indemnity and personal accident insurance. (D)

3.6.1.4 The transfer team should be provided with a means of communication with their base hospital and the neurosurgical unit during the transfer. A portable phone may be suitable providing it is not used in close proximity (that is, within 1 metre) of medical equipment prone to electrical interference (for example, infusion pumps). (D)
3.6.1.5 While it is understood that transfer is often urgent, initial resuscitation and stabilisation of the patient must be completed and comprehensive monitoring established before transfer to avoid complications during the journey. A patient persistently hypotensive, despite resuscitation, should not be transported until the cause of the hypotension has been identified and the patient stabilised. (D)

3.6.1.6 All patients with a GCS less than or equal to 8 requiring transfer to a neuroscience unit should be intubated and ventilated as should any patients with the indications detailed in section 3.6.1.7 and 3.6.1.8. (D)

3.6.1.7 Intubation and ventilation should be used immediately in the following circumstances:

- Coma – not obeying commands, not speaking, not eye opening (that is, GCS less than or equal to 8)
- Loss of protective laryngeal reflexes
- Ventilatory insufficiency as judged by blood gases: hypoxaemia (PaO\(_2\) less than 9 kPa on air or less than 13 kPa on oxygen) or hypercarbia (PaCO\(_2\) greater than 6 kPa)
- Spontaneous hyperventilation causing PaCO\(_2\) less than 4 kPa
- Respiratory arrhythmia (D)

3.6.1.8 Intubation and ventilation should be used before the start of the journey in the following circumstances:

- Significantly deteriorating conscious level (one or more points on the motor score), even if not coma
- Bilateral fractured mandible
- Copious bleeding into mouth (for example, from skull base fracture)
- Seizures (D)

3.6.1.9 An intubated patient should be ventilated with muscle relaxation and appropriate sedation and analgesia. Aim for a PaO\(_2\) greater than 13kPa, PaCO\(_2\) 4.5 to 5.0 kPa unless there is clinical or radiological evidence of raised
in intracranial pressure when more aggressive hyperventilation is justified to a PaCO2 of not less than 4 kPa. If hyperventilation is used the inspired oxygen concentration should be increased. (D)

3.6.1.10 Education, training and audit are crucial to improving standards of transfer; appropriate time and funding for these activities should be provided. (D)

3.6.1.11 Care and relatives should have as much access to the patient as is practical during transfer and be fully informed on the reasons for transfer and the transfer process.

3.6.2 Transfer of children

3.6.2.1 The recommendations in section 3.5.10.2 were written for adults but the principles apply equally to children and infants, providing that the paediatric modification of the Glasgow Coma Scale is used. (D)

3.6.2.2 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 3.5.10.2. (D)

3.6.2.3 Transfer of a child or infant to a specialist neurosurgical unit should be undertaken by staff experienced in the transfer of critically ill children. (D)

3.6.2.4 Families should have as much access to their child as is practical during transfer and be fully informed on the reasons for transfer and the transfer process. (D)

3.6.2.5 A multiply injured child should not be transferred to a service that is unable to deal with other aspects of trauma. [NEW]

3.6.3 Transfer of isolated severely head injured patients

3.6.3.1 Isolated severely head injured patients (GCS 8 or less) should ideally be transferred directly to a neurosciences unit to receive treatment
irrespective of any need for a neurosurgical operation instead of receiving treatment at an acute care centre for initial assessment. [NEW]

3.7 **Observation of admitted patients**

3.7.1 **Training in observation**

3.7.1.1 Medical, nursing and other staff caring for patients with head injury admitted for observation should all be capable of performing the observations listed in 3.7.2 and 3.7.5. (D)

3.7.1.2 The acquisition and maintenance of observation and recording skills require dedicated training and this should be available to all relevant staff. (D)

3.7.1.3 Specific training is required for the observation of infants and young children. (D)

3.7.2 **Minimum documented observations**

3.7.2.1 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. (D)

3.7.3 **Frequency of observations**

3.7.3.1 Observations should be performed and recorded 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 A&E:

- half-hourly for two hours;
- then one hourly for four hours;
- then two hourly thereafter. (D)

3.7.3.2 Should the patient with GCS equal to 15 deteriorate at any time after the initial two-hour period, observations should revert to half-hourly and follow the original frequency schedule. (D)
3.7.4 Observation of children and infants

3.7.4.1 Observation of infants and young children (that is, aged less than 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. (D)

3.7.5 Patient changes requiring review while under observation

3.7.5.1 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 one point in GCS level (greater weight should be given to a drop of one point in the motor score of the GCS).
- Any drop of greater than two points in GCS level regardless of duration or GCS sub-scale.
- 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. (D)

3.7.5.2 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. (D)

3.7.6 Imaging following confirmed patient deterioration

3.7.6.1 An immediate CT scan should be considered in patients confirmed as having any of the changes noted in 3.7.5.1 above. (D)
3.7.7 Further imaging if GCS equal to 15 not achieved at 24 hours

3.7.7.1 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. (D)

3.8 Discharge

General:

3.8.1 Discharge and GCS status

3.8.1.1 No patients presenting with head injury should be transferred to the community 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.

3.8.2 Discharge advice

3.8.2.1 All patients with any degree of head injury who are deemed safe for appropriate transfer to the community from A&E or the observation ward should receive verbal advice and a written head injury advice card. The details of the card should be discussed with the patients and their carers. If necessary (for example, patients with literacy problems, visual impairment or speaking languages without a written format), other formats (for example, tapes) should be used to communicate this information. Communication in languages other than English should also be facilitated. (D)

3.8.2.2 The risk factors outlined in the card should be the same as those used in the initial community setting to advise patients on A&E attendance. Patients and carers should also be alerted to the possibility that some patients may make a quick recovery, but go on to experience delayed complications. Instructions should be included on contacting community services in the event of delayed complications. (D)
3.8.2.3 Patients who presented to A&E with drug or alcohol intoxication and are now fit for discharge should receive information and advice on alcohol or drug misuse. (D)

Suggested written advice cards for patients and carers are provided in Appendices E, F and G.

3.8.3 Discharge of patients with no carer at home

3.8.3.1 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. Patients with no carer at home should only be discharged if suitable supervision arrangements have been organised, or when the risk of late complications is deemed negligible. (D)

Discharge of specific patient groups:

3.8.4 Low-risk patients with GCS equal to 15

3.8.4.1 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). (D)

3.8.5 Patients with normal imaging of the head

3.8.5.1 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). (D)
3.8.6 **Patients with normal imaging of the cervical spine**

3.8.6.1 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).(D)

3.8.7 **Patients admitted for observation**

3.8.7.1 Patients admitted after a head injury may be transferred to the community after resolution of all significant symptoms and signs providing they have suitable supervision arrangements at home. (D)

3.8.8 **Patients at risk of non-accidental injury**

3.8.8.1 No infants or children presenting with head injuries that require imaging of the head or cervical spine should be transferred to the community until assessed by a clinician experienced in the detection of non-accidental injury. (D)

3.8.8.2 It is expected that all personnel involved in the triage and assessment of infants and children with head injury should have training in the detection of non-accidental injury. (D)

3.8.9 **Outpatient appointments**

3.8.9.1 Every patient who has undergone imaging of their head and/or been admitted to hospital (that is, those initially deemed to be at high risk for clinically important brain injury) should be routinely referred to their GP for follow-up within a week after discharge. (D)

3.8.9.2 When a person who has undergone imaging of the head and/or been admitted to hospital experiences persisting problems, there should be an opportunity available for referral from primary care to an out-patient
appointment with a professional trained in assessment and management of sequelae of brain injury (for example, clinical psychologist, neurologist, neurosurgeon, specialist in rehabilitation medicine). (D)

3.8.10 Advice about long-term problems and support services
3.8.10.1 All patients and their carers should be made aware of the possibility of long-term symptoms and disabilities following head injury and should be made aware of the existence of services that they could contact should they experience long-term problems. Details of support services should be included on patient discharge advice cards. Patients should also be advised to contact their doctor about these problems. (D)

3.8.11 Communication with community services
3.8.11.1 A communication (letter or e-mail) should be generated for all patients who have attended A&E with a head injury, and sent to the patient’s GP within one week of the end of the hospital episode. This letter should include details of the clinical history and examination. This letter should be open to the person or their carer, or a copy should be given to them. (D)

3.8.11.2 A communication (letter or e-mail) should be generated for all children who received head or cervical spine imaging, and sent to the relevant general practitioner and school nurse for all school aged children within one week of the end of the hospital episode. This letter should include details of the clinical history and examination. (D)

3.8.11.3 A communication (letter or e-mail) should be generated for pre-school children who received head or cervical spine imaging, and sent to the general practitioner and health visitor within 1 week of the end of the hospital episode. This letter should include details of the clinical history and examination. (D)
3.9 **New Recommendations**

3.9.1 **Pre-hospital management**

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

3.9.1.1 Patients who have sustained a head injury should initially be assessed and managed according to clear principles and standard practice as embodied in the Advanced Trauma Life Support (ATLS) course and for children the principles as outlined in the Advanced Paediatric Life Support (APLS)/European Paediatric Life Support (EPLS) course materials. (D) [NEW]

[Replaces recommendation 1.3.2.1 in the original NICE guideline 2003]

3.9.2 **Investigations for clinically important brain injuries**

3.9.2.1 Plain X-rays of the skull have no role in the diagnosis of significant brain injury. However, they are useful as part of the skeletal survey in children presenting with suspected non-accidental injury. [NEW]

3.9.2.2 For patients over 65 presenting out of hours it is safe to admit for effective over-night observation instead of initiating an immediate CT unless GCS< 15. [NEW]

[Replaces recommendation 1.4.2.5 in original NICE clinical guideline 4]

3.9.3 **Selection of patients for CT imaging of the head**

3.9.3.1 Children who have sustained a head injury and present with any one of the following risk factors should have an immediate CT request of the head:

- History
  - Witnessed loss of consciousness of >5 min duration
  - History of amnesia (either antegrade or retrograde) of >5 min duration
  - Abnormal drowsiness (defined as drowsiness in excess of that expected by the examining clinician)
- 3 vomits after head injury (a vomit is defined as a single discrete episode of vomiting)
- Suspicion of non-accidental injury (NAI, defined as any suspicion of NAI by the examining clinician)
- Seizure after head injury in a patient who has no history of epilepsy

**Examination**
- Glasgow Coma Score (GCS)<14, or GCS<15 if <1 year old on assessment in the emergency department.
- Suspicion of penetrating or depressed skull injury or tense fontanelle
- Signs of a basal skull fracture (defined as evidence of blood or cerebrospinal fluid from ear or nose, panda eyes, Battles sign, haemotympanum, facial crepitus or serious facial injury)
- Positive focal neurology (defined as any focal neurology, including motor, sensory, coordination or reflex abnormality)
- Presence of bruise, swelling or laceration >5 cm if <1 year old

**Mechanism**
- High-speed road traffic accident either as pedestrian, cyclist or occupant (defined as accident with speed >40 m/h)
- Fall of >3 m in height
- High-speed injury from a projectile or an object

If none of the above variables are present, the patient is at low risk of intracranial pathology. [NEW]

[Replaces recommendation 1.4.2.9 in the original NICE clinical guideline 4]

### 3.9.4 Investigation for injuries to the cervical spine

3.9.4.1 CT is also indicated in patients with severe head injury (GCS ≤8), if the plain film series is technically inadequate (for example, desired view
unavailable), suspicious or definitely abnormal or if there is continued clinical suspicion of injury despite a normal X ray. [NEW]

[Replaces recommendation 1.4.3.3 in the original NICE clinical guideline 4]

### 3.9.5 Selection of patients for imaging of the cervical spine

3.9.5.1 In children under 10 years, because of the increased risks associated with irradiation, particularly to the thyroid gland, and the generally lower risk of significant spinal injury, CT of the cervical spine should only be used in exceptional circumstances for example, cases where patients have a severe head injury (GCS ≤ 8), or where there is a strong suspicion of injury despite normal plain films, or cases where there is a strong suspicion of injury and plain films are inadequate). [NEW]

[Replaces recommendations 1.4.3.15 and 1.4.3.19 in the original NICE clinical guideline 4]

### 3.9.6 Urgency in performing cervical spine imaging

3.9.6.1 Children less than 10 years old who have a GCS of 8 or less should have a CT of the cervical spine within 1 hour of presentation. CT should also be undertaken when the GCS is between 14 and 9 if there is high clinical concern (for example, focal neurological deficit or paraesthesia in the extremities). Finally, CT should be undertaken in any child when an x ray is found to be inadequate or there is continuing clinical concern. [NEW]

### 3.9.7 Investigations of non-accidental injury in children

3.9.7.1 Owing to the distinct pattern of injuries involved, skull X-ray as part of a series of plain x-rays (skeletal survey), along with other well-established examinations (for example, opthalmoscopic examination for retinal haemorrhage; examination for pallor, anaemia, tense fontanelle) and investigations (for example, CT, MRI), has a role in detecting non-accidental head injuries in children (that is, aged less than 12 years). A clinician with expertise in non accidental injury must be involved in any suspected case of non-accidental injury. [NEW]
3.9.8 Radiation exposure management

3.9.8.1 Emerging evidence suggests that plain x rays of the cervical spine may fail to identify clinically important injury. CT is therefore recommended in those most at risk. In children this risk is less and the potential damage from radiation greater. The guidelines reflect this concern by restricting the recommendations for CT in children to those who have indicators of more serious injury. [NEW]

3.9.9 A&E assessment

3.9.9.1 Pain management is important. Indeed, pain can lead to a rise in intracranial pressure. Reassurance and splintage of limb fractures is helpful; catheterisation of a full bladder will reduce irritability. Significant pain should be treated with small doses of intravenous opiates titrated against clinical response and baseline cardiorespiratory measurements. [NEW]

[Replaces recommendation 1.4.1.9 in the original NICE clinical guideline 4.]

3.9.10 Transfer of isolated severely head injured patients

3.9.10.1 Isolated severely head injured patients (GCS 8 or less) should ideally be transferred directly to a neurosciences unit to receive treatment irrespective of any need for a neurosurgical operation instead of receiving treatment at an acute care centre for initial assessment. [NEW]

3.9.11 Transfer of children

3.9.11.1 A multiply injured child should not be transferred to a service that is unable to deal with other aspects of trauma. [NEW]
3.10 Recommendations for research

The GDG identified the following priority area for research.

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

The aim of this study is to conduct a comparison in patient outcome (mortality/morbidity) for those isolated head injured patients that are transported directly to a centre with neurosciences facilities with the outcomes of those who are transported to the nearest hospital without neurosciences facilities, possibly necessitating a secondary transfer. Patients suffering from isolated serious head injuries with a reduced level of consciousness are currently transported to the nearest hospital by land ambulance or helicopter. The nearest hospital may not have the resources or expertise to provide definitive care for these patients. Patients will be followed as they pass through the care system with mortality and morbidity outcomes collected. These will be compared to allow, using sub-group analysis, the identification of patients for whom direct transfer is most beneficial.

- Why this research is important

Limited evidence shown in various studies has shown that patients do better in terms of outcome if they are transported direct to a neurosciences centre when compared to those who are taken to the nearest DGH. This evidence however does not appear to have influenced current practice.

Guidelines are required for those working in the prehospital arena which define those patients who have sustained an head injury would be better served by being transported direct to a neurosciences centre.

Currently patients are either always transported to the nearest DGH as is the case in most land vehicle deployment or in some organisations especially
those involving helicopter emergency medical services the decision is left to
the judgement of the clinicians at the scene. Those patients transported to the
nearest DGH suffer a significant delay in receiving definitive treatment for their
head injury.

Information from this study will define which patients should be transported
direct to a neurosciences centre bypassing the nearest hospital.

Guidance will be required to define the patient population in terms of their
injuries. For example, researchers may focus on isolated injuries or head
injuries associated with multi trauma. Further specification about what level of
consciousness would be suitable for primary transfer to a neurosciences unit
would be required.

3.10.2 Research is needed to establish the validity of previously
derived clinical decision rules on the selection of head
injured infants and children for CT scanning to exclude
significant brain injury.

- Why this research is important

The 2002 NICE guidelines recommended that children be selected for CT
scanning on the basis of the Canadian Head CT rule, a clinical decision rule
derived and validated in adults. This was due to the absence of such a rule
derived in children. However since this date the CHALICE rule has been
published which presents a clinical decision rule derived in a large group of
children and infants from the UK with good sensitivity and specificity.

However, clinical decision rules often provide an overestimate of their
performance when applied to new populations. We now recommend the
usage of the CHALICE rule for all patients suffering a head injury in the UK,
with the caveat that a validation of the rule in a new population of head injured
UK patients be urgently undertaken to ensure its reliability and reproducibility.

Such a study is now essential and performing a validation of the CHALICE
study in a novel UK population may easily be performed in a 1-2 year
timeframe with acceptable costs, and considerable benefits in terms of assuring clinicians as to the safety of this novel rule.

3.10.3 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.

- 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 Class I 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.
3.10.4 **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?**

- 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 health care 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 health care 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%.
3.10.5 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, at the time of injury, relevant patients. 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 6mths-1yr. 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.
4 Pre-hospital assessment, advice and referral to hospital

4.1 Predictor variables

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.

4.2 Loss of consciousness

A history of altered consciousness after a head injury increases the risk of intracranial complications although the absolute risk remains low.\textsuperscript{278,315} 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.

4.3 Amnesia

Amnesia after head injury increases the risk of intracranial complications, although the length and type of amnesia are controversial.\textsuperscript{278,315} 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 (i.e. for memories before the trauma) is a more important risk factor.\textsuperscript{304} Amnesia is a less useful predictor variable in infants and young children, simply because it is difficult to measure.

4.4 Neurological signs

Post-traumatic neurological signs such as focal neurological deficits or seizure are highly associated with the risk of an intracranial complication\textsuperscript{314} 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.

4.5 **Bleeding disorders and use of anticoagulants**

Patients with coagulopathy have an elevated risk of intracranial complications
but the exact strength of this relationship has not been established.142,263

4.6 **Skull fracture**

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.135 There is variation in diagnostic practice for skull fracture. Some
guidelines advocate the use of skull X-ray in the diagnosis of skull fracture,273
while others advocate the use of signs alone (e.g. cerebrospinal fluid leak,
periorbital haematoma, depressed or open skull injury, penetrating injury).304

4.7 **Age**

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.205 Commonly used thresholds are 60 years11,126 and 65
years.205,304 To avoid confusion, the Guideline Development Group 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.304

There is evidence that the prevalence of intracranial complications in children
and infants is much lower than in adults.6 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.

4.8 Mechanism of injury

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. A further study has defined ‘axial load to head’ as a high risk factor for cervical spine injury after an accident. 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 (e.g. the variety of blunt instruments that could be used in a violent assault) which were considered to be important by the Guideline Development Group.

The height threshold for a high-risk fall is sometimes defined as greater than three feet, and sometimes as greater than one metre. For the sake of consistency, this guideline will use the term ‘one metre’. A lower threshold should be used when dealing with infants and young children (i.e. less than five years of age). The recent CHALICE rule recognises falls of greater then 3 metres were highly associated with the development of intracranial lesions.

4.9 Drug or alcohol intoxication

Drug or alcohol intoxication can result in signs and symptoms which are risk factors for intracranial complications (e.g. vomiting, headache, amnesia, impaired consciousness) but have also been identified as independent risk factors following head injury, making a differential diagnosis difficult. 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.

4.10 **Headache**

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

4.11 **Vomiting**

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. 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 (e.g. previous tendency to vomit) rather than specific features of the head injury. 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.

4.12 **Irritability and altered behaviour**

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. However, they may be an important sign in the pre-verbal child, where other problems like amnesia or headaches cannot be detected.
4.13 **History of cranial neurosurgical interventions**

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

4.14 **Public health literature**

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.

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

4.15 **Telephone advice lines**

Telephone advice services (for example, NHS Direct, A&E helplines) should refer people who have sustained a head injury to the emergency ambulance services (that is 999) for emergency transport to A&E if they have experienced any of the following (alternative terms to facilitate communication are in parentheses).

- Unconsciousness, or lack of full consciousness (for example, problems keeping eyes open).
- 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).
- Any suspicion of a skull fracture or penetrating head 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).

- Any seizure (‘convulsion’ or ‘fit’) since the injury.

- A 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 metre or more than five stairs, diving accident, high-speed motor vehicle collision, rollover motor accident, accident involving motorised recreational vehicles, bicycle collision, or any other potentially high energy mechanism). A lower threshold for height of falls should be used when dealing with infants and young children (that is, aged less than 5 years).

- The injured person or their carer is incapable of transporting the injured person safely to the hospital A&E Department without the use of ambulance services (providing any other risk factors indicating A&E referral are present).

Telephone advice services (for example, NHS Direct, A&E helplines) should refer people who have sustained a head injury to a hospital A&E department if the history related indicates the presence of any of the following risk factors (alternative terms to facilitate communication are in parentheses).

- Any previous loss of consciousness (‘knocked out’) as a result of the injury, from which the injured person has now recovered.

- Amnesia for events before or after the injury (‘problems with memory’). The assessment of amnesia will not be possible in pre-verbal children and is unlikely to be possible in any child aged less than 5 years.

- Persistent headache since the injury.

- Any vomiting episodes since the injury.
Any previous cranial neurosurgical interventions ('brain surgery').
History of bleeding or clotting disorder.
Current anticoagulant therapy such as warfarin.
Current drug or alcohol intoxication.
Age greater than or equal to 65 years.
Suspicion of non-accidental injury.
Irritability or altered behaviour ('easily distracted' 'not themselves' 'no concentration' 'no interest in things around them') particularly in infants and young children (that is, aged less than 5 years).
Continuing concern by the helpline personnel about the diagnosis.

In the absence of any of the above factors, the helpline should advise the injured person to seek medical advice from community services (e.g. General Practice) if any of the following factors are present.

- Adverse social factors (for example, no-one able to supervise the injured person at home).
- Continuing concern by the injured person or their carer about the diagnosis.

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

4.16 Community health services and NHS minor injury clinics

Community health services (General Practice, paramedics, NHS walk-in centres, dental practitioners) and NHS minor injury clinics should refer patients who have sustained a head injury to a hospital A&E department, using the ambulance service if deemed necessary, if any of the following is present.
• GCS less than 15 on initial assessment.

• Any loss of consciousness as a result of the injury.

• Any focal neurological deficit since the injury (examples include problems understanding, speaking, reading or writing; decreased sensation; loss of balance; general weakness; visual changes; abnormal reflexes; and problems walking).

• Any suspicion of a skull fracture or penetrating head injury since the injury (for example, clear fluid running from the ears or nose, black eye with no associated damage around the eyes, 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 of concern to the professional).

• Amnesia for events before or after the injury. The assessment of amnesia will not be possible in pre-verbal children and is unlikely to be possible in any child aged under 5 years.

• Persistent headache since the injury.

• Any vomiting episodes since the injury (clinical judgement should be used regarding the cause of vomiting in those aged less than or equal to 12 years, and whether referral is necessary).

• Any seizure since the injury.

• Any previous cranial neurosurgical interventions.

• A 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 metre or more than five stairs, diving accident, high-speed motor vehicle collision, rollover motor accident, accident involving motorised recreational vehicles, bicycle collision, or any other potentially high energy
mechanism). A lower threshold for height of falls should be used when dealing with infants and young children (that is, aged less than 5 years).

- History of bleeding or clotting disorder.
- Current anticoagulant therapy such as warfarin.
- Current drug or alcohol intoxication.
- Age greater than or equal to 65 years.
- Suspicion of non-accidental injury.
- Continuing concern by the professional about the diagnosis.

In the absence of any of the above factors, the professional should consider referral to A&E if any of the following factors are present depending on their own judgement of severity.

- Irritability or altered behaviour, particularly in infants and young children (that is, aged under 5 years).
- Visible trauma to the head not covered above but still of concern to the professional.
- Adverse social factors (for example, no one able to supervise the injured person at home).
- Continuing concern by the injured person or their carer about the diagnosis.

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

4.17 Transport from community health services and NHS minor injury clinics

Patients referred from community health services and NHS minor injury clinics should be accompanied by a competent adult during transport to
A&E. 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. 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.

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

4.18 Training in risk assessment

It is recommended that GPs, nurse practitioners, dentists and paramedics should all be capable of assessing the presence or absence of the risk factors listed in 4.16. There is some evidence that paramedics using written triage guidelines in a United States context may fall short of acceptable levels of triage accuracy.238 The Guideline Development Group is under the impression that the triage skills of other community professionals may sometimes be below a desirable standard. Training should be available as required to ensure head injury triage accuracy in paramedics, GPs, nurse practitioners and dentists.

This recommendation is based on level five evidence and is considered to be a grade D recommendation.
5 Immediate management at the scene and transport to hospital

5.1 Pre-hospital management

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

- Patients who have sustained a head injury should initially be assessed and managed according to clear principles and standard practice as embodied in the Advanced Trauma Life Support (ATLS) course and for children the principles as outlined in the Advanced Paediatric Life Support (APLS)/European Paediatric Life Support (EPLS) course materials. [NEW]

- Paramedics should be fully trained in the use of the adult and paediatric versions of the GCS and its derived score.

- Paramedics should have some training in the detection of non-accidental injury and should pass this information to A&E personnel when the relevant signs and symptoms arise.

- The first priority for those administering immediate care is to treat first the greatest threat to life and avoid further harm.

- Patients who have sustained a head injury should be transported directly to a facility that has been identified as having the resources necessary to expeditiously assess and intervene to optimise outcome. These are defined in Chapter 6. It is expected that all acute hospitals accepting patients who have sustained a head injury should have these resources, and that these resources should be appropriate for the patient’s age.

- Patients who have sustained a head injury and present with any of the following risk factors should have full cervical spine immobilisation attempted unless other factors prevent this:
- GCS less than 15 on initial assessment in the emergency department
- neck pain or tenderness
- focal neurological deficit
- paraesthesia in the extremities
- any other clinical suspicion of cervical spine injury

- Cervical spine immobilisation should be maintained until full risk assessment including clinical assessment (and imaging if deemed necessary) indicates it is safe to remove the immobilisation device.

- Standby calls to the destination A&E Department should be made for all patients with a GCS less than or equal to 8, to ensure appropriately experienced professionals are available for their treatment and to prepare for imaging.

- An alerting call to the destination A&E Department should be made for all patients with a GCS less than 15.

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

5.2 Glasgow Coma Scale

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.

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.\(^{147,313,314}\) 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.

- Monitoring and exchange of information about individual patients should be based 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).

- If a total score is recorded or communicated, it should be based on a sum of 15, and to avoid confusion this denominator should be specified (for example, 13/15).

- The individual components of the GCS should be described in all communications and every note and should always accompany the total score.

- The paediatric version of the GCS should include a ‘grimace’ alternative to the verbal score to facilitate scoring in pre-verbal or intubated patients.312

- Best practice in paediatric coma observation and recording as detailed by the National Paediatric Neuroscience Benchmarking Group should be followed at all times. These principles are detailed in Appendix N.331

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

5.3 Glasgow Coma Scale score

It is well established that the risk of intracranial complications, and of subsequent need for surgery increases as GCS score declines.278,304,315 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 13.147 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.  

5.4 Immediate management of patients with severe head injuries

There are specific questions regarding the early management of patients with severe head injuries (i.e. GCS less than or equal to 8). Exhaustive systematic reviews have examined evidence on the management of severe traumatic brain injury.39,98 These reviews found evidence for only a small number of “standards” (i.e. 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 in the original guideline.

5.5 The benefits of direct transport to a specialist neurosciences centre compared to transport to the nearest acute centre

5.5.1 Introduction and rationale for the clinical question

This question has been addressed in this update because many healthcare staff especially ambulance staff may be uncertain when deciding on the most appropriate destination for a patient with severe head injury, what the benefits of directly transporting patients to a neurosciences unit compared to transporting patients to the nearest acute care centre from the injury scene. This is pertinent as the severity of head injury may not be known at the scene and the nearest neuroscience unit may be further in distance than the acute care centre. 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 are but do require neurosurgical care may remain in
the acute centres and receive treatment there when they actually require specialist treatment at a neuroscience unit. For interhospital transfers please see Chapter 7.

An acute care centre 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.

5.5.2 Studies considered for this review

Two studies\(^8\)\(^2\),\(^1\)^\(^1\)\(^6\) were identified that looked at direct transport from the injury scene to an acute centre or to a neurosciences unit. One study\(^1\)^\(^1\)\(^6\) is a retrospective observational cohort study looked at patients transported to regional/area trauma centre or patients transferred to non trauma centre who were assessed via American Triage system (pre hospital care) and referred directly to a non trauma centre. The second study\(^8\)\(^2\) a cohort of paediatric patients using a large national US paediatric trauma registry. These two studies are investigating primary transfer of head injured patients (direct from scene to neurosciences centre).

The outcome measures were mortality, neurological outcome, disability and hospital duration. Studies were excluded where data on head injury patients was not provided, where the patient group is up to 50% non head injured patients, where intervention is about pre hospital care rather than transfer and where the outcomes are only duration of transfer but no other data reported.

5.5.3 Clinical evidence

The first study\(^1\)^\(^1\)\(^6\) an observational cohort study (level 2+), obtained data from the New York State Trauma Registry from 1996-1998. The population group were adults >13 yrs, GCS<14. A sub group data of 2763 head injured patients from data set of 5419 trauma patients was 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 transferred to non
trauma centre who 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 but the extent of head injury was unknown, because GCS classified as <14. The results of this study\textsuperscript{116} showed that the mortality rate of immediate transfer to a neurosciences centre versus non trauma centre were in favour of transfer to neuroscience centre with an odds ratio 0.88, CI (0.64-1.22).

The second study\textsuperscript{82} (evidence level 2-) described a cohort of paediatric patients aged less than 20 years old, admitted to one of ninety paediatric hospitals or trauma centres. The cohort compared 3 branches defined by the site of intubation; in the field, in the trauma centre or in a non-trauma centre. Taking the data from the latter two branches, a 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). No significant differences were found between the two scales, or the place of intubation. However, a correlation was drawn between severity of injury and increased likelihood of survival with direct transfer to a trauma centre. 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.

5.5.4 Economics Evidence

See economics chapter 11.

5.5.5 Evidence statement

With one study\textsuperscript{82} there is some doubt over the definition of head injured patients as it is unclear if these were isolated injury or part of a multiple trauma. This would affect the conclusions one can draw from this study. From this evidence review there is weak evidence for direct transfer of head injured patients from the scene to a neurosciences unit being beneficial.
5.5.6 Rationale behind recommendation

There is no strong evidence to suggest a change in the previous recommendation.

5.6 Recommendations for research

The GDG identified the following priority area for research.

5.6.1 Research Question

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

The aim of this study is to conduct a comparison in patient outcome (mortality/morbidity) for those isolated head injured patients that are transported directly to a centre with neurosciences facilities with the outcomes of those who are transported to the nearest hospital without neurosciences facilities, possibly necessitating a secondary transfer. Patients suffering from isolated serious head injuries with a reduced level of consciousness are currently transported to the nearest hospital by land ambulance or helicopter. The nearest hospital may not have the resources or expertise to provide definitive care for these patients. Patients will be followed as they pass through the care system with mortality and morbidity outcomes collected. These will be compared to allow, using sub-group analysis, the identification of patients for whom direct transfer is most beneficial.

5.6.2 Why this research is important

Limited evidence shown in various studies has shown that patients do better in terms of outcome if they are transported direct to a neurosciences centre when compared to those who are taken to the nearest DGH. This evidence however does not appear to have influenced current practice.
Guidelines are required for those working in the prehospital arena which define those patients who have sustained an head injury would be better served by being transported direct to a neurosciences centre.

Currently patients are either always transported to the nearest DGH as is the case in most land vehicle deployment or in some organisations especially those involving helicopter emergency medical services the decision is left to the judgement of the clinicians at the scene. Those patients transported to the nearest DGH suffer a significant delay in receiving definitive treatment for their head injury.

Information from this study will define which patients should be transported direct to a neurosciences centre bypassing the nearest hospital.

Guidance will be required to define the patient population in terms of their injuries. For example, researchers may focus on isolated injuries or head injuries associated with multi trauma. Further specification about what level of consciousness would be suitable for primary transfer to a neurosciences unit would be required.

### Advanced life support training for ambulance crews

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.281

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.
5.8 **Priority dispatch of emergency ambulances**

The use of an emergency medical dispatch (EMD) system is controversial. The EMD system requires a form of telephone triage 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.\(^{338}\) 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.\(^{223}\)

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.
6 Assessment in A&E

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

1. A communication system with the ambulance service to enable advanced warning to be given of an injured patient.

2. 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.

3. A clinician trained in the emergency care of head injured children

4. Direct access to 24 hour CT scanning on site.

5. An effective CT image reporting service and an image transfer facility linked to the regional neuroscience unit

6. Head injury management agreements which clearly set out roles and responsibilities of the admitting hospital and the neuroscience unit.

7. A patient transfer team trained and equipped to standards described in chapter 7. (NB This refers to the section on inter-hospital transfers)

6.1 Focus of A&E assessment in patients with a head injury

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 an early neurosurgical intervention (e.g. 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.
The main focus of A&E 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, 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.41,197

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

### 6.2 Investigation of clinically important brain injuries

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 studies86,126,178,196,249,297 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'135 and a level two study that reported on the first part of a project likely to produce level one evidence.304

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%.135 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 discharged178. 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.\(^{86,297}\) The task is therefore to derive a more sophisticated clinical decision rule for patient selection that will improve specificity without impairing sensitivity.

### 6.3 The best initial diagnostic tool to determine which patients with head injury require care in a neurosciences centre

#### 6.3.1 Introduction and rationale for the clinical question

This review was carried out to ascertain whether CT was still 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. 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\(^ {115}\) (evidence level 2+). In a recent large, pragmatic, randomised controlled trial\(^ {5}\) examined CT compared with admission for observation. This study was evidence level 1++). This study included hospital patients aged \(\geq 6\) years of age with mild head injury within the past 24hrs who attended acute care centres. The study found CT strategy to be not inferior to observation with regards to patient outcomes with similar rates of complications, mortality and morbidity in the groups. A cohort study\(^ {339}\) was also retrieved (evidence level 2+), comparing unenhanced with perfusion CT, and both with clinical assessment, although no sensitivity or specificity figures were given for the latter. The results recommend using a CT scan as part of the admission survey, but the comparison used is not directly relevant to this question and is therefore not included in this review.

#### 6.3.2 Studies considered for this review

One study was identified\(^ {115}\) that examined the diagnostic value of physical examination (including neurological exam) for positive CT scan findings in children with closed head injury. This was a prospective descriptive study. This evidence is level 2+ quality. The interventions included the comparison of
CT imaging tool with physical examination. The outcome measures for this review was sensitivity and specificity with or without mortality, disability, neurological outcome, cost and hospital duration.

### 6.3.3 Clinical evidence
Halley et al (2004) study examined 98 children (2-16yrs) with isolated closed head injury. This study was based in San Diego, US. Halley et al study concludes that CT imaging shows brain injury and physical examination does not show brain injury. Physical examination method 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.

### 6.3.4 Economics Evidence
See chapter 11 for economic evidence.

### 6.3.5 Evidence statement
The evidence is relatively weak however it does suggest that CT is still a favoured tool when identifying patients with head injury. There is no evidence to suggest otherwise. There is limited evidence especially in the mild head injured population group.

### 6.3.6 Rationale behind recommendation
In light of this and the evidence from Af Geijerstam study (2006), the GDG agreed to add a recommendation that for patients presenting out of hours it is safe to admit fully conscious patients (GCS 15/15) over the age of 65 years for over-night observation when they would otherwise warrant an immediate CT. Overnight observation was not associated with any increase in morbidity or mortality compared with immediate CT.

A delay in diagnosis and treatment of neurosurgical haematomas is known to produce a worse outcome. For extradural haematomas, Mendelow et al showed in 1979 that delays of longer than 2 hours from first recorded deterioration in consciousness to surgery were associated with poor outcome. For acute Subdural haematomas, Seelig et al showed in 1981
that delays of more than 4 hours from injury to operation were associated with poor outcome\(^{274}\).

6.3.7 Recommendation

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

This recommendation is based on level one evidence and is considered to be a grade A recommendation.

For safety, logistic and resource reasons, MRI scanning is not currently indicated 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.\(^{159}\) MRI is contraindicated in both head and cervical spine investigations unless there is absolute certainty that the patient does not harbour an incompatible device, implant or foreign body. There should be appropriate equipment for maintaining and monitoring the patient within the MRI environment and all staff involved should be aware of the dangers and necessary precautions for working near an MRI scanner. MRI safety, availability and speed may improve in the future to the point where it becomes a realistic primary investigation option for head injury.

Plain X-rays of the skull have no role in the diagnosis of significant brain injury. However, they are useful as part of the skeletal survey in children presenting with suspected non-accidental injury.

For patients over 65 presenting out of hours it is safe to admit for effective over-night observation instead of initiating an immediate CT unless GCS< 15.

Skull X-rays in conjunction with high quality in-patient observation also have a role where CT scanning resources are unavailable.
These recommendations are based on level five evidence and are considered to be grade D recommendations.

6.4 The best clinical prediction rule for selecting adults, infants and children with head injury for CT imaging of the head

6.4.1 Introduction and rationale for the clinical question

In order to improve the efficiency of the management of minor head injury, clinical prediction rules can be applied. A clinical prediction rule is derived from original research and is defined as a decisional making tool that incorporates 3 or more variables from the history, examination or simple tests. This review was carried out to examine which clinical prediction rule was the best for selecting patients for CT imaging who experienced a minor head injury. This question was deemed important as the current use of CT for minor head injury is increasing rapidly; it is highly variable and may be inefficient.

6.4.2 Studies considered for this review

Four studies discussed decision rules for selecting patients for CT imaging which attempted to identify those at a high risk for traumatic brain injury (usually ICH). On examination of these studies it was felt that one study had validated the rules in a population with a much lower prevalence of abnormal CT scans than an average UK population and this study was not considered. A second study described a rule that had only a 65% sensitivity for abnormal CT scan results and was also not considered further. The sensitivity of these rules have been questioned in another study.

The remaining two sets of rules, the Canadian CT-rules and the ‘New Orleans’ criteria are now considered. Two versions of the Canadian rules are available, a five point version designed to detect ‘need for neurological intervention’, and a seven point version designed to detect ‘clinically important brain injury’. The remit of this guideline is on the latter outcome, and the seven point rule is therefore the focus of this review. However, it is recognised that
the five point rule has some utility in determining the urgency with which CT imaging should be performed.

Both papers present high quality evidence, but strictly the New Orleans criteria represents level one evidence as it has used separate samples for the derivation and validation phases. The Canadian rules represent level two evidence as they have not yet been validated in a separate sample (this study is ongoing and will report in 2003). Both sets of authors caution against adoption of their rules, the Canadians because of the need for validation, and the New Orleans group because their rules were developed in one centre (the Canadian rules were developed in a multi-centre study).

Three new studies\textsuperscript{203,293,302} were retrieved for this review in addition to the studies above looking at clinical prediction rule in adults. Stiell et al\textsuperscript{302} study is a prospective cohort study (validation study). In the previous guideline (2003) the derivation study was included. The study compared the Canadian CT head rule (CCHR) with the New Orleans Criteria (NOC). Smits et al\textsuperscript{293} prospective cohort study compared the NOC and CCHR rules. The final study was a derivation study by Mower et al\textsuperscript{203} for the NEXUS II rules. This is a prospective cohort study.


The interventions included any prediction rule ranging from NEXUS, NOC, CHR and any other new rules. The outcomes included sensitivity and specificity of prediction rules.

\textbf{6.4.3 Clinical evidence}

The Canadian sample\textsuperscript{304} for a derivation sample, was much larger with 3,121 patients than the New Orleans sample\textsuperscript{126} with 520 patients in the derivation phase and 909 patients in the validation phase. This led to statistical power
problems with certain key variables (e.g. coagulopathy) as not enough patients with these risk factors experienced a negative outcome. It should be noted that the Canadian study considered a much broader range of possible predictive variables, and has outlined in great detail the steps taken to ensure the validity and reliability of the data. Both studies used recursive partitioning as the multivariate technique used to derive the rules.

Both studies excluded patients who had experienced no loss of consciousness. The New Orleans study reports an overall abnormal CT rate of 6.5% and a surgical intervention rate of 0.4%, while the Canadian study reports a rate of clinically important brain injury of 8% and a neurosurgical intervention rate of 1%. The Canadian study included only patients with an initial GCS on arrival at hospital of 13 to 15 and assumed that all patients with GCS less than 13 would receive immediate CT. Four per cent of patients in this study had an initial GCS of 13 and 17% had a GCS of 14, with the remaining 79% having a GCS of 15. The New Orleans study focused on patients with GCS equal to 15 in the A&E Department (assuming that all patients with GCS less than 15 would receive immediate CT) and therefore had a lower severity sample than was seen in the Canadian sample.

The cohort used for the derivation of the Canadian Head CT rule contained 69% males, 11% greater than or equal to 65 years and 31% patients who had sustained a fall, similar to figures for the UK. However, as noted in section 1.8: cause of injury, the proportion of assaults seen in the Canadian sample (11%) is lower than is usually quoted for the UK (30-50%). By contrast, the proportion of road traffic accidents in the Canadian sample (43% if injuries involving pedestrians and cyclists are included) is higher than estimates of 25% for the UK. It is not clear whether this reflects broad difference in injury patterns between the two countries, or simply reflects the specific group of patients selected for the Canadian study (i.e. hospital attendees that had experienced some loss of consciousness or amnesia).

It is also important to note that the Guideline Development Group is under the impression that head injury episodes are more likely to involve alcohol in the UK than in Canada, although exact data on this variable is not available.
Both studies report 100% sensitivity (95% CI: 92-100) for need for neurosurgical intervention. The New Orleans criteria reports a 100% (95% CI: 95-100) sensitivity for positive CT scans, whereas the Canadian seven point rules are 98% (95% CI: 96-99) sensitive for detecting clinically important brain injury. The New Orleans rules have a 25% (95% CI: 22-28) specificity for detecting positive CT scans whereas the Canadian rules are reported to have a 50% (95% CI: 48-51) specificity rate for detecting clinically important brain injury.

The New Orleans criteria would lead to a 78% CT ordering rate in patients with GCS equal to 15. The Canadian seven point rules would lead to a 54% ordering rate in patients with a GCS of 13 to 15. It is important to note that the New Orleans study reports 100% CT-scanning of the sample, whereas the Canadian study had a scanning rate of only 67%, and the remaining 33% had a proxy outcome assessment via telephone interview. The final sample in the Canadian study does not include some 10% of eligible patients who did not undergo CT and subsequently could not be contacted for follow-up.

The rules have the following similarities. Both suggest that patients with GCS less than 15 on presentation at A&E should have immediate CT imaging. The only caveat to this is that the Canadian rules specify GCS less than 15 two hours after injury. However, it should be born in mind that 93% of adults and 96% of children report to A&E with GCS equal to 15, implying that CT imaging for those with GCS less than 15 will not greatly impact on resources. The area of controversy is generally accepted to relate to patients with GCS equal to 15.

Neither rule suggests a role for skull X-ray or admission for observation without CT imaging. Both rules agree that vomiting should be included as an indication for imaging, although the Canadian rule specifies more than one episode. Both rules agree that skull fracture (linear, basal, depressed, open, depressed and penetrating) should be an indication for CT imaging but these are defined and dealt with in different ways. In the New Orleans rules this is included as part of a category named ‘physical evidence of trauma above the clavicles’ which also includes contusions, abrasions and lacerations.
Presumably these would include facial surface wounds and not only wounds to the skull. The Canadian rules seem to have considered obvious penetrating skull injury and/or obvious depressed skull fracture as a priori indications for imaging and have also included any sign of basal skull fracture, and any ‘suspicion’ of open or depressed skull fracture as part of their rules.

Both rules include an age category. The New Orleans rules specify age greater than 60 years, and the Canadian rules specify age greater than or equal to 65 years.

Both rules agree that post-traumatic seizure should be an indication for CT imaging, but the Canadian rules considered this an a priori variable, whereas it is explicitly included in the New Orleans rules.

It is also important to note that coagulopathy is not included in either set of rules but for very different reasons. The Canadian study excluded these patients deliberately, presumably because they were considered a priori candidates for CT imaging. The New Orleans rules included these patients but did not have enough power to detect a significant predictive effect. The New Orleans study explicitly states that this variable was not considered by their study and imply that it should be considered an important predictive variable. A further exclusion from both samples is focal neurological deficit (this is not completely clear from the New Orleans study) again, presumably because CT imaging of the head for these patients was considered non-controversial.

The rules differ in their treatment of amnesia. The Canadian rules include pre-traumatic amnesia (retrograde – for events before the injury) of greater than 30 minutes, whereas the New Orleans rules include post-traumatic ‘short-term memory deficits’ (anterograde - for events after the injury). The Canadian rules contain a variable called ‘dangerous mechanism’ (of injury), which is defined as a pedestrian struck by a motor vehicle, an occupant ejected from a motor vehicle or a fall from a height of greater than three feet or five stairs. The New Orleans rules did not consider this variable. The New Orleans rules contain a headache variable, which was dropped from the Canadian rules.
The New Orleans rules contain a variable for drug or alcohol intoxication whereas this is not included in the Canadian rules. The Canadian authors seem to imply that having a variable "GCS less than 15 after 2 hours" will allow the less severe intoxications to resolve and eliminate a corresponding number of unnecessary scans. The Canadian authors measured ethanol levels in a sub-sample and found that it had no predictive power for the outcomes studied.

(1) UPDATE 2007: Adult rules-

One of the 3 new studies looking at clinical prediction rule in adults were Stiell et al (2005), a validation study of 1822 blunt head trauma patients in nine Canadian emergency departments (evidence level 2+). The inclusion criteria were defined as blunt trauma to the head resulting in the witnessed loss of consciousness, definite amnesia or witnessed disorientation, GCS score of 13 or greater and injury within the previous 24 hours. The Canadian CT head rule (CCHR) was compared to the New Orleans Criteria (NOC). There were 97 patients (5.3%) with clinically important brain injury and 8 patients (0.4%) required neurosurgical intervention. For the outcome clinically important brain injury both rules had 100% (95% CI, 96% to 100%) sensitivity but the Canadian CT head rule had a higher specificity of 50.6% (95% CI, 48% to 53%) than NOC 12.7% (95% CI, 11% to 14%). The reference standard was the CT scan.

The second study was by Smits et al (2005) which included 3181 Dutch patients with blunt head injury compared the NOC and CCHR rules (evidence level 2+). The inclusion criteria were patients older than 16 years, GCS of 13 to 14 and presenting within 24 hours. GCS score of 15 were included with one of the following risk factors; history of loss of consciousness, short-term memory deficit, amnesia for traumatic event, posttraumatic seizure, vomiting, severe headache, clinical evidence of intoxication, use of anticoagulants, physical evidence of injury above clavicles or neurological deficit.

The prevalence of neurocranial traumatic CT finding was 9.8% and the incidence of neurosurgical intervention was 0.5%. The CT scan was used as
the reference standard. For neurosurgical intervention both rules had 100% (95% CI, 81.6 to 100%) sensitivity and the CCHR had a higher specificity of 37.5% (95% CI, 34.9 to 40.0%) compared to NOC 3.0% (95% CI, 1.2% to 4.8%). Neurocranial traumatic CT findings and important CT findings reported a higher sensitivity for the NOC rule. Outcomes were also reported on the entire population, which resulted in the authors adapting the rules to their study population. This study has methodological concerns as the rules tested were adapted to fit into their study population.

The final study was a derivations study for the NEXUS II rules by Mower et al (2005). This study had an evidence level of 2+. This study comprised of 13,728 blunt trauma patients that had undergone head CT scan in 21 participating centres. The prevalence of intracranial injury was 6.7% (917 out of 13,728). The prediction rule had 8 criteria highly associated with intracranial injuries. The rule had a sensitivity of 98.3% (95% CI, 97.2% to 99.0%) and specificity of 13.7% (95% CI, 13.1% to 14.3%).

(2) UPDATE 2007: Child rules-

One of the 3 new studies looking at clinical prediction rule in children were Oman at el (2006) which comprised of 1666 children (under 18 years) with blunt head trauma (evidence level 2+). Patients underwent CT scanning from 21 emergency departments in the NEXUS cohort. This study looked at children in the NEXUS II derivation study to determine if the prediction rule was effective on children. The prevalence of clinically important ICI was 8.3%. The sensitivity was 98.6% (95% CI, 94.9-99.8) and the specificity was 15.1% (95% CI, 13.3-16.9). When the sub-group of children under 3 years old was examined the sensitivity was 100%(95% CI, 86.3-100).

The second study (evidence level 2+) by Haydel et al (2003) comprised of 175 children (5-17 years) with minor head injury from trauma centre in US. Minor head injury was defined as blunt head trauma with loss of consciousness with a normal GCS score, or modified coma scale for infants and children and normal brief neurological examination. The reference standard was the CT scan. The NOC prediction rule was applied to the population to determine
children with intracranial injury. The prevalence was 8%. The sensitivity was 100% (95% CI, 73-100) and the specificity was 25.5% (95% CI, 19.1-33.0%). The CT ordering rate was reduced by 23.4% (95% CI, 17.7-30.2).

Palchak reported a study (evidence level 2+) of 2,043 children (under 18 years) presenting with blunt head trauma (all severities) at a paediatric emergency department of level 1 trauma centre. Significant predictors of traumatic brain injury were determined and the prediction rule was derived using recursive partitioning. The reference standard was CT scanning and clinical follow-up. The prediction rule had a sensitivity of 100% (95% CI, 97.2% to 100%) and a specificity of 42.7% (95% CI, 40.5% to 44.9%) to identify traumatic brain injury requiring intervention. The prediction rule was used on the sub-group of patients that had a CT scan (n=1271) to identify traumatic brain injury identified on CT. The sensitivity was 99.0% (95% CI 94.4% to 100%) and specificity of 25.8% (95% CI 23.3% to 28.4%). One patient was missed using this prediction rule that had a positive traumatic brain injury identified on CT. This is a derivation study and has not yet been validated.

Palchak prediction rule:

A CT scan is required if any of the following predictors are present:

- Abnormal mental status
- Clinical signs of skull fracture
- History of vomiting
- Scalp hematoma in children aged 2 years or younger
- Headache

The final study by Dunning (2006) reported 22,772 children (under 16 years) presenting at ten hospital emergency departments in the North West of England with any severity of head injury (evidence level 2+). Significant predictors of intracranial haemorrhage were determined and the Children's
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Head Injury Algorithm to predict Important Clinical Events (CHALICE) prediction rule was derived using recursive partitioning. The reference standard was CT scanning and clinical follow-up by a multi-modal method of patient monitoring. The CHALICE prediction rule had a sensitivity of 98.6% (95% CI, 96.4% to 99.6%) and a specificity of 86.9% (95% CI, 86.5% to 87.4%). The CT scan ordering rate was 14%. This is a derivation study and has not yet been validated.

Figure 2: The Chalice Prediction Rule:

A computed tomography scan is required if any of the following criteria are present.

History

- Witnessed loss of consciousness of >5 min duration
- History of amnesia (either antegrade or retrograde) of >5 min duration
- Abnormal drowsiness (defined as drowsiness in excess of that expected by the examining clinician)
- 3 vomits after head injury (a vomit is defined as a single discrete episode of vomiting)
- Suspicion of non-accidental injury (NAI, defined as any suspicion of NAI by the examining clinician)
- Seizure after head injury in a patient who has no history of epilepsy

Examination

- Glasgow Coma Score (GCS)<14, or GCS<15 if <1 year old
- Suspicion of penetrating or depressed skull injury or tense fontanelle
- Signs of a basal skull fracture (defined as evidence of blood or cerebrospinal fluid from ear or nose, panda eyes, Battles sign, haemotympanum, facial crepitus or serious facial injury)
• Positive focal neurology (defined as any focal neurology, including motor, sensory, coordination or reflex abnormality)

• Presence of bruise, swelling or laceration >5 cm if <1 year old

Mechanism

• High-speed road traffic accident either as pedestrian, cyclist or occupant (defined as accident with speed >40 m/h)

• Fall of >3 m in height

• High-speed injury from a projectile or an object

If none of the above variables are present, the patient is at low risk of intracranial pathology.

6.4.4 Economics Evidence

See economic section chapter 11

6.4.5 Conclusion

Two evidence based decision rules for selection of patients who have sustained a head injury for CT imaging of the head have been described. There is no clear means of choosing one over the other, and the decision on which rule to choose was therefore based on consensus. Based on the Guideline Development Group consensus, it was decided that the seven point Canadian CT head rules should be used to identify patients who will need CT imaging of the head.

In order to provide guidance that covers all possibilities, the seven point Canadian CT rule has been slightly adapted as follows.

• Patients with post traumatic seizure, focal neurological deficit or coagulopathy should be included in the rule.

• Patients with non-symptomatic risk factors (i.e. age greater than or equal to 65 years, coagulopathy, dangerous mechanism of injury)
should at least have had an instance of loss of consciousness or amnesia (i.e. the main signs and symptoms used to screen patients for inclusion in the Canadian CT-head rule study) before receiving CT. This is to prevent the possibility of patients with no signs or symptoms receiving a CT.

- As noted above, falls from three feet have been changed to falls from greater than one metre, to ensure consistency with other rules adopted by this guideline. A lower threshold for height of falls should be used when dealing with infants and young children (i.e. aged less than five years). See section 4.8.

- Clinical judgement regarding the cause of vomiting in those aged less than or equal to 12 years should be used, and this judgement should guide whether imaging is considered necessary.

- The assessment of amnesia will not be possible in pre-verbal children and is unlikely to be possible in any child aged less than five years.

The 3 studies\textsuperscript{203,293,302} within this review compared different decision rules in adults. One study\textsuperscript{302} showed that for patients with minor head injury and GCS score of 15, the Canadian CT head rule had a higher specificity than NOC for clinical important outcomes. This study also showed that the Canadian CT head rule and NOC have equivalent high sensitivities for need for neurosurgical intervention and clinically important brain injury. The second study\textsuperscript{293} showed for patients with minor head injury and a GCS score of 13 to 15, the Canadian CT head rule has a lower sensitivity than the NOC for neurocranial traumatic or clinically important CT findings. The final study\textsuperscript{203} included the NEXUS II rule which had a sensitivity of 98.3% and specificity of 13.7%.

The 4 new studies\textsuperscript{84,127,225,228} within this review compared different decision rules in children. One study\textsuperscript{225} concluded that the decision rule derived in the large NEXUS II cohort performed with similar high sensitivity among the subgroup of children who were included in this study. The second study\textsuperscript{127}
found that CT use in children aged 5yrs or older with minor head injury could be safely reduced by 23% by using a clinical decision rule previously validated in adults. The Palchak study derived a clinical decision rule for the identification of children who should undergo CT after head injury. The final study derived a highly sensitive clinical decision rule for the identification of children who should undergo CT scanning after head injury.

6.4.6 Evidence statement

For the adult head prediction rules there was again no clear means of choosing one over the other, and the decision on which rule to choose was therefore based on consensus.

However for the children’s head prediction rule, Dunning (2006) study is a highly sensitive clinical decision rule for the prediction of significant intracranial pathology in children according to strict methodological standards.

6.4.7 Rationale behind recommendation

The 2003 Guideline Development Group considered these recommendations see below (highlighted in grey) to be interim and dependant on future research which was likely to appear in the literature in time for the update. These include the validation phase of the Canadian CT head rules, and a new clinical decision instrument based upon the NEXUS II study. The latter study recruited approximately 15,000 patients to the overall project (derivation and validation).MOWER2002.

In relation to selection of patients for imaging of the head, a recent level two study has produced a clinical decision rule for use in children aged less than two years. It is likely that a validation study for this rule will appear in the near future, although methodological concerns will remain about the derivation phase (see Appendix i). A strong predictive power is ascribed to scalp haematoma in young children.106.

The literature on skull X-ray in children and infants indicates that, as with adults, the specificity of skull X-ray is too low to be the primary investigation (i.e. the absence of skull fracture does not predict absence of intra-cranial
In studies which have included both children and adults, there is evidence that adult rules can be safely applied to children, but these studies have suffered from statistical power problems. The evidence regarding the safety of adult rules with infants is inconclusive.

Based on the 3 adult prediction rule studies, the GDG decided that no change in recommendation was required as they felt there was not enough evidence to warrant a change.

However, the GDG decided that a new recommendation was required for clinical prediction rules of the head in children. Original recommendation was that validated adult rules on imaging of the head may be safely used in children and infants. The current recommendation for adult rules is the Canadian CT Head Rules. So for children with head injury, clinicians could use the Canadian CT Head Rules. However, the GDG decided that a new recommendation was required for clinical prediction rules of the head in children with the emerging evidence in the Dunning (2006) study in this update. The GDG considers the recommendation of CHALICE rule for children currently represents the best evidence for the treatment of head injuries in children, but the GDG cautions that this rule is a derivation study only and requires prospective validation. Therefore future recommendations will be dependent on future validation studies.

**6.4.8Recommendation**

**For Adults**

Adult patients who have sustained a head injury and present with any one of the following risk factors should have CT scanning of the head immediately requested.

- GCS less than 13 on initial assessment in the emergency department.
- GCS equal to 13 or 14 at two 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 otorrhoea, Battle’s sign).

• Post traumatic seizure.

• Focal neurological deficit.

• More than one episode of vomiting.

• Amnesia for greater than 30 minutes of events before impact.

CT should also be immediately requested in patients with any of the following risk factors provided they have experienced some loss of consciousness or amnesia since the injury:

• Age greater than or equal to 65 years.

• Coagulopathy (history of bleeding, clotting disorder, current treatment with warfarin).

• Dangerous mechanism of injury (a pedestrian struck by a motor vehicle, an occupant ejected from a motor vehicle or a fall from a height of greater than 1 metre or five stairs).

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

For Children

Children who have sustained a head injury and present with any one of the following risk factors should have an immediate CT request of the head:

History

• Witnessed loss of consciousness of >5 min duration
• History of amnesia (either antegrade or retrograde) of >5 min duration

• Abnormal drowsiness (defined as drowsiness in excess of that expected by the examining clinician)

• 3 vomits after head injury (a vomit is defined as a single discrete episode of vomiting)

• Suspicion of non-accidental injury (NAI, defined as any suspicion of NAI by the examining clinician)

• Seizure after head injury in a patient who has no history of epilepsy

Examination

• Glasgow Coma Score (GCS)<14, or GCS<15 if <1 year old on assessment in the emergency department

• Suspicion of penetrating or depressed skull injury or tense fontanelle

• Signs of a basal skull fracture (defined as evidence of blood or cerebrospinal fluid from ear or nose, panda eyes, Battles sign, haemotympanum, facial crepitus or serious facial injury)

• Positive focal neurology (defined as any focal neurology, including motor, sensory, coordination or reflex abnormality)

• Presence of bruise, swelling or laceration >5 cm if <1 year old

Mechanism

• High-speed road traffic accident either as pedestrian, cyclist or occupant (defined as accident with speed >40 m/h)

• Fall of >3 m in height
• High-speed injury from a projectile or an object

If none of the above variables are present, the patient is at low risk of intracranial pathology.

6.5 Investigation of cervical spine injuries

There is a 2-6% incidence of significant cervical spine injury in patients who are symptomatic following head trauma. 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.

6.5.1 Imaging options

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.

• Plain films:
  o cross table lateral
  o 3 film series (with swimmer’s view for cervico-dorsal junction if required)
  o 5 film series including ‘trauma obliques’.

• Lateral flexion/extension series – immediate and/or delayed.

• CT (localised or whole cervical spine including cervico-dorsal junction).

• Magnetic Resonance Imaging.

(3) Plain films

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%. 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. If fractures that are clinically important are used as the gold standard then sensitivity is approximately 94% and overall specificity 96% in a low risk group.

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

Patients who have sustained major trauma are more difficult to evaluate with plain films 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-dorsal junction.

(4) 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. Ten per cent of ‘normals’ may have ‘abnormal’ flexion/extension views.

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

(5) CT imaging of the cervical spine

CT imaging of the cervical spine may be localised (e.g. craniocervical or cervico-dorsal to clarify a clinical or plain radiographic area of suspicion), or cover the whole cervical spine. Modern multislice helical CT scanners enable the whole cervical spine to be scanned at high resolution with ease. Multiplanar reformatted images can be generated rapidly on modern workstations. Use of these modern facilities is increasing in the NHS, but total coverage has not yet been achieved.
Several studies report 100% sensitivity for detection of injuries in areas poorly visualised or suspicious on plain films. These studies are flawed however in that they have not used an alternative gold standard. If CT imaging of the head has been requested the cost of cervical CT is reduced and can be accomplished quickly without patient transfer.

(6) 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 film and CT but the clinical significance of these injuries is unclear. MRI is less effective than CT in the detection of bony injury. It has also been demonstrated that MRI can miss ligamentous injuries if delayed. Injuries of the mid-cervical spine, especially subluxation and lateral fractures are associated with vertebral artery injury which may be detected by MRI.

(7) 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 plain films is extremely difficult and radiological diagnosis requires good quality CT.

6.6 The best or imaging tool(s) to determine which patients have sustained damage to the cervical spine and require assessment of cervical spine

6.6.1 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.
6.6.2 Studies considered for this review

This review included one meta-analysis\textsuperscript{139} which compared plain X-rays with CT. This meta-analysis included seven diagnostic cohort studies. The studies varied in type of X-rays (3 and 5 views) and some were retrospective and others prospective. Another prospective diagnostic cohort study\textsuperscript{222} was also retrieved comparing 3 view X-ray with CT. The final study prospective diagnostic cohort study\textsuperscript{44} comparing helical CT and X-rays (single cross-table lateral). All 3 studies were graded 2+ evidence level. All these studies included patients over 16yrs of age. There were no studies found in children and infants.

The population group were patients with head injury and suspected c-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 were sensitivity and specificity of the imaging tool.

6.6.3 Clinical evidence

A meta-analysis\textsuperscript{139} was retrieved which included seven diagnostic cohort studies (evidence level 2+). 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 the seven studies were reviewed individually. The sensitivities in these seven studies
ranged from 39 to 76%. The studies varied in type of X-rays (3 and 5 views) and some were retrospective and others prospective.

A prospective cohort study\(^222\) was retrieved (evidence level 2+). 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 c-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\(^44\) comprised of 442 unconscious intubated blunt trauma patients in the UK. This study is an evidence level 2+ study. 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 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.

6.6.4 Economics Evidence

See Economics section in chapter 11

6.6.5 Conclusion

There is no evidence at present to suggest that CT screening is required for everyone regardless of head injury severity. The GDG previously recommended that X-ray should be the initial imaging modality of choice in all cases and if the injured area was not visible then CT would be indicated. There was also an assumption that if the X-ray was clear or that the clinician could see the injury, then X-ray plates would suffice. From the updated evidence in this guideline it is evident that sometimes a clinically significant injury is not visible on X-ray, therefore a change to the previous recommendation is necessary. CT scanning is the best initial diagnostic tool for cervical spine injuries in severe head injured patients.
6.6.6 Evidence statement

From the meta-analysis\textsuperscript{139} the GDG decided that in severely head injured patients CT was the best initial diagnostic tool for assessment of the cervical spine. GDG suggested a change in wording of the recommendation - to add that patients with severe head injury (GCS ≤ 8) should have CT scans of the cervical spine rather than X-rays. All the studies in this review looked at adults over 16yrs and no studies were found looking at children.

6.6.7 Rationale behind recommendation

Rationale for this amendment to the previous recommendation is that in this group of severely head injured patients (GCS ≤ 8) X-rays are not detecting all cervical spine injuries. The update evidence is of grade 2+ quality and 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.

6.6.8 Recommendation

The current investigations of choice for the detection of injuries to the cervical spine are three view plain radiographs of good technical quality. Where it is not possible to achieve the cervical spine views desired with X-ray, CT imaging is indicated.

CT is also indicated in patients with severe head injury (GCS ≤ 8), if the plain film series is technically inadequate (for example, desired view unavailable), suspicious or definitely abnormal or if there is continued clinical suspicion of injury despite a normal X ray.

CT imaging of the cervical spine should be considered if the patient is having other body areas scanned for head injury/multi-region trauma, and a definitive diagnosis of cervical spine injury is required urgently.

As a minimum, CT should cover any areas of concern or uncertainty on plain film or clinical grounds. With modern multislice scanners the
whole cervical spine can be scanned at high resolution with ease and multiplanar reformatted images generated rapidly. Facilities for multiplanar reformatting and interactive viewing should be available.

MRI is indicated in the presence of neurological signs and symptoms referable to the cervical spine and if there is suspicion of vascular injury (for example, subluxation or displacement of the spinal column, fracture through foramen transversarium or lateral processes, posterior circulation syndromes). MRI may add important information about soft tissue injuries associated with bony injuries demonstrated by plain films and/or CT. MRI has a role in the assessment of ligamentous and disc injuries suggested by plain films, CT or clinical findings.

In CT, the occipital condyle region should be routinely reviewed on 'bone windows' 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.

In patients who have sustained high energy trauma or are showing signs of lower cranial nerve palsy, the results of initial imaging should be considered and particular attention should be paid to the region of the foramen magnum. If necessary, additional high resolution imaging for coronal and sagittal reformatting should be performed while the patient is on the scanner table.

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

### 6.7 Cervical spine imaging of Infants and children

#### 6.7.1 Recommendation

Children aged 10 years or more can be treated as adults for the purposes of cervical spine imaging.

In children under 10 years, because of the increased risks associated with irradiation, particularly to the thyroid gland, and the generally lower
risk of significant spinal injury, CT of the cervical spine should only be used in exceptional circumstances (for example, cases where patients have a severe head injury (GCS \( \leq 8 \)), or where there is a strong suspicion of injury despite normal plain films, or cases where there is a strong suspicion of injury and plain films are inadequate).

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

It is recognised that physical examination of an immobilised, distressed child can be extremely difficult. Based on consensus the following recommendations were formulated by the Guideline Development Group:

Children under 10 years should receive anterior/posterior and lateral views without an anterior/posterior peg view. Abnormalities or uncertainties in those under 10 years should be clarified by CT imaging. When minor trauma is associated with subsequent torticollis the plain films are almost uninterpretable; CT is very helpful in this situation.

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

6.8 The best clinical prediction rule(s) for selecting patients that have sustained damage to the cervical spine for the imaging technique selected above?

6.8.1 Introduction and rationale for the clinical question

In order to improve the efficiency of the management of cervical spine injury, clinical prediction rules can be applied. A clinical prediction rule is derived from original research and is defined as a decisional making tool that incorporates 3 or more variables from the history, examination or simple tests\(^{302-304}\). This review was carried out to examine which clinical prediction rule was the best for determining which patients should undergo CT of the cervical spine. This question was deemed important as emerging evidence shows that the current practice of using plain films is not always reliable in
identifying clinically important injuries to the cervical spine. This is particularly true in patients with severe head injury in whom assessment is more difficult.

6.8.2 Studies considered for this review

In the 2003 guideline, a systematic review of clinical decision rules for selection of patients who have sustained a head injury for imaging of the cervical spine was carried out according to the methods outlined in Chapter Two. Two level one studies were identified.133,305 These were the NEXUS study group from America and the Canadian cervical spine rule.

The remaining papers that were reviewed all contained non-level one evidence for a variety of rules and were derived in small cohorts. In addition some papers considered a variety of different aspects of cervical spine imaging. These included studies in patients who are not fully conscious, studies on the utility of flexion-extension views, studies in children and studies on the utility of CT scanning or MRI scanning. These studies are included in the evidence table but contribute little to the decision as to which rule to use to exclude low-risk patients from cervical imaging.

In the update two studies18,301 were identified that examined patients with head injury and suspected cervical spine injury. One prospective diagnostic cohort study301 validates the Canadian Cervical Spine Rule (CHR) and also compares the outcomes to the NEXUS low risk criteria (NLR). A second prospective diagnostic cohort study included18 compared the CCR and physicians judgement

The interventions included any prediction rule ranging from NEXUS, NOC, CHR and any other new rules. The outcomes included sensitivity and specificity of prediction rules.

6.8.3 Clinical evidence

The Canadian cervical spine rule involves the following questions.
Is there any high risk factor present that mandates radiography: age greater than or equal to 65 years, dangerous mechanism, or paraesthesia in the extremities?

Is there a low risk factor present that allows the safe assessment of range of motion (i.e. simple rear-end motor vehicle collision, sitting position in ED, ambulatory at any time since injury, delayed onset of neck pain, absence of midline cervical spine tenderness?)

Is the patient able to actively rotate their neck 45 degrees to the left and right?

For the NEXUS rule, absence of five criteria are used to classify the patient as low risk.

- No midline cervical tenderness.
- No focal neurological deficit.
- Normal alertness.
- No intoxication.
- No painful distracting injury.

Both papers present high quality evidence, the NEXUS rule is level one evidence although they validated their rule by asking each doctor whether the patient was high or low risk using the rule rather than compelling the attending physician to follow the rule. The validation phase of the Canadian cervical spine rules has now been completed and successfully validates the rule.

The NEXUS study collected prospective data on 34,069 patients in twenty-one hospitals in the USA who underwent cervical imaging following blunt trauma. Included were patients at all levels of alertness, and children. The Canadian cervical spine rule studied 8,924 patients in ten large Canadian community and university hospitals who underwent cervical imaging following blunt trauma. Only adults with a GCS score equal to 15 were included.
The Canadian cervical spine rule excluded patients who were not fully alert at the time of assessment (i.e. GCS equal to 15) on the assumption that these patients would automatically receive cervical spine imaging. The NEXUS rule included all levels of alertness. The NEXUS paper reports an overall cervical fracture rate of 2.4% and a clinically significant fracture rate of 1.7%, while the Canadian paper reports an overall fracture rate of 2.0% with a clinically significant cervical spine fracture rate of 1.7%. The NEXUS rule had no age exclusion whereas the Canadian rules were derived and validated only on patients aged over 16 years.

The Canadian cervical spine rule gives a sensitivity of 100% (95% CI: 98-100) and NEXUS gives a sensitivity of 99.6% (95% CI: 98.6-100). The NEXUS rule is not 100% sensitive but of the two clinically significant missed fractures one had an extension-teardrop fracture and self discharged. He was well at six months. One had a fracture of the right lamina of the sixth cervical vertebra requiring open fixation, but may have been incorrectly classified as low risk by the institution as he had loss of consciousness and neurological signs. Of interest, Stiell et al tested the NEXUS rule on the Canadian cervical spine cohort and found that the sensitivity of the NEXUS rule was only 93%. They also criticise the NEXUS rule for the poor reproducibility of ‘presence of intoxication’ and ‘distracting painful injuries’. These criticisms have not been accepted by the developers of the NEXUS rules, who have argued that the data collected by the Canadian group was inadequate to properly test the NEXUS criteria (Hoffman JR, personal communication).

The main difference in the performance of the rules lies in specificity. The NEXUS rule has a specificity of 13% (95% CI: 12.8-13.0) whereas the specificity of the Canadian cervical spine rule is 42% (95% CI: 40-44) for clinically significant injuries. In addition the Canadian cervical spine rule detected 27 out of 28 clinically insignificant spine fractures.

Because of the very large difference in specificity the ordering rate produced by the two rules is also markedly different. The NEXUS rule requires an 87% three view plain radiography rate, whereas the Canadian cervical spine rule requires a 58% rate. It is important to note that NEXUS only found 498 of the
818 cervical spine abnormalities on plain radiography, as a very high number of plain radiographs were of inadequate quality. Another issue of concern is that 23 of the cervical fractures that were categorised as high risk by the NEXUS rule had plain radiographs that missed the fracture even though they were of good quality. These fractures were only picked up as further imaging was performed. The Canadian cervical spine rule paper did not comment on how many of their plain radiographs were of inadequate quality, and therefore how many patients had their fracture picked up by additional imaging.

In the Canadian study, 68% of the sample underwent plain radiography. All participants were telephoned at 14 days to assess for any missed injuries, as there was no other universal gold standard imaging applied, but 577 participants originally entered into the study could not be traced by telephone and did not have a cervical spine radiograph and so were later excluded. This is clearly of methodological concern. The NEXUS study performed three view imaging in 87% of all participants. They had a different follow up protocol in that they set up a surveillance protocol, looking for any missed fractures returning to any of the participating hospitals. None was found.

The two rules overall adopt very different strategies in the generation of their rules in that the NEXUS group has selected clinical correlates from the history and the examination without advising any specific tests in the examination, whereas the Canadian rules have been generated around an interim test of the ability to actively rotate the neck, thereby increasing the specificity markedly. With regard to the similarities of the rules, NEXUS categorises patients who are not alert as high risk, whereas the Canadian rules considers such patients to be at high risk on an a priori basis. Both identify absence of midline tenderness as a means of triaging to low risk. NEXUS immediately puts them at low risk whereas the Canadian rule marks them as low risk if they can also rotate the neck. NEXUS identifies focal neurology as high risk and the Canadian rule identifies paraesthesia as high risk.

The main difference in the nature of the rules lies in the use of active neck rotation. NEXUS did not consider removal of the collar for examination as a safe procedure prior to imaging, whereas the Canadian rule found low risk
criteria for safely performing active neck rotation, a manoeuvre that has an excellent specificity for exclusion of neck fracture. Due to this great difference in ethos, there are many differences in the two rules. The Canadians cite age greater than or equal to 65 years and dangerous mechanism as indications for immediate radiography, whereas these were not identified in the NEXUS rule. The Canadian rule also cites several specific low risk factors for the simple neck rotation test. The NEXUS rule uses painful distracting injury and intoxication to select patients for radiography, whereas the Canadian investigators did not find these as useful as their other high risk factors.

The two rules differ greatly in their approach to the triage of patients at risk for a cervical injury. The NEXUS study is a much larger cohort and includes children and those who had a GCS score of less than 15. The Canadian rule is however much more specific and provides a validated rule that safely excludes 42% of patients who have sustained a head injury from radiography. Neither rule however fully describes how to diagnose the fracture once someone has been identified as at high risk, because plain radiography is often inadequate and is not always 100% sensitive.

One prospective cohort study\textsuperscript{301} comprised of 7438 consecutive adult patients with acute trauma to the head or neck who were in a stable and alert (GCS 15) condition who had neck pain or no neck pain but visible injury above the clavicle and were non-ambulatory and had a dangerous mechanism of injury in nine Canadian emergency departments. This is an evidence level 2+ study. This study validates the CCR and also compares the outcomes to the NEXUS low risk criteria (NLR). Patients received an X-ray when ordered by the treating physician or were followed up with a structured telephone interview with a nurse to ensure no injuries were missed.

162 patients (2\%) had cervical spine injury. The CCR had a higher sensitivity than NLC, which was 99.4\% (95\% CI, 96-100) compared to 90.7\% (95\% CI, 85-94) respectively. CCR had a higher specificity (45.1\% [95\% CI, 44-46]) compared to NLC (36.8\% [95\% CI, 36-38]). CCR had a lower ordering rate than NLC (55.9\% vs 66.6\%). The CCR missed one injury compared to NLC which only identified 147 of the 162 cervical spine injuries.
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There was an additional 845 patients selected that were excluded for the primary analysis. These patients were excluded as they were not tested on range of motion which is one of the criteria for the CCR prediction rule. Secondary analysis was conducted including these ‘indeterminate’ patients.

The second prospective cohort study retrieved\(^1\)\(^8\) compared the CCR and physicians judgement (evidence level 2+). This study comprised of 6265 adult patients who were in a stable and alert (GCS 15) condition who had neck pain or no neck pain but visible injury above the clavicle and were non-ambulatory and had a dangerous mechanism of injury in ten Canadian emergency departments. This population was from Phase 1 of the original derivation study for the CCR. Physician's judgement was assessed to predict at least 0% probability of clinically important c-spine injury. Patients received X-rays as requested by judgement of treating physician or were followed up at 14 days by structured telephone interview.

There were 64 (1%) clinically important c-spine injuries detected. CCR had a higher sensitivity of 100% (95% CI, 94-100) compared to physician judgement of 92.2% (95% CI, 94-100). Specificity was 44.0% (95% CI, 43-45) for CCR compared to 53.9% (95% CI, 82-96) for physician judgement.

6.8.4 Economics Evidence

See economics section 11

6.8.5 Conclusion

In the 2003 guideline two evidence based decision rules for selection of patients who have sustained a head injury for imaging of the cervical spine have been described. There was no clear means of choosing one over the other, and the choice of rule was therefore based on consensus. Based on the Guideline Development Group 2003 consensus, it was decided that the Canadian cervical spine rules should be used to identify patients who will require imaging of the cervical spine.

In order to provide guidance that covers all possibilities, the Canadian cervical spine rule had been slightly adapted as follows.
• Patients with GCS less than 15 at the time of assessment should have cervical spine imaging.

• Patients with focal neurological deficit should be included in the rule.

• Patients who have non-symptomatic risk factors (i.e. are aged greater than or equal to 65 years, or who have had a dangerous mechanism of injury) should have some neck pain or tenderness before receiving cervical spine imaging.

The original NICE guideline recommended that the seven point Canadian CT head rules (CCHR) should be used to identify patients who will need CT imaging of the head. One study indicated that the Canadian Cervical Spine Rule (CCR) had a higher sensitivity than NLC, which was 99.4% compared to 90.7% respectively. CCR had a higher specificity of 45.1% compared to NLC of 36.8%. One study showed Canadian Cervical Spine Rule had a higher sensitivity of 100% compared to physician judgement of 92.2% and specificity was 44.0% for CCR compared to 53.9% for physician judgement.

6.8.6 Evidence statement

The Canadian Cervical Spine Rule had a higher sensitivity than NEXUS low risk criteria and physician judgement. It should be noted that both studies came from the Canadian Cervical Spine Rule group. There is no new evidence to support CT spine for people with mild head injuries.

6.8.7 Rationale behind recommendation

The GDG decided that no change should be made to the original recommendation that Canadian Cervical Spine Rule (CCR) should be used for selecting patients with cervical spine damage for the most accurate imaging technique.

GDG agreed that in cases where there is a severe head injury to an adult, a CT spine examination is required. There is a box on the child algorithm that allows some children to have a CT for severe injury. Adults and children
should get CT spine if they are getting CT head. CT of all necks is not recommended as there is no evidence to suggest so.

6.8.8 Recommendation

Adult patients with any one of the following risk factors should have three view radiograph imaging of the cervical spine immediately requested.

- GCS less than 15 on initial assessment in the emergency department.
- Paraesthesia in the extremities
- Focal neurological deficit
- Not possible to test for range of motion in the neck (safe assessment of range of motion can be performed with the following: simple rear-end motor vehicle collision, sitting position in A&E, ambulatory at any time since injury, delayed onset of neck pain, absence of midline cervical spine tenderness).
- Patient not able to actively rotate neck to 45 degrees to the left and right (if assessment is possible).

Cervical spine imaging should also be immediately requested in the patients with the following risk factors provided they have some neck pain or tenderness.

- Age greater than or equal to 65 years
- Dangerous mechanism of injury (fall from greater than 1 metre or five stairs; axial load to head for example, diving; high-speed motor vehicle collision greater than 65 miles per hour; rollover motor accident; ejection from a motor vehicle; accident involving motorized recreational vehicles; bicycle collision). A lower threshold for height of falls should be used when dealing with
These recommendations are based on level one evidence and are considered to be grade A recommendations.

The Guideline Development Group 2003 considered this recommendation to be interim and dependant on future research likely to appear in time for the update guideline specifically the peer reviewed publication of the validation phase of the Canadian cervical spine rules.

Children less than 10 years old who have a GCS of 8 or less should have a CT of the cervical spine within 1 hour of presentation. CT should also be undertaken when the GCS is between 14 and 9 if there is high clinical concern (for example, focal neurological deficit or paraesthesia in the extremities). Finally, CT should be undertaken in any child when an x-ray is found to be inadequate or there is continuing clinical concern.

6.9 Using adult rules with infants and children

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 13 but to date no clearly defined rules with acceptable sensitivity and specificity have been produced.78,114

In this update new clinical prediction rules for head imaging have been examined in children and have been recommended for the head. However no studies have investigated clinician prediction rules for the cervical spine in children, therefore no new recommendation is suggested for use in children.

6.10 Recommendations for research

The GDG identified the following priority areas for research.
6.10.1 Research Question

Research is needed to establish the validity of previously derived clinical decision rules on the selection of head injured infants and children for CT scanning to exclude significant brain injury.

6.10.2 Why this research is important

The 2002 NICE guidelines recommended that children be selected for CT scanning on the basis of the Canadian Head CT rule, a clinical decision rule derived and validated in adults. This was due to the absence of such a rule derived in children. However since this date the CHALICE rule has been published which presents a clinical decision rule derived in a large group of children and infants from the UK with good sensitivity and specificity.

However, clinical decision rules often provide an overestimate of their performance when applied to new populations. We now recommend the usage of the CHALICE rule for all patients suffering a head injury in the UK, with the caveat that a validation of the rule in a new population of head injured UK patients be urgently undertaken to ensure its reliability and reproducibility.

Such a study is now essential and performing a validation of the CHALICE study in a novel UK population may easily be performed in a 1-2 year timeframe with acceptable costs, and considerable benefits in terms of assuring clinicians as to the safety of this novel rule.

6.11 Piloting the new rules

The process of implementing these guidelines is beyond the Guideline Development Group 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 Guideline Development Group 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.

6.12 Non-accidental injury in children

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.

Owing to the distinct pattern of injuries involved, skull x-ray as part of a series of plain x-rays (skeletal survey), along with other well-established examinations (for example, opthalmoscopic examination for retinal haemorrhage; examination for pallor, anaemia, tense fontanelle) and investigations (for example. CT, MRI), has a role in detecting non-accidental head injuries in children (that is, aged less than 12 years). A clinician with expertise in non accidental injury must be involved in any suspected case of non-accidental injury.

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

Work on the derivation of clinical decision rules to predict non-accidental injury based on imaging patterns has recently been begun. 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.

6.13 Good practice in A&E assessment

The following should be practised during A&E assessment.

1. The priority for all A&E patients is the stabilisation of airway, breathing and circulation (ABC) before attention to other injuries.
2. Depressed conscious level should be ascribed to intoxication only after a significant brain injury has been excluded.

3. All A&E clinicians involved in the assessment of patients with a head injury should be capable of assessing the presence or absence of the risk factors in the guidance on patient selection and urgency for imaging (head and neck cervical spine – see above recommendations). Training should be available as required to ensure that this is the case.

4. Patients presenting to A&E with impaired consciousness (GCS less than 15) should be assessed immediately by a trained member of staff (for example, triage nurse).

5. In patients with a GCS less than or equal to 8 there should be early involvement of an anaesthetist or critical care physician to provide appropriate airway management, as described in section 7.9, and to assist with resuscitation.

6. All patients presenting to A&E with a head injury should be assessed by triage by a trained member of staff 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, using the guidance on patient selection and urgency for imaging (head and neck cervical spine – see recommendations above).

7. Patients found to be high risk on triage for clinically important brain injury and/or cervical spine injury should be assessed within 10 minutes of triage by an A&E clinician. Part of this assessment should fully establish the need to request CT imaging of the head and/or imaging of the cervical spine. The guidance on patient selection and urgency for imaging (head and cervical spine) should form the basis for the final decision on imaging after discussion with the radiology department.
8. Patients with head injury who are discovered to be at low risk for clinically important brain injury and/or cervical spine injury on initial triage should be assessed within a further hour by an A&E clinician. Part of this assessment should fully establish the need to request CT imaging of the head and/or imaging of the cervical spine. The guidance on patient selection and urgency for imaging (head and cervical spine) should again form the basis for the final decision on imaging after discussion with the radiology department.

9. Pain management is important. Indeed, pain can lead to a rise in intra-cranial pressure. Reassurance and splintage of limb fractures is helpful; catheterisation of a full bladder will reduce irritability. Significant pain should be treated with small doses of intravenous opiates titrated against clinical response and baseline cardiorespiratory measurements.

10. Throughout the hospital episode, all care professionals should use a standard head injury proforma in their documentation when assessing and observing patients with head injury. Excellent proformas have been produced in previous guidelines from the Scottish Intercollegiate Guidelines Network and the Royal College of Surgeons of England. A separate proforma for those under 16 years should be used. Areas to allow extra documentation should be included (for example, in cases of non-accidental injury).

Examples of the proformas that should be used in patients with head injury are shown in Appendices J and K.

These recommendations are based on level five evidence and are considered to be grade D recommendations.
7 Imaging practice and involvement of the neurosurgical department.

7.1 Good practice in imaging of patients with a head injury

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. In 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.

7.2 Urgency in performing CT of the head

Given the demands on CT scanners and radiologists trained in their use it is important to distinguish between those patients for whom CT imaging is required ‘urgently’ and those where CT can be performed ‘within a reasonable period’.

Given that it is proposed that selection for head imaging be based upon the Canadian CT-head rules, 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 (i.e. within one hour of the request having been received) whereas the latter patients can wait for a reasonable period (4 hours) before imaging.

CT imaging of the head should be performed (that is, imaging carried out and results analysed) within 1 hour of the request having been received by the radiology department in those patients where imaging is requested because of any of the following risk factors.

- GCS less than 13 on initial assessment in the emergency department.
- GCS equal to 13 or 14 at two hours after the injury.
- Suspected open or depressed skull fracture.
- Any sign of basal skull fracture (haemotympanum, ‘panda’ eyes, cerebrospinal fluid otorrhoea, Battle’s sign).
- More than one episode of vomiting in adults. In children more than 3 vomiting episodes (clinical judgement should be used regarding the cause of vomiting in those aged less than or equal to 12 years, and whether imaging is necessary).
- Age greater than or equal to 65 years, providing that some loss of consciousness or amnesia has been experienced.
- Post traumatic seizure.
- Coagulopathy (history of bleeding, clotting disorder, current treatment with warfarin) providing that some loss of consciousness or amnesia has been experienced.
- Focal neurological deficit.

Patients who have any of the following risk factors and none of the above risk factors should have their CT imaging performed within 8
hours of the injury (imaging should be performed immediately in these patients if they present 8 hours or more after their injury).

- Amnesia for greater than 30 minutes of events before impact (the assessment of amnesia will not be possible in pre-verbal children and is unlikely to be possible in any child aged less than five years).
- Dangerous mechanism of injury (a pedestrian struck by a motor vehicle, an occupant ejected from a motor vehicle or a fall from a height of greater than 1 metre or five stairs) providing that some loss of consciousness or amnesia has been experienced. A lower threshold for height of falls should be used when dealing with infants and young children (that is, aged less than five years). See section 4.8

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

### 7.3 Cervical spine imaging urgency

The demands on X-ray facilities are not as pressing as those on CT facilities and there is no consequent need to discriminate between different categories of patient requiring cervical spine imaging. Cervical spine imaging if indicated should be carried out urgently as these patients will often need CT of the head once the cervical spine has been cleared.

Imaging of the cervical spine should be performed within 1 hour of a request having been received by the radiology department. Where a request for urgent head CT (that is, within 1 hour) has also been received, the cervical spine imaging should also be carried out within 1 hour.

This recommendation is based on level five evidence and is considered to be a grade D recommendation.
7.4 **Involving neurosurgical care**

The care of all patients with new, surgically significant abnormalities on imaging should be discussed with a neurosurgeon. The definition of ‘surgically significant’ should be developed by local neurosurgical centres and agreed with referring hospitals. An example of a neurosurgical referral letter is shown in Appendix L.273

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.304 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.

7.5 **Recommendations for research**

The GDG identified the following priority areas for research in the original guideline as well as in this update.

7.5.1 **Research Question**

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.
7.5.2 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 Class I 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.

7.6 Other reasons for discussing a patient’s care with a neurosurgeon

Other criteria for discussing a patient’s care with a neurosurgeon were developed by both Guideline Development Group consensus and recommendations from previous guidelines.273

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

- persisting coma (GCS less than or equal to 8) 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.

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

7.7 Criteria for neurosurgical interventions

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.

7.8 Transfer from secondary to tertiary care settings

The risk of a further injury to patients during transfer to tertiary care is well established. 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. The recommendations are listed below see section 7.9.7 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. 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??
7.9 The benefits for patients who have suffered a clinically important brain injury that does not require surgical intervention, of receiving treatment at a neurosciences centre

7.9.1 Introduction and rationale for the clinical question

There is no uncertainty about 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 acute care centre 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 acute centre.

An acute care centre 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.

7.9.2 Studies considered for this review

One paper235 a prospective observational study looked interhospital transfer (secondary transfer from one hospital to another).

Three additional studies were found looking at the by pass issue. Three studies116,123,241 were identified that looked at direct transport from the injury scene to an acute centre or transfer to a neurosciences unit from an acute centre. One study116 is a retrospective observational cohort study. Another study241 is low quality study were patients were transported to a neurosurgical care or secondarily transferred from a district general hospital. The final study123 is a well designed cohort study (evidence level 2++) 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 was a well-conducted study with rigorous analysis methods.

The main outcome measures were mortality neurological outcome, disability and hospital duration and at least one of these outcomes were reported in the studies. Studies were excluded where no data on patients who had a head injury was provided, where the patient group was up to 50% non head injured patients, where the intervention is about pre hospital care rather than transfer and where the outcome was duration of transfer and no other outcomes were reported.

7.9.3 Clinical evidence

One study\textsuperscript{235} included a population of patients of any age who were injured by blunt trauma between 1996-2003 (n=6921). This study had an evidence level of 2+. These patients were treated by participating hospitals in the Trauma Audit and Research Network (TARN), (UK). 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 acute care centre were 61% (95% CI, 59-63%), p=0.000. 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%), p=0.00 and for those that were transported to the acute care centre the rate was 34% (95% CI, 39-40%), p=0.005.

The first study\textsuperscript{116} that examined bypassing was an observational cohort study, obtained data from the New York State Trauma Registry from 1996-1998 (evidence level 2+). The population group were adults >13 yrs, GCS<14. A sub group of 2763 head injured patients from 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 results showed that mortality for transfer to regional centre versus non trauma centre were odds ratio 0.67, CI (0.53-0.85).

In another study the population group were neurosurgical unit patients with an extradural haematoma requiring surgery (n=104). This study had an evidence level 3). Group 1 (n=71) with a mean age of 22yrs ±2SE were directly transported to neurosurgical care. Group 2 (n=33) with a mean age 20yrs ±3SE were transferred from the district general hospital 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 it was 24% (8/33) and the moderate/severe disability in group 1 was 10% (7/71) and group 2 it 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.

Hartl 2006 described a cohort study in patients with severe traumatic brain injury (evidence level 2++). 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 well-defined criteria, including the basis of 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 < or >60yrs old, pupil status on day 1, and initial GCS. Admission time and time by transport status were found to not effect the significance of the results. The odds ratio was 1.48, and patients were found to have a
significantly lower chance of mortality with direct transfer \( p = 0.04, \text{ CI } 1.03-2.12 \).

### 7.9.4 Economics Evidence

See economics chapter 11

### 7.9.5 Evidence statement

Only one study\(^2^{35}\) shows 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 acute care centre. This study found data which supports 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.

With regards to the evidence on by pass\(^{1^{23},2^{41}}\) there is evidence of good recovery and better mortality and morbidity rates amongst severely injured patients. However another study\(^^{1^{16}}\) shows very little difference. In conclusion, there was not enough good evidence to recommend that all patients with head injuries should go direct to a neurosciences unit.

### 7.9.6 Rationale behind recommendation

No change to previous recommendation is required; however we have included a new recommendation that all patients with isolated severe head injuries should receive treatment in a neurosurgical unit irrespective of any need for a neurosurgical operation. 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, A&E, paediatric and geriatric services that currently care for these patients.

The GDG agreed that the studies\(^{1^{16},2^{3},2^{41}}\) did not provide enough evidence for this question to demonstrate that all patients should be sent directly to a neurosciences centre. 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.

7.9.7 Recommendation

1. 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.

2. 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. These should be consistent with established national guidelines. Details of the transfer of the responsibility for patient care should also be agreed.

3. While it is understood that transfer is often urgent, initial resuscitation and stabilisation of the patient must be completed and comprehensive monitoring established before transfer to avoid complications during the journey. A patient persistently hypotensive, despite resuscitation, should not be transported until the cause of the hypotension has been identified and the patient stabilised.

4. All patients with a GCS less than or equal to 8 requiring transfer to a neurosurgical unit should be intubated and ventilated as should any patients with the indications detailed in point 8 and 9 below.

5. Patients with head injuries 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 must have a dedicated and adequately trained
assistant. They should be provided with appropriate clothing for the transfer, medical indemnity and personal accident insurance.

6. The transfer team should be provided with a means of communication with their base hospital and the neurosurgical unit during the transfer. A portable phone may be suitable providing it is not used in close proximity (that is, within 1 metre) of medical equipment prone to electrical interference (for example, infusion pumps).

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

8. Intubation and ventilation should be used immediately in the following circumstances:
   - I. Coma – not obeying commands, not speaking, not eye opening (that is, GCS less than or equal to 8)
   - II. Loss of protective laryngeal reflexes
   - III. Ventilatory insufficiency as judged by blood gases: hypoxaemia (PaO2 less than 9 kPa on air or less than 13 kPa on oxygen) or hypercarbia (PaCO2 greater than 6 kPa)
   - IV. Spontaneous hyperventilation causing PaCO2 less than 4 kPa
   - V. Respiratory arrhythmia

9. Intubation and ventilation should be used before the start of the journey in the following circumstances:
   - I. Significantly deteriorating conscious level (one or more points on the motor score), even if not coma

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II. Bilateral fractured mandible

III. Copious bleeding into mouth (for example, from skull base fracture)

IV. Seizures

An intubated patient should be ventilated with muscle relaxation and sedation and analgesia. Aim for a PaO2 greater than 13kPa, PaCO2 4.5 to 5.0 kPa unless there is clinical or radiological evidence of raised intracranial pressure when more aggressive hyperventilation is justified to a PaCO2 of not less than 4 kPa. If hyperventilation is used the inspired oxygen concentration should be increased.

Carers and relatives should have as much access to the patient as is practical during transfer and be fully informed on the reasons for transfer and the transfer process.

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

These principles are largely based on consensus, and their use should be audited in future research.

Isolated severely head injured patients (GCS 8 or less) should ideally be transferred directly to a neurosciences unit to receive treatment irrespective of any need for a neurosurgical operation instead of receiving treatment at an acute care centre for initial assessment.

7.10 Transfer of children

The recommendations in section 7.6 were written for adults but the principles apply equally to children and infants, providing that the paediatric modification of the Glasgow Coma Scale is used.

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 section 7.6\textsuperscript{74}.
Transfer of a child or infant to a specialist neurosurgical unit should be undertaken by staff experienced in the transfer of critically ill children. Families should have as much access to their child as is practical during transfer and be fully informed on the reasons for transfer and the transfer process.

A multiply injured child should not be transferred to a service that is unable to deal with other aspects of trauma.

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

7.11 **Recommendations for research**

The GDG also identified the following priority areas for research.

7.11.1 **Research Question**

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?

7.11.2 **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 health care 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 health care 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%.
8 Discharge and follow-up

8.1 Introduction

One consequence of these guidelines will be a tendency to discharge a higher proportion of patients with head injury directly from the A&E 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. There is also a clear need for systematic follow up of all grades of patient, given the high likelihood of long-term disabilities.

8.2 Discharge of low risk patients with GCS equal to 15

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).

This recommendation is based on level five evidence and is considered to be a grade D recommendation.
8.3 Discharge of patients with normal imaging of the head

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).

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

8.4 Discharge of patients with normal imaging of the cervical spine

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).

This recommendation is based on level five evidence and is considered to be a grade D recommendation.
8.5 **Discharge of patients admitted for observation**

Patients admitted after a head injury may be transferred to the community after resolution of all significant symptoms and signs providing they have suitable supervision arrangements at home.

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

8.6 **Discharge of patients at risk of non-accidental injury**

No infants or children presenting with head injuries that require imaging of the head or cervical spine should be transferred to the community until assessed by a clinician experienced in the detection of non-accidental injury.

It is expected that all personnel involved in the triage and assessment of infants and children with head injury should have training in the detection of non-accidental injury.

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

Guidance on the process of transferring patients of all ages who may have sustained non-accidental injury, including liaison with appropriate community care and legal organisations are contained in a recent Department of Health manual.73

8.7 **Discharge and GCS status**

No patients presenting with head injury should be transferred to the community 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.

This recommendation is based on level five evidence and is considered to be a grade D recommendation.
8.8 Discharge advice

All patients with any degree of head injury, who are deemed safe for appropriate transfer to the community from A&E or the observation ward, should receive verbal advice and a written head injury advice card. The details of the card should be discussed with the patients and their carers. If necessary (for example, patients with literacy problems, visual impairment or speaking languages without a written format), other formats (for example, tapes) should be used to communicate this information. Communication in languages other than English should also be facilitated.

The risk factors outlined in the card should be the same as those used in the initial community setting to advise patients on A&E attendance (see Chapter 7). Patients and carers should also be alerted to the possibility that some patients may make a quick recovery, but go on to experience delayed complications. Instructions should be included on contacting community services in the event of delayed complications.

Patients who presented to A&E with drug or alcohol intoxication and are now fit for discharge should receive information and advice on alcohol or drug misuse.

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

Suggested written advice cards for patients and carers are provided in Appendices E, F and G.

8.9 Discharge of patients with no carer at home

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. Patients with no carer at home should only be discharged if suitable supervision arrangements have been organised, or when the risk of late complications is deemed negligible.
This recommendation is based on level five evidence and is considered to be a grade D recommendation.

8.10  The best tool for identifying the patients who should be referred to rehabilitation services following the initial management of a head injury

8.10.1  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 guideline. However from these papers, only one paper 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.

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.

8.10.2 Studies considered for this review

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 >1yr, 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.

8.10.3 Clinical evidence

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).

8.10.4 Economics Evidence

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 found from reviews: Aronow1987, Cope1982, Wood1999
Economic evaluations of intensive versus less intensive rehabilitation

- 1 study published since 2002: Ponsford2006\textsuperscript{240}
- 2 studies found from reviews: Ashley1997\textsuperscript{14}, Salazar2000\textsuperscript{265}

Reviews of economic evaluations

- 4 studies published since 2002: Turner2004\textsuperscript{322}, Berg2004\textsuperscript{28}, Wehman2005\textsuperscript{332}, Turnerstokes2004\textsuperscript{323}

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

8.10.5 Conclusion

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.

8.11 Recommendations for research

The GDG identified the following priority area for research.
8.11.1 Research Question

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, at the time of injury, relevant patients. This would in turn lay the foundation for a derivation cohort study.

8.11.2 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 6mths-1yr. 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.
8.12 **Outpatient appointments**

Every patient who has undergone imaging of their head and/or been admitted to hospital (that is, those initially deemed to be at high risk for clinically important brain injury) should be routinely referred to their GP for follow-up within a week after discharge. When a person who has undergone imaging of the head and/or been admitted to hospital experiences persisting problems, there should be an opportunity available for referral from primary care to an out-patient appointment with a professional trained in assessment and management of sequelae of brain injury (for example, clinical psychologist, neurologist, neurosurgeon, specialist in rehabilitation medicine).

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

8.13 **Prognosis in severe head injury**

A recent systematic review focusing only on severe head injuries examined evidence on early indicators of prognosis. 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 and include information on the rehabilitation of patients following acquired brain injury. The contents of this guideline are therefore outside the scope of this guideline.

8.14 **Advice about long-term problems and support services**

All patients and their carers should be made aware of the possibility of long term symptoms and disabilities following head injury and should be made aware of the existence of services that they could contact.
should they experience long term problems. Details of support services should be included on patient discharge advice cards. Patients should also be advised to contact their doctor about these problems.

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

8.15 Communication with community services

A communication (letter or e-mail) should be generated for all patients who have attended A&E with a head injury, and sent to the patient’s GP within one week of the end of the hospital episode. This letter should include details of the clinical history and examination. This letter should be open to the person or their carer, or a copy should be given to them.

A communication (letter or e-mail) should be generated for all children who received head or cervical spine imaging, and sent to the relevant general practitioner and school nurse for all school aged children within one week of the end of the hospital episode. This letter should include details of the clinical history and examination.

A communication (letter or e-mail) should be generated for pre school children who received head or cervical spine imaging, and sent to the general practitioner and health visitor within one week of the end of the hospital episode. This letter should include details of the clinical history and examination.

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

8.16 Re-attendees

There is evidence that patients who re-attend in the days immediately after head injury are a high risk group for intracranial complications.328

Patients who return to an A&E department within 48 hours of transfer to the community with any persistent complaint relating to the initial head injury should be referred back to A&E. This should be arranged through the community services or the patient’s GP. These recommendations are based on level five evidence and are considered to be grade D recommendations.
injury should be seen by or discussed with a senior clinician experienced in head injuries, and considered for a CT scan.

This recommendation is based on level two evidence and is considered a grade B recommendation.
9 Admission and observation

9.1 Introduction
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 A&E 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.

9.2 Admission
The following patients meet the criteria for admission to hospital following a head injury.
• Patients with new, clinically significant abnormalities on imaging.
• Patients who have not returned to GCS equal to 15 after imaging, regardless of the imaging results.
• When a patient fulfils the criteria 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 co-operative 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).

Some patients may require an extended period in a recovery setting due to the use of sedation or general anaesthetic during CT imaging. These patients should not normally require admission.

Patients with multiple injuries should be admitted under the care of the team that is trained to deal with their most severe and urgent problem.

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

9.3 Good practice in observation of patients with head injury

There is some evidence that A&E 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. ¹¹² There have also been concerns about the experience and skills of staff on general and orthopaedic acute wards in head injury care. ²⁶⁰ 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 A&E Department. 260

In circumstances where a patient with a head injury requires hospital admission, it is recommended that the patient only be admitted under the care of a Consultant who has been trained in the management of this condition during his/her higher specialist training.

It is recommended that in-hospital observation of patients with a head injury, including all A&E observation, should only be conducted by professionals competent in the assessment of head injury.

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.

9.4 Minimum documented observations

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.

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

9.5 Frequency of observations

As the risk of an intracranial complication is highest in the first six hours after a head injury, observations should have greatest frequency in this period.167

Observations should be performed and recorded 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 A&E:
• half-hourly for two hours;
• then one hourly for four hours;
• then two hourly thereafter.

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

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

9.6 Patient changes requiring review while under observation

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 one point in
  GCS level (greater weight should be given to a drop of one point
  in the motor score of the GCS).
• Any drop of greater than two points in GCS level regardless of
duration or GCS sub-scale.
• 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.

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.

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

9.7 Imaging following confirmed patient deterioration during observation

An immediate CT scan should be considered in patients confirmed as having any of the changes noted in 9.6 above.

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

9.8 Further imaging if GCS equal to 15 not achieved at 24 hours

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.

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

9.9 Observation of children and infants

Observation of infants and young children (that is, aged less than 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.

This recommendation is based on level five evidence and is considered to be a grade D recommendation.
9.10 Training in observation

Medical, nursing and other staff caring for patients with head injury admitted for observation should all be capable of performing the observations listed in 9.4 and 9.6. The acquisition and maintenance of observation and recording skills require dedicated training and this should be available to all relevant staff. Specific training is required for the observation of infants and young children.

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

9.11 Support for families and carers

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.

There should be a protocol for all staff to introduce themselves to family members or carers and briefly explain what they are doing. In addition a photographic board with the names and titles of personnel in the hospital departments caring for patients with head injury can be helpful.

Information sheets detailing the nature of head injury and any investigations likely to be used should be available in the A&E Department. The patient version of these NICE guidelines may be helpful.

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.
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.

Health care professionals should encourage carers and relatives 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 many hours at the bedside and if they are healthcare professionals should encourage them to take a break.

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.

There should be a board or area displaying leaflets or contact details for patient support organisations either locally or nationally to enable family members to gather further information.

This recommendation is based on level five evidence and is considered to be a grade D recommendation.
10 Medical radiation

10.1 Introduction

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. \(^{290}\) By 2002 these figures had risen to 7% and 47% respectively. \(^{122}\)

National patient dose surveys for CT examinations have been carried out in the UK in 1989\(^ {291}\) and in 2003\(^ {289}\). 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\(^ {49,102,145}\). 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.

10.2 Patient doses from head CT

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\textsuperscript{289} 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\textsuperscript{121}, 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\textsuperscript{291}. 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.
10.3 **Patient doses from cervical spine CT**

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\(^2\) 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\(^1\) 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.

10.4 **Summary of effective doses from CT and conventional x-ray examinations of the head and cervical spine**

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\(^2\) 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.

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 10.4.1 Effective radiation doses for different imaging techniques by age group.

<table>
<thead>
<tr>
<th>Patient Age (y)</th>
<th>Effective dose (mSv)</th>
<th>Head</th>
<th>Cervical spine</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Radiographs*</td>
<td>CT</td>
<td>Radiographs**</td>
</tr>
<tr>
<td>0-1</td>
<td>0.06</td>
<td>2.5</td>
<td>0.07</td>
</tr>
<tr>
<td>5</td>
<td>0.06</td>
<td>1.5</td>
<td>0.07</td>
</tr>
<tr>
<td>10</td>
<td>0.06</td>
<td>1.6</td>
<td>0.07</td>
</tr>
<tr>
<td>Adult</td>
<td>0.06</td>
<td>1.5</td>
<td>0.07</td>
</tr>
</tbody>
</table>

* assumes 1 PA + 1 AP + 1 lateral radiograph per examination

** assumes 1 AP + 1 lateral radiograph per examination

### 10.5 Cancer risks

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. 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. 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). 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.\textsuperscript{40} 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 pediatric 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 pediatric 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.

### 10.6 Radiation exposure management

In line with good radiation exposure practice every effort should be made 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.

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.

Emerging evidence suggests that plain x rays of the cervical spine may fail to identify clinically important injury. CT is therefore recommended in those most at risk. In children this risk is less and the potential damage from radiation greater. The guidelines reflect this concern by
restricting the recommendations for CT in children to those who have indicators of more serious injury.

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

11.1 Introduction

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.1 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 health care procedures.2,3,4 There is still some debate over some of the specific methods of economic evaluation in health care but essentially there are six steps to evaluating the relative efficiency of any procedure.

1. Identify the target group (e.g. patients attending A&E with GCS greater than 12), the procedure to be evaluated (e.g. head CT scanning) and its alternative strategy (e.g. 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 (e.g. 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.

11.2 Methods

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.

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.
A fourth area was added during the 2007 update – the issue of which patients can bypass the nearest A&E and go straight to a neurosciences centre from the scene of injury – see 11.6.

11.2.1 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

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.

11.2.2 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 (i.e. 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 11.1). The first is an approximation of the current 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 11.1 - Description of different strategies for the target group**

<table>
<thead>
<tr>
<th>Indications for test</th>
<th>Skull X-ray</th>
<th>24 hour admission</th>
<th>CT</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Current UK system</td>
<td>All</td>
<td>headache, vomiting or other neurological indication</td>
<td>skull fracture or deterioration in 24 hours</td>
</tr>
<tr>
<td>2. Canadian CT Head 5-rule</td>
<td>None</td>
<td>+ve CT scan</td>
<td>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</td>
</tr>
<tr>
<td>3. Canadian CT Head 7-rule</td>
<td>None</td>
<td>+ve CT scan</td>
<td>As for 5-rule but also CT if pre-impact amnesia greater than 30 mins or dangerous mechanism</td>
</tr>
<tr>
<td>4. US system</td>
<td>None</td>
<td>All</td>
<td>All</td>
</tr>
</tbody>
</table>

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 11.2, outcomes 4-10).
Table 11.2 - Health and resource consequences of Canadian CT head rule versus current UK system

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Net social effect</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Definite or likely outcomes</strong></td>
<td></td>
</tr>
<tr>
<td>1. Reduced use of skull X-ray</td>
<td>+ve</td>
</tr>
<tr>
<td>2. Increased use of CT scanning</td>
<td>-ve</td>
</tr>
<tr>
<td>3. Reduced inpatient stay</td>
<td>+ve</td>
</tr>
<tr>
<td><strong>Possible outcomes</strong></td>
<td></td>
</tr>
<tr>
<td>4. Improved neurosurgical outcomes</td>
<td>+ve</td>
</tr>
<tr>
<td>5. Increased incidence of cancer as a result of increased radiation exposure</td>
<td>-ve</td>
</tr>
<tr>
<td>6. Change in health service resource use as a result of 4 and 5</td>
<td>+ve/-ve</td>
</tr>
<tr>
<td>7. Change in patient/family resource use as a result of 3</td>
<td>+ve/-ve</td>
</tr>
<tr>
<td>8. Change in patient/family resource use as a result of 4 and 5</td>
<td>+ve/-ve</td>
</tr>
<tr>
<td>9. Reduction in litigation costs</td>
<td>+ve</td>
</tr>
<tr>
<td>10. Change in primary care use as a result of 3, 4 and 5</td>
<td>+ve/-ve</td>
</tr>
</tbody>
</table>

NB – 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 5 for the current UK system and from Stiell et al 6 for the Canadian rules (Table 11.3). For the US model, usage was determined by the model definition.

Table 11.3 – Proportion of target group receiving each test

<table>
<thead>
<tr>
<th></th>
<th>Proportion of target group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Skull X-ray £26ea</td>
</tr>
<tr>
<td>1. Current UK system³</td>
<td>100%</td>
</tr>
<tr>
<td>2. Canadian CT Head 5-rule⁶</td>
<td>0%</td>
</tr>
<tr>
<td>3. Canadian CT Head 7-rule⁶</td>
<td>0%</td>
</tr>
<tr>
<td>4. US system</td>
<td>0%</td>
</tr>
</tbody>
</table>

* Stiell et al⁶ propose discharging patients that have a negative CT scan, although they are only halfway 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 (i.e. had no loss of consciousness or amnesia).

11.2.3 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 7
- Canadian cervical spine rule 8

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 11.4, 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 and that these are followed up with a CT scan.

Table 11.4 - Outcomes from cervical spine scanning

<table>
<thead>
<tr>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Use of cervical spine X-ray</td>
</tr>
<tr>
<td>2. Use of cervical spine CT scanning</td>
</tr>
<tr>
<td>3. Number of surgical interventions resulting from detection of fractures</td>
</tr>
<tr>
<td>4. Incidence of paralysis</td>
</tr>
<tr>
<td>5. Incidence of cancer as a result of radiation exposure</td>
</tr>
<tr>
<td>6. Change in health service resource use as a result of 4 and 5.</td>
</tr>
<tr>
<td>7. Change in patient/family resource use as a result of 4 and 5.</td>
</tr>
<tr>
<td>8. Change in litigation costs</td>
</tr>
</tbody>
</table>

11.2.4 Unit costs

The unit costs of skull X-ray and head CT scan were taken from the published literature (Table 11.5). HEED and NHS EED were searched. This was not restricted to the head injury context, as the cost of the test should be identical.
or similar regardless of the setting. It is worth noting that any search for published unit costs is likely to be relatively insensitive because a unit cost is usually only a small component of an economic evaluation and hence is unlikely to get a mention in the abstract or MeSH headings. The search was limited to studies conducted in the UK NHS because staff costs and overheads vary considerably between health systems. Abstracts and/or database reviews of the papers found were reviewed by the health economist and were discarded if it appeared not to contain a unit cost for any of the tests under study. Costs extracted were inflated to 2001 prices using the health component of the Retail Prices Index.

Table 11.5 - Unit cost estimates for the UK NHS

<table>
<thead>
<tr>
<th></th>
<th>Cost per patient tested (2001 UK£):***</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Lower</td>
</tr>
<tr>
<td>Skull X-ray*</td>
<td>14</td>
</tr>
<tr>
<td>Cranial CT scan*</td>
<td>60</td>
</tr>
<tr>
<td>24 hour observation**</td>
<td>150</td>
</tr>
</tbody>
</table>

* Unit costs extracted from published literature.11-13,19-22
** Cost per day of an inpatient stay for a ‘Head injury without significant brain injury: uncomplicated’ from the NHS Reference Cost 2000 database 9 (153,000 inpatient days) – 25th, 50th and 75th centiles.
*** Costing methods of studies may vary but all include staff time, equipment cost and consumable cost, although not necessarily overheads.

Given the lack of relevant data, cervical spine X-ray and cervical spine CT scans were assumed to cost the same as skull X-ray and head CT scans respectively.

A unit cost of 24-hour observation was estimated approximately using the median cost per day of an inpatient stay for a ‘Head injury without significant brain injury: uncomplicated’ from the NHS Reference Cost 2000 database. This was extracted from the NHS Reference Costs 2000 database. 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 (e.g. out-patient, elective in-patient, etc) clinical specialty and Healthcare Resource Group (HRG). The NHS Reference cost 2000 database contains information for 69.4 million hospital episodes amounting to 88% of annual expenditure on services by NHS hospitals. 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.10

Sensitivity analyses were conducted to test the sensitivity of the results to the model parameters:

- for the unit costs, the range of estimates from the literature was used,
- for the cost of an in-patient day, the inter-quartile range from the NHS Reference Costs database was used, and
- for the probabilities, the confidence intervals were used.

11.3 Diagnosis of intracranial haematoma in patients with a minor/mild head injury

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 (i.e. value for money) if extended to a larger group of patients.

11.3.1 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.11-13

Three overseas studies have compared CT scanning with alternative strategies. Ingebrigtsen and Romner 14 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 15 and Stein et al 16 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 11.3.7.

### 11.3.2 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 11.6. The least cost strategy is the 5-point Canadian CT Head rule. Although the cost of CT scanning is higher than for the current UK system, the extra cost is more than offset by the reduction in skull X-rays and admissions.

#### Table 11.6 – Cost per patient for each strategy

<table>
<thead>
<tr>
<th></th>
<th>Component costs (£)</th>
<th>Total cost (£)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Skull x-ray</td>
<td>24 hour admission</td>
</tr>
<tr>
<td>1. Current UK system</td>
<td>26</td>
<td>51</td>
</tr>
<tr>
<td>2. Canadian CT Head five point rule</td>
<td>0</td>
<td>18</td>
</tr>
<tr>
<td>3. Canadian CT Head seven point rule</td>
<td>0</td>
<td>18</td>
</tr>
</tbody>
</table>
These results would suggest that moving from the current system to the five point Canadian head rule could actually save the NHS money (although the seven point rule, which scans more patients, is likely to add to costs). It would require investment in additional CT scanning facilities but these costs would, at least in part, be offset by the freeing up of ward space and X-ray capacity.

These results were, however, sensitive to the unit costs (Table 11.7). For example, the seven point rule could potentially save money if we use the lower estimate for the cost of a CT scan and the higher estimate for the cost of an in-patient day.

### Table 11.7 - Sensitivity analysis for head CT scanning rules

<table>
<thead>
<tr>
<th></th>
<th>Additional cost per patient (£) - Canadian seven point rule compared with current UK system</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>20.84</td>
</tr>
<tr>
<td>Sensitivity to unit costs*</td>
<td>-63.22, 61.18</td>
</tr>
<tr>
<td>Sensitivity to proportion of patients scanned</td>
<td>11.52, 30.16</td>
</tr>
<tr>
<td>Sensitivity to both unit costs and proportions</td>
<td>-72.34, 70.22</td>
</tr>
</tbody>
</table>

* Lower limit: High skull X-ray cost (£45ea), High admission cost (£290ea), Low CT cost (£60ea)
Upper limit: Low skull X-ray cost (£14ea), Low admission cost (£150ea), High CT cost (£200ea)

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 only less costly than the current UK system because it is assumed that it reduces the number of admissions. In fact Stiell et al 6 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 11.8). The seven point rule would only reduce costs if the current CT rate is at least 40%. If there are no reductions in admissions associated with the seven point rule then the incremental cost per patient is more than doubled.

Table 11.8 Additional cost per patient (£) - Canadian seven point rule compared with current UK system - two-way sensitivity analysis.

<table>
<thead>
<tr>
<th>Reduction in admissions</th>
<th>CT Scanning rate in current UK system</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0%</td>
</tr>
<tr>
<td>0%</td>
<td>61</td>
</tr>
<tr>
<td>2.5%</td>
<td>60</td>
</tr>
<tr>
<td>5%</td>
<td>58</td>
</tr>
<tr>
<td>10%</td>
<td>56</td>
</tr>
<tr>
<td>20%</td>
<td>51</td>
</tr>
<tr>
<td>40%</td>
<td>40</td>
</tr>
<tr>
<td>60%*</td>
<td>30</td>
</tr>
<tr>
<td>80%</td>
<td>20</td>
</tr>
</tbody>
</table>

* 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 11.2.

Evidence retrieved in 2007 provides real data on the impact of the Canadian head CT rule on the NHS - see below in 11.3.7.

11.3.3 Health outcomes (4 and 5, see Table 11.2)

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.17

However, there is cohort study evidence suggesting reduced mortality associated with prompt surgery193,274. A paper retrieved during the 2007 update299 had estimated the quality-adjusted life-years (QALYs) gained from prompt surgery by comparing the recovery and mortality rates in different case series (see 11.3.7 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).

11.3.4 Other health service costs (6, see Table 11.2)

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.

11.3.5 Patient costs (7&8, see Table 11.2)

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.

11.3.6 Litigation costs (9, see Table 11.2)

It has been suggested that litigation might be reduced if more patients were scanned. However, Bramley et al 18 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. Current medico-legal costs for the NHS associated with acute head injuries are being sought from the NHS Legal Authority and it is hoped they will inform later versions of this guideline. However, it should be born in mind that successful litigation usually arises out of organisations not abiding by guidelines, and, given that other guidelines are currently in circulation, this is clearly still a risk.

11.3.7 Update 2007

We found three new studies that evaluated diagnostic tools: a decision analysis4 and an RCT219 were comparing admission with CT scanning, and a case series94 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 analysis4 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 patients2194. 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\textsuperscript{94} 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\textsuperscript{125} 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\textsuperscript{288} 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. We had predicted a modest increase in cost. 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.
Table 11.9: Resource use before and after implementation of NICE head CT rule

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Before</td>
<td>After</td>
<td>Before</td>
<td>After</td>
</tr>
<tr>
<td>CT</td>
<td>2%</td>
<td>29%</td>
<td>2%</td>
<td>8%</td>
</tr>
<tr>
<td>SXR admission</td>
<td>54%</td>
<td>0%</td>
<td>11%</td>
<td>0%</td>
</tr>
<tr>
<td>admission</td>
<td>14%</td>
<td>4%</td>
<td>8%</td>
<td>9%</td>
</tr>
<tr>
<td></td>
<td>3%</td>
<td>18%</td>
<td>1%</td>
<td>9%</td>
</tr>
<tr>
<td>SXR admission</td>
<td>37%</td>
<td>4%</td>
<td>19%</td>
<td>1%</td>
</tr>
<tr>
<td>admission</td>
<td>9%</td>
<td>4%</td>
<td>7%</td>
<td>5%</td>
</tr>
</tbody>
</table>

One of the centres in the Hassan study\textsuperscript{125} 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 GDG agreed that this was an acceptable deviation from the head rule, since the RCT evidence shows no significant differences in clinical outcomes between admission and CT. The guideline recommendations were modified accordingly.

A decision analysis\textsuperscript{299} 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.
## 11.4 Identifying cervical spine damage in patients with head injury

Table 11.4 identifies the resource and health outcomes that could differ between different diagnostic strategies.

### 11.4.1 Literature review

There are three cost-effectiveness studies in this area:

- **Kaneriya et al** 23 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** 24 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** 25, 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 less than 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.7,26

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 11.4.3.

11.4.2 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 £26 per patient (Table 11.10).

Table 11.10 – Comparison of the Canadian and NEXUS cervical spine rules

<table>
<thead>
<tr>
<th>Strategy</th>
<th>Proportion of patients receiving test</th>
<th>Cost of testing (£) per patient</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>X-ray</td>
<td>CT</td>
</tr>
<tr>
<td>Canadian</td>
<td>58.2%</td>
<td>22.8%</td>
</tr>
<tr>
<td>NEXUS</td>
<td>87.4%</td>
<td>34.2%</td>
</tr>
<tr>
<td>Increment</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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 £8 per patient scanned. Sensitivity ranges are presented in Table 11.11.

Table 11.11 - Sensitivity analysis for cervical spine scanning rules

<table>
<thead>
<tr>
<th>Incremental cost per patient (£) of NEXUS rule compared with Canadian cervical spine rule</th>
<th>X-ray costs only</th>
<th>X-ray and CT cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline estimate</td>
<td>7.58</td>
<td>25.84</td>
</tr>
<tr>
<td>Sensitivity to unit costs</td>
<td>4.08, 13.13</td>
<td>10.93, 41.66</td>
</tr>
<tr>
<td>Sensitivity to proportions tested</td>
<td>7.23, 7.94</td>
<td>24.62, 27.06</td>
</tr>
<tr>
<td>Sensitivity to both unit costs and proportions</td>
<td>3.89, 13.73</td>
<td>10.42, 43.55</td>
</tr>
</tbody>
</table>

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 11.4.

11.4.3 Update 2007

Five new studies were found: a non-randomised controlled trial, two cohort studies, a case series and a decision model. One study was evaluating the role of MRI scanning in children and the rest were comparing CT scanning with x-ray in adults.

A non-RCT compared the costs of helical CT with those of x-ray in a population of 136 children who required c-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 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, 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 averted – it’s difficult to assess whether this represents good value without knowing what proportion of fractures would lead to paralysis.

The decision analysis of helical CT vs x-ray of the c-spine in patients undergoing cranial CT for head injury by Grogan et al was based on an earlier model by Blackmore and colleagues 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>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 evaluated a protocol of MRI scanning patients whose c-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.

11.5 Discussion

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, other strategies that lead to a very high CT scanning rate are likely to increase health service costs. The imprecision of the data available (unit costs and test frequencies) means that it is not possible to identify with any degree of certainty those specific strategies that will increase cost and those that will decrease cost. Furthermore there are health outcomes and some additional changes to resource use that cannot be quantified using currently available data.

Table 11.12 (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 Tables 11.3, 11.6 and 11.10 and assumes an incidence of 700,000 head injury attendees to A&E 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). 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.

Clearly 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 certainly not be the case for patients who have other comorbid traumatic symptoms.
Table 11.12 – Imaging and admission volumes and costs England and Wales associated with different clinical decision rules

<table>
<thead>
<tr>
<th></th>
<th>Number per year (000)</th>
<th>Cost per year (£m)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Head</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Skull x-ray</td>
<td>378</td>
<td>0</td>
</tr>
<tr>
<td>Head CT</td>
<td>16</td>
<td>205</td>
</tr>
<tr>
<td>24-hr Obs</td>
<td>96</td>
<td>33</td>
</tr>
<tr>
<td><strong>Cervical spine</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>X-ray</td>
<td>330</td>
<td>220</td>
</tr>
<tr>
<td>CT</td>
<td>129</td>
<td>86</td>
</tr>
<tr>
<td><strong>All</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* 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 increase costs, however this result was sensitive to the unit costs incorporated into the model. Although costs are increased, there are 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 possibly even improvements in long-term outcomes (although this is speculative). If patient outcomes were improved then this in turn might lead to additional cost-savings (again speculative). 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 £21 per head trauma patient associated with adopting the Canadian head CT and a cost saving of £26 associated with adopting the Canadian cervical spine rule. This suggests a combined impact of £5 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 £1.9m that could be reinvested in the health service would result. However, we should be very cautious about this figure given that the sensitivity ranges are consistent with a substantial increase in cost as well as a cost saving. Furthermore the long-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. The capital cost of CT scanners should in principle be incorporated into the unit costs that we have used in our cost-effectiveness model, as is the convention in NHS costing practice. The unit costs that we used, however, were taken from the published literature and therefore we cannot be sure about precisely how they were calculated. 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 (e.g. 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;
- 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 (e.g. 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.28 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.

11.5.1 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.

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. Furthermore all the studies were conducted in the USA; the observed health care costs and savings might not be transferable to a UK NHS setting.
11.6 Addendum 2007 – Direct transport from injury scene to a specialist neurosciences centre

11.6.1 Literature review

We did not find any cost-effectiveness evidence for this question but we did find a simulation model that evaluated the impact of 10 different transport strategies on survival of patients with serious or worse HI (AIS>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 was used to simulate 10,000 HI patients and their outcomes under each strategy.

Table 11.13 shows the results for each strategy. All direct transport strategies had higher expected survival than a strategy of sending all patients to the nearest A&E 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, a 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 11.6.2.

**Table 11.13: Stevenson’s Transport model - results**

<table>
<thead>
<tr>
<th>Patients transported directly to specialist centre</th>
<th>Bypass DGH</th>
<th>Survival gain vs 1) (near)</th>
<th>Survival gain vs 1) (far)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) None</td>
<td>0%</td>
<td>0.00%</td>
<td>0.00%</td>
</tr>
<tr>
<td>2) HI AIS&gt;2</td>
<td>100%</td>
<td>3.40%</td>
<td>4.50%</td>
</tr>
<tr>
<td>3) HI AIS&gt;3</td>
<td>78%</td>
<td>3.50%</td>
<td>4.60%</td>
</tr>
<tr>
<td>4) HI AIS=5</td>
<td>44%</td>
<td>3.40%</td>
<td>4.30%</td>
</tr>
<tr>
<td>5) Non-HI AIS&lt;4</td>
<td>89%</td>
<td>3.30%</td>
<td>4.00%</td>
</tr>
<tr>
<td>6) Non-HI AIS&lt;5</td>
<td>95%</td>
<td>3.40%</td>
<td>4.50%</td>
</tr>
<tr>
<td>7) Isolated head injury</td>
<td>75%</td>
<td>2.80%</td>
<td>3.60%</td>
</tr>
<tr>
<td>8) Intubated pre-hospital</td>
<td>20%</td>
<td>1.70%</td>
<td>1.90%</td>
</tr>
<tr>
<td>9): 7) and 8)</td>
<td>5%</td>
<td>1.30%</td>
<td>1.50%</td>
</tr>
<tr>
<td>10) Out of hours</td>
<td>40%</td>
<td>1.50%</td>
<td>2.00%</td>
</tr>
</tbody>
</table>

### 11.6.2 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 A&E 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.

(8) General method

The model is represented by a decision tree (Fig.1): once the paramedics arrive at the accident scene, the patient can be transported either to the nearest District General Hospital (DGH) or to a Neurosciences Hospital (NSH). Some 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. To assess the cost-effectiveness of direct transport we need to assess not just changes to ambulance and A&E 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) – Poon et al 1991. 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 (see 11.6.1). 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.

**Fig.1: Transport model decision tree**

Each model has advantages and limitations (Table 11.14).

**Table 11.14: Summary of the models**

<table>
<thead>
<tr>
<th>Model</th>
<th>Description</th>
<th>Advantages</th>
<th>Limitations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model B</td>
<td>Mortality: Simulation study (Stevenson 2001) GOS: retrospective cohort study (Patel 2002).</td>
<td>More conservative and hopefully less biased than Poon data.</td>
<td>Outcomes include only mortality, not differences in health status.</td>
</tr>
</tbody>
</table>

For each strategy in both models, the expected health care 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 was assumed to be fixed over the lifetime.
HEAD INJURY UPDATE FULL GUIDELINE: DRAFT FOR CONSULTATION (FEB 2007)

The base case models assume that only patients with serious head injury would be transported. A concern is the ability of paramedics to triage patients at the injury scene. There might be a risk of over-triaging patients – 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.

(9) Methods: Effectiveness

In Model A, the mortality rate together with the outcomes were derived from a study by Poon at al 241 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 11.15).

Table 11.15: GOS score and death rate after neurosurgical care in a NSH (Model A)

<table>
<thead>
<tr>
<th>GOS</th>
<th>% DGH+NSH patients 6 months after injury</th>
<th>% NSH patients 6 months after injury</th>
<th>Utility score</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Poon 1991</td>
<td>Poon 1991</td>
<td></td>
</tr>
<tr>
<td>GR</td>
<td>49%</td>
<td>86%</td>
<td>0.83</td>
</tr>
<tr>
<td>MD/SD</td>
<td>27%</td>
<td>10%</td>
<td>0.45</td>
</tr>
<tr>
<td>Death</td>
<td>24%</td>
<td>4%</td>
<td>0</td>
</tr>
</tbody>
</table>

The survival gain in Model B was derived from the results of a simulation model by Stevenson et al 300, where the target patient population were adults with a serious head injury (AIS of 3 or more) – see 11.6.1.

The model evaluated 10 different strategies of transporting patients directly to the NSH, which triaged 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 3.4% for injury scenes near to the NSH and 4.5% 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. We used 6-month GOS data from the surviving patients in a UK study, Patel 2002\textsuperscript{236} (Table 11.16). 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 11.16: GOS score after neurosurgical care in a NSH (Model B)**

<table>
<thead>
<tr>
<th>GOS</th>
<th>% NSH patients 6 months after injury</th>
<th>Utility</th>
</tr>
</thead>
<tbody>
<tr>
<td>GR</td>
<td>49.6%</td>
<td>0.83</td>
</tr>
<tr>
<td>MD</td>
<td>27.1%</td>
<td>0.63</td>
</tr>
<tr>
<td>SD</td>
<td>20.3%</td>
<td>0.26</td>
</tr>
<tr>
<td>VS</td>
<td>3.0%</td>
<td>0.08</td>
</tr>
</tbody>
</table>

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).

(10) **Methods: Estimating QALYs**

The life expectancy of patients in a vegetative state (VS) was assumed to be 10 years\textsuperscript{287,306}. 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\textsuperscript{286}, to the general population of England and Wales, using the Life Tables. According to Shavelle, the SMR decreases after 4 years post-injury but remains constant afterwards. 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 respectively).

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.

The utility scores in Table 11.16 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. The other utility scores were taken from a decision analysis, Aoki 1998. 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.

For each health state we estimate QALYs (Quality-Adjusted Life Years) by multiplying the discounted life expectancy by the utility score. 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 the triage sensitivity analysis, 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.

Methods: Ambulance and A&E costs
A&E 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\(^63\); the total cost per patient transferred was estimated to be £159.

The cost of patient management at the A&E 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\(^63\).

We have not calculated transportation and A&E 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\(^63\), multiplied by the distance of the accident scene to the hospital, which was 20 minutes (near) or 53 minutes (far) in the simulation study\(^300\).
We derived the cost of rehabilitation from two UK studies: one, Wood 1999, applicable to the severely disabled patients and the other one, Nyein 1999, applicable to the moderately disabled patients (Table 11.17). 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 into the cost of long-term care.

The same two UK studies were used to calculate the annual care costs (Tab.11.17); 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 11.17: Cost of rehabilitation and long-term care**

<table>
<thead>
<tr>
<th></th>
<th>total cost of rehabilitation</th>
<th>annual care costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>GR</td>
<td>19,575</td>
<td>0</td>
</tr>
<tr>
<td>MD</td>
<td>19,575</td>
<td>7,472</td>
</tr>
<tr>
<td>SD</td>
<td>108,874</td>
<td>45,450</td>
</tr>
<tr>
<td>VS</td>
<td>0</td>
<td>45,450</td>
</tr>
</tbody>
</table>
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 costs of 7 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 at £1338 per day.

(13) 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 11.18). With Model B – the conservative model - the QALYs gained are smaller and costs are overall not decreased (Table 11.19). 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 11.18 and Table 11.19). In the tables we report the results for the groups of patients of 20 and 60 of age as well. Also in these cases the direct transport was the dominant strategy in Model A and the ICER was still below the threshold of £20,000 per QALY in Model B.

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 23 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 11.18: Results - Model A.

<table>
<thead>
<tr>
<th></th>
<th>Mean cost</th>
<th>QALYs</th>
<th>Incremental cost per QALY gained vs 1)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Base case – Age 40</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1) First to DGH</td>
<td>227,110</td>
<td>9.99</td>
<td>-</td>
</tr>
<tr>
<td>2) Direct to NSH</td>
<td>97,002</td>
<td>14.99</td>
<td>NSH dominates DGH</td>
</tr>
<tr>
<td><strong>Age 20</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1) First to DGH</td>
<td>299,237</td>
<td>13.06</td>
<td>-</td>
</tr>
<tr>
<td>2) Direct to NSH</td>
<td>123,715</td>
<td>18.35</td>
<td>NSH dominates DGH</td>
</tr>
<tr>
<td><strong>Age 60</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1) First to DGH</td>
<td>78,070</td>
<td>3.02</td>
<td>-</td>
</tr>
<tr>
<td>2) Direct to NSH</td>
<td>41,802</td>
<td>4.76</td>
<td>NSH dominates DGH</td>
</tr>
</tbody>
</table>

Table 11.19: Results - Model B.

<table>
<thead>
<tr>
<th></th>
<th>Incremental cost</th>
<th>QALYs gained</th>
<th>Incremental cost per QALY gained</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct to NSH vs First to DGH (base case age 40)</td>
<td>7,058</td>
<td>0.41</td>
<td>17,228</td>
</tr>
<tr>
<td>Direct to NSH vs First to DGH (age 20)</td>
<td>9,382</td>
<td>0.51</td>
<td>18,343</td>
</tr>
<tr>
<td>Direct to NSH vs First to DGH (age 60)</td>
<td>2,259</td>
<td>0.12</td>
<td>18,367</td>
</tr>
</tbody>
</table>

Using model B, we conducted a threshold sensitivity analysis to take into account the negative effects of over-triaging patients to the NSH. For the purposes of this analysis, we define a false positive as being a patient with a less than serious head injury, who is transported directly to the NSH. And we define the false positive rate as being the number of false positives divided by the number of true 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 still the most cost-effective if the false positive rate is less than 260%. If the NSH is near the accident scene (20 minutes), the direct transport to the NSH is the most cost-effective strategy even if the number of false positives is up to 900%.

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 11.20). However, the authors found that the results were not sensitive to these parameters.

Table 11.20: Parameters for which the value was estimated by clinicians.

<table>
<thead>
<tr>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deaths from injuries in areas excluding the head if medical intervention could be given immediately</td>
</tr>
<tr>
<td>Deaths from a head injury that required neurosurgery if neurosurgical intervention could be given immediately</td>
</tr>
<tr>
<td>Deaths from a head injury that did not require neurosurgery if medical intervention could be given immediately</td>
</tr>
<tr>
<td>Reduction in transfer deterioration due to staff expertise</td>
</tr>
<tr>
<td>Delays administering intubation and delay before making a neurosurgical decision (according to the level of staff expertise)</td>
</tr>
<tr>
<td>Increased mortality risk due to a secondary referral</td>
</tr>
<tr>
<td>Extra risk of mortality if the patient suffers hypotension or full hypoxia</td>
</tr>
</tbody>
</table>

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.

We assumed that the cost of care prior to neurosurgery/intensive care would be no different in an NSH than a DGH. This was the opinion of our GDG experts and is suggested elsewhere. If all the patients that are directly transported to a NSH were transferred under the current system, then the costs to the NSH would be little higher. Alternatively, if a direct transport policy leads to additional patients being taken to the NSH, as is likely, then a certain amount of resources will need to be shifted from DGHs to NSHs. Such a shift might involve additional implementation costs – not accounted for in our models.

The sensitivity analysis showed that the direct transport of severe head injury is likely to be cost-effective even with a substantial amount of over-triaging. A US study reports a successful rate of GCS assessment (410/412 patients) by paramedics at the incident site, after an 8-hour training course. Hence, training for ambulance staff in the triaging of head injury patients would be necessary to safeguard the effectiveness and cost-effectiveness of the direct transport strategy.

(15) 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 paramedics can triage patients accurately then a policy of direct transport to an NSH is likely to produce a net cost saving to A&E 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 paramedics (unintentionally) over-triage, 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 over-atriaged patients would have to be quite high for the direct transport strategy to be no longer cost-effective.
Appendix A. Remit and Scope

Scope for the development of a clinical guideline on Head Injury in Children and Adults - assessment, investigation, early management.

Version 3
1 October 2001

1. Objective
1. The National Institute for Clinical Excellence has commissioned a clinical guideline for patients and clinicians on the early management of head injury. The guideline will provide advice on effective care using the best possible research evidence.
2. The commission received from the Department of Health and the National Assembly for Wales is in Figure 1

Figure 1: Commission from the Department of Health and National Assembly for Wales

All patients with head injuries are initially seen in an Accident & Emergency Department or walk-in centre. The A&E department must determine:
- which patients can go home without admission to hospital,
- which patients with a relatively minor injury require admission to a hospital for a short period, i.e. not more than 48 hours,
- which patients require transfer to a neurosurgical unit and may require neurosurgery,
- after discussion with neurosurgeons, which severely head-injured patients do not require neurosurgical intervention but do require admission to a neuroscience unit,
- which accompanying injuries require the involvement of other specialities. We would like NICE to give guidance on these matters as they relate to both children and adults.

3. The Institute’s clinical guidelines will support the implementation of National Service Frameworks (NSF) in those aspects of care where a framework has been published. The statements in each NSF reflect the evidence that was used at the time the framework was prepared. The clinical guidelines and technology appraisals published by the Institute after a NSF has been issued will have the effect of updating the framework.

2. Title
Head Injury in Children and Adults - assessment, investigation and early management.

3. Clinical Need and Practice

4. Each year 1.4 million people attend hospitals in England and Wales with a history of a recent head injury. Between 40 and 50% of these are children under 15 years of age. The majority, around 80%, are diagnosed with ‘mild’ head injury and do not require hospital admission.

5. Annually, around 150,000 people are admitted to hospital with head injury. Of these, one third have features suggesting that their injury may have been sufficient to cause a skull fracture, or have evidence of brain damage. Approximately 6% of children with head injuries and 18% of adults with head injuries suffer from impaired consciousness and around 4,000 patients a year undergo a neurosurgical operation for an intracranial complication. Most patients recover without specific or specialist intervention but in others, persistent disability or even death result from the effects of complications, which can potentially be minimised or avoided with early detection and appropriate treatment.

6. Much of the controversy and uncertainty in the early care of head injured patients is focused upon how these patients are best managed.


4. Population

8. The guideline should offer best practice advice on the care of adults and children (including infants) who present with a suspected or confirmed traumatic head injury with or without other major trauma.

9. The guideline will not provide advice on the management of patients with other traumatic injury to the head (e.g. to the eye or face).

10. 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.

11. 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.
5. Health care setting

12. The guideline will cover the care received from primary care, ambulance and A&E staff who have direct contact with and make decisions concerning the care of patients who present with suspected or confirmed head injury. It will recognise the need for care to be integrated between the primary and secondary sectors.

13. It will address the management of patients in primary care, pre-hospital, in Accident and Emergency or similar units.

14. The guideline will be relevant to the work but will not cover the practice of others who may manage or treat people with a head injury (e.g. the police and first aiders).

15. The guideline will not address management within the neurosurgical unit.

16. Service configuration, competencies, skill mix and training requirements of staff are outside the scope of the guidelines, as they are the remit of the Modernisation Agency.

17. Whilst service configuration is best addressed at a local level, the developers will consider any strong evidence which links service settings and organisation, to patient outcomes.

6. Interventions and treatment

18. The guideline will address assessment and early management of suspected or confirmed head injury and will include:

1. **Pre-hospital** management including assessment, airway management and ventilation, cervical spine protection and appropriate transfer.

2. **Referral to hospital.** The guideline will cover indications for referral to hospital from pre-hospital care.

3. **Secondary care** with the aim of early detection of intracranial complications. To include:

   1. **Admission for observation.** This may be to a specific observation unit, in association with an Accident & Emergency Department, or to a surgical ward. The aim is to monitor neurological stability and arrange for appropriate diagnostic procedures and treatment, if necessary. Deterioration carries a high likelihood of an intracranial complication but at this stage there may be insufficient time to intervene. Conversely, there is a longstanding concern that, despite existing guidelines, many patients are admitted unnecessarily and inappropriately.

   2. **Skull Radiography.** The guideline will advise on the appropriate use of skull radiography to detect skull fracture and identify those at risk of intracranial complications.
3. Other imaging procedures, including computed tomography (CT) scanning and nuclear magnetic resonance. The guideline will advise on the appropriate use of these and on radiation dosage where relevant.

4. Criteria for transfer and discharge including circumstances when patients should be admitted to a Neurosurgical Unit, admitted for a short period or discharged home.


6. Information for patients and their carer/s prior to and during hospital admission.

4. Early discharge. The guideline will address the management at home of patients who are discharged within 48 hours of admission including:

1. Advice to primary care and Accident and Emergency staff on the management of patients who re-present with suspicious symptoms.
2. Guidance on appropriate handover arrangements
3. Information for patients and carers.

19. The guideline will not address investigative or surgical techniques.

7. Presentation

The guideline will be available in three forms:

20. The full guideline containing the evidence base used by the developers.

21. A short form version, using a standard template, which will form the Institute’s guidance to the NHS including a clinical practice algorithm.

22. A version, prepared specifically for patients and their carers, which will interpret the recommendations made in the Institute’s short form version and will be designed to help patients and carers to make informed choices about their care.

8. Status

23. This scoping statement has been out for a four-week period of consultation with stakeholders. The scope was then re-drafted and submitted to the Guidelines Advisory Committee and subsequently the Institute’s Guidance Executive, for approval. Once approved, it was posted on the Institute’s website, together with details of the Commissioning Brief and the name of the Collaborating Centre through which the guideline is being commissioned. The development of the guideline will begin in November 2001.
24. Information on the guidelines development process, stakeholder involvement and the progress of this guideline is available on the website http://www.nice.org.uk/.
## Appendix B. Declarations of Interest

GDG members, expert advisors and staff declarations of interest

<table>
<thead>
<tr>
<th>Name</th>
<th>Interest</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>GDG Members</strong></td>
<td></td>
</tr>
<tr>
<td>David Yates</td>
<td>None</td>
</tr>
<tr>
<td>Nichola Chater</td>
<td>None</td>
</tr>
<tr>
<td>Paul Cooper</td>
<td>Small share holdings in a range of Pharmaceutical Companies.</td>
</tr>
<tr>
<td>Hilary Dent</td>
<td>None</td>
</tr>
<tr>
<td>Roger Evans</td>
<td>None</td>
</tr>
<tr>
<td>Chris Rowland Hill</td>
<td>None</td>
</tr>
<tr>
<td>David Lloyd</td>
<td>None</td>
</tr>
<tr>
<td>Gabrielle Lomas</td>
<td>Board member of Trauma Research Audit Network, TARN.</td>
</tr>
<tr>
<td></td>
<td>Steering group member of RCN Emergency Care Association.</td>
</tr>
<tr>
<td></td>
<td>Director and shareholder, Trauma Nursing Limited.</td>
</tr>
<tr>
<td>Ian Maconochie</td>
<td>None</td>
</tr>
<tr>
<td>David Mendelow</td>
<td>President of EMN. Chairman of Newcastle Neurosurgery Foundation LTD.</td>
</tr>
<tr>
<td></td>
<td>Chairman of Spontaneous Intracranial Haemorrhage Group LTD Co.</td>
</tr>
<tr>
<td></td>
<td>Consultant advisor for Astra-Zeneca and Novo Nordisc.</td>
</tr>
<tr>
<td>David Menon</td>
<td>Paid consultant/lecturer for GlaxoSmithKline Ltd, Solvay Ltd and British Oxygen Corporation Ltd.</td>
</tr>
<tr>
<td></td>
<td>Member of Management Board of Intensive Care National Audit and Research Centre.</td>
</tr>
<tr>
<td></td>
<td>Member of Council of the Intensive Care Society.</td>
</tr>
<tr>
<td></td>
<td>Member of Executive Board of the European Brain Injury Consortium.</td>
</tr>
<tr>
<td></td>
<td>Director of Cambridge Neuromatics.</td>
</tr>
<tr>
<td>Edward Moss</td>
<td>None</td>
</tr>
<tr>
<td>David Murfin</td>
<td>Research Phase I pharmaceutical trials for Marix LTD.</td>
</tr>
<tr>
<td>Paul Sidi</td>
<td>None</td>
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<tr>
<td><strong>Co-opted Advisors</strong></td>
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</tr>
<tr>
<td>Joel Dunning</td>
<td>No interests were declared that required action</td>
</tr>
<tr>
<td>Archie Morson</td>
<td>No interests were declared that required action</td>
</tr>
<tr>
<td><strong>NCC-AC Staff</strong></td>
<td></td>
</tr>
<tr>
<td>Jennifer Hill</td>
<td>None</td>
</tr>
<tr>
<td>Carlos Sharpin</td>
<td>None</td>
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<tr>
<td>David Wonderling</td>
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<tr>
<td>Enrico De Nigris</td>
<td>None</td>
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<tr>
<td>Peter B Katz</td>
<td>None</td>
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<tr>
<td>Clare Jones</td>
<td>No interests were declared that required action</td>
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<tr>
<td>Kathryn Oliver</td>
<td>None</td>
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<tr>
<td>Rifna Akhtar</td>
<td>None</td>
</tr>
<tr>
<td>Susan Murray</td>
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<tr>
<td>Kelly Dickinson</td>
<td>None</td>
</tr>
<tr>
<td>John Browne</td>
<td>None</td>
</tr>
<tr>
<td>Elisabetta Fenu</td>
<td>None</td>
</tr>
<tr>
<td>Caroline Lawson</td>
<td>None</td>
</tr>
</tbody>
</table>

GDG agreed: No action was required.
Appendix C.  Key Clinical Questions included in the update

<table>
<thead>
<tr>
<th>Question Number</th>
<th>Questions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>In deciding on the most appropriate destination for a patient with severe head injury, what are the benefits of direct transport to a specialist neurosciences centre compared to transport to the nearest acute centre?</td>
</tr>
<tr>
<td>2</td>
<td>For patients who have suffered a clinically important brain injury that does not require surgical intervention and who have been transported to a non specialist centre, what are the benefits of the patient continuing on receiving treatment at that acute centre versus being transferred to a neurosciences centre?</td>
</tr>
<tr>
<td>3</td>
<td>Which is the best initial diagnostic tool to determine which patients with head injury require care in a neurosciences centre?</td>
</tr>
<tr>
<td>4</td>
<td>Which is the best clinical prediction rule for selecting patients with head injury for the imaging technique selected in question 2?</td>
</tr>
<tr>
<td>5</td>
<td>Which are the best diagnostic tool(s) to determine which patients have sustained damage to the cervical spine and require assessment of cervical spine?</td>
</tr>
<tr>
<td>6</td>
<td>Which are the best clinical prediction rule(s) for selecting patients that have sustained damage to the cervical spine for the imaging technique selected in question 4?</td>
</tr>
<tr>
<td>7</td>
<td>What is the harm associated with radiation to the head and/or spine?</td>
</tr>
<tr>
<td>8</td>
<td>Which is the best tool for identifying the patients who should be referred to rehabilitation services following the initial management of a head injury?</td>
</tr>
</tbody>
</table>
Appendix D. Search strategies

Systematic review of indications for computed tomography of the head

Medline search
1. Craniocerebral-Trauma/
2. Head-Injuries-Penetrating/
3. exp Head-Injuries-Closed/
4. exp Brain-Injuries/
5. (cerebral trauma).tw.
6. (craniocerebral trauma or cranio-cerebral trauma).tw.
7. (head injur$ or brain injur$).tw.
8. (brain trauma or head trauma).tw.
9. Skull-Fractures/
10. Skull-Fracture-Depressed/
11. Skull-Fracture-Basilar/
13. exp Intracranial-Hemorrhage-Traumatic/
14. (intracranial injur$ or intracranial hematoma$ or intracranial haematoma$ or intracranial hemorrhage$ or epidural hematoma$ or epidural haematoma$ or epidural haemorrhage$ or epidural haemorrhage$ or subdural hematoma$ or subdural haematoma$ or subdural hemorrhage$ or subdural haemorrhage$ or extradural hematoma$ or extradural haematoma$ or extradural haemorrhage$ or extradural haemorrhage$).tw.
15. (brain lesions or intracranial lesions or neurological lesions).tw.
16. (cerebral oedema$ or cerebral edema$ or brain oedema$ or brain edema$).tw.
17. or/1-12
18. or/13-16
19. or/1-13
20. Tomography-X-Ray-Computed/
22. Tomography-X-Ray/
23. Radiography-/
24. (skull radiograph$ or skull xray$ or skull X-ray$).tw.
25. or/20-24
26. ((glasgow coma scale or gcs) near (13 or 14 or 15)) or mild or minor or minimal).tw.
27. Animal/ not (Human/ and Animal/)
28. (biography or comment or editorial or letter or news).pt.
29. or/27 or 28
30. (19 and 25 and 26) not 29
31. (17 and 18 and 25) not 29
32. 29 or 30
33. limit 32 to yr=1990-2002

Embase search
head-injury/
exp brain-injury/
skull-injury/
skull-fracture/
skull-base-fracture/
(craniocerebral trauma or cranio-cerebral trauma or cerebral trauma).tw.
(brain trauma or head trauma).tw.
(head injur$ or brain injur$).tw.
(skull fracture$).tw.
or/1-9
exp brain-hematoma/
epidural-hematoma/
brain-hemorrhage/
(intracranial injur$ or intracranial hematoma or intracranial haematoma$ or intracranial hemorrhage$ or intracranial haemorrhage$).tw.
(epidural hematoma$ or epidural haematoma$ or epidural hemorrhage$ or epidural haemorrhage$ or extradural hematoma$ or extradural haematoma$ or extradural hemorrhage$ or extradural haemorrhage$).tw.
(subdural hematoma$ or subdural haematoma$ or subdural hemorrhage$ or subdural haemorrhage$).tw.
(brain lesions or intracranial lesions or neurological lesions).tw.
(cerebral edema or cerebral oedema or brain edema or brain oedema).tw.
or/11-18
radiography/
skull-radiography/
computer-assisted-tomography/
brain-tomography/
(compute$ tomograph$ or ct).tw.
skull radiograph$ or skull xray$ or skull X-ray$
or/20-25
((glasgow coma scale or gcs) near (13 or 14 or 15)) or mild or minor or minimal
Animal/ not (Human/ and Animal/)
(letter or comment or editorial).pt.
or/28 or 29
(10 and 26 and 27) not 30
(10 and 19 and 26) not 30
31 30
32 31 or 32
33 limit 33 to yr=1990-2002

Systematic review for indications for imaging of the cervical spine

Medline search
radiography/ or exp neuroradiography/
Spine/ra [Radiography]
exp Cervical Vertebrae/ra [Radiography]
Neck/ra [Radiography]
((radiograph$ or xray$ or X-ray$) adj25 (neck or spine or spinal)).mp.
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Embase search

1 Cervical Spine Radiography/
2 spine/ or cervical spine/
3 Neck/
4 (neck or spine or spinal).tw.
5 (radiograph$ or xray$ or X-ray$).tw.
6 1 or ((2 or 3 or 4) and 5)
7 spine injury/ or exp cervical spine injury/ or cervical spine fracture/ or cervical spine dislocation/
8 spinal cord injury/ or exp cervical spinal cord injury/
9 neck injury/ or exp whiplash injury/
10 whiplash.tw.
11 ((trauma or injur$) adj25 (neck or spine or spinal)).tw.
12 or/7-10
13 cervical.mp.
14 (letter or comment or editorial).pt.
15 (Animal/ not (Human/ and Animal/))
16 14 or 15
17 (6 and 12 and 13) not 16
18 limit 17 to yr=1990-2002

Systematic review of means of identifying patients at high risk of late sequelae

Medline

1 Craniocerebral Trauma/
2 Head Injuries, Penetrating/
3 exp Head Injuries, Closed/
4 exp Brain Injuries/
5 (cerebral trauma or craniocerebral trauma or cranio-cerebral trauma).tw.
6 (head injur$ or brain injur$ or brain trauma or head trauma).tw.
7 skull fractures/ or skull fracture, basilar/ or skull fracture, depressed/
8 skull fracture$.tw.
9 exp intracranial hemorrhage, traumatic/
10 or/1-9
HEAD INJURY UPDATE FULL GUIDELINE: DRAFT FOR CONSULTATION (FEB 2007)

EMBASE

1 Head Injury/
2 exp Brain Injury/
3 skull injury/ or skull fracture/ or skull base fracture/
4 (cranio-cerebral trauma or cranio-cerebral trauma or cerebral trauma).tw.
5 (head injur$ or brain injur$ or brain trauma or head trauma).tw.
6 or/1-5 (47310)
7 ((glasgow coma scale adj ("13" or "14" or "15")) or (gcs adj ("13" or "14" or "15"))).tw.
8 (minor or mild or minimal or trivial).tw.
9 or/7-8
10 exp "Prediction and Forecasting"/
11 exp Treatment Outcome/
12 incidence/ or exp mortality/
13 exp Follow Up/
14 (prognosis$ or predict$ or course).mp.
15 or/10-14
16 (editorial or comment or letter).pt.
17 (animal/ not (animal/ and human/))
18 (comment or letter or editorial).pt.
19 19 or 21
20 (10 and 13 and 18) not 21
21 limit 21 to yr=1990-2002

MEDLINE

1 Tomography, X-ray Computed/ or (compute$ tomograph$ or ct).tw.
2 exp Radiation Injuries/
3 exp Neoplasms/
4 (neoplas$ or cancer or tumor$ or tumour$ or carcinoma$ or adenocarcinoma$).mp.
5 or/3-4
6 exp Radiation/

Systematic review of radiation risks associated with computed tomography of the head

235
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</tr>
<tr>
<td>8</td>
<td>(radiation adj5 (dose or dosage or doses)).tw.</td>
</tr>
<tr>
<td>9</td>
<td>or/6-8</td>
</tr>
<tr>
<td>10</td>
<td>exp Risk/</td>
</tr>
<tr>
<td>11</td>
<td>exp Cohort Studies/</td>
</tr>
<tr>
<td>12</td>
<td>(odds and ratio).mp.</td>
</tr>
<tr>
<td>13</td>
<td>(relative and risk).mp.</td>
</tr>
<tr>
<td>14</td>
<td>(case and control).mp.</td>
</tr>
<tr>
<td>15</td>
<td>risk.mp.</td>
</tr>
<tr>
<td>16</td>
<td>or/13-18</td>
</tr>
<tr>
<td>17</td>
<td>(biography or comment or editorial or letter or news).pt.</td>
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<tr>
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<tr>
<td>19</td>
<td>10 or 11</td>
</tr>
<tr>
<td>20</td>
<td>(1 and (2 or (5 and 9 and 16))) not 19</td>
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**Embase**

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</tr>
<tr>
<td>2</td>
<td>(compute$ tomograph$ or ct).tw.</td>
</tr>
<tr>
<td>3</td>
<td>or/1-2</td>
</tr>
<tr>
<td>4</td>
<td>exp Radiation/</td>
</tr>
<tr>
<td>5</td>
<td>radiation/ or ionizing radiation/</td>
</tr>
<tr>
<td>6</td>
<td>exp Radiation Injury/</td>
</tr>
<tr>
<td>7</td>
<td>exp Radiation Exposure/</td>
</tr>
<tr>
<td>8</td>
<td>Radiation Dose/</td>
</tr>
<tr>
<td>9</td>
<td>Radiation Response/</td>
</tr>
<tr>
<td>10</td>
<td>(radiation adj (dose or dosage or doses or expos$)).tw.</td>
</tr>
<tr>
<td>11</td>
<td>or/4-10</td>
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<tr>
<td>12</td>
<td>exp Neoplasm/</td>
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<tr>
<td>13</td>
<td>(neoplas$ or cancer or tumour$ or tumor$ carcinoma$ or adenocarcinoma$).tw.</td>
</tr>
<tr>
<td>14</td>
<td>or/12-13</td>
</tr>
<tr>
<td>15</td>
<td>Cancer Risk/</td>
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<td>Radiation Carcinogenesis/</td>
</tr>
<tr>
<td>17</td>
<td>or/18-19</td>
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<td>18</td>
<td>risk/ or risk assessment/ or risk factor/</td>
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<td>Cohort Analysis/</td>
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<tr>
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<td>(odds and ratio).mp.</td>
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<td>21</td>
<td>(relative and risk).mp.</td>
</tr>
<tr>
<td>22</td>
<td>(case and control).mp.</td>
</tr>
<tr>
<td>23</td>
<td>or/21-25</td>
</tr>
<tr>
<td>24</td>
<td>(letter or comment or editorial).pt.</td>
</tr>
<tr>
<td>25</td>
<td>(Animal/ not (Animal/ and Human/))</td>
</tr>
<tr>
<td>26</td>
<td>or/15-16</td>
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<tr>
<td>27</td>
<td>(3 and (17 or (11 and 14 and 23))) not 26</td>
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<tr>
<td>28</td>
<td>limit 27 to yr=1990-2002</td>
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</table>
Head Injury Search Terms for HEED and NHS Economic Evaluation Database

NHS Economic Evaluation Database

1. explode 'Craniocerebral-Trauma' (MESH term)
2. cerebral trauma
3. cranioencephalic trauma or cranio-cerebral trauma
4. head injur* or brain injur*
5. brain trauma or head trauma
6. skull fracture*
7. or/1-6

HEED

Similar search strategy used without the exploded MESH terms

Cervical Spine Search Terms for HEED and NHS Economic Evaluation Database

NHS Economic Evaluation Database

1. neuroradiography
2. radiograph* or xray* or X-ray*
3. spine or spinal or neck or cervical vertebrae or cervical spine
4. 1 or (2 and 3)

HEED

Similar search strategy used

Medline and Embase used the same strategies for each clinical question, the cost papers being filtered from the search using the cost filter:

cost OR costs OR cost-effective OR cost-effectiveness OR costeffect OR costeffectiveness OR cost-benefit OR benefit-cost OR cost-effect* OR costeffect* OR cost-benefi* OR benefit-cost* OR benefitcost* OR costbenefi* OR costutility OR economic OR cost-utility* OR costutility* OR economics OR econom* OR economics[MESH] OR “cost-effective” OR “cost-effectiveness” OR “cost-benefit” OR “benefit-cost” OR “cost-utility” OR costing OR costings OR costed OR QALY OR life-year OR “life year”

Direct transport/transfer to appropriate destination for a patient with severe head injury

Medline search
1. Craniocerebral-Trauma.DE. OR Head-Injuries-Penetrating.DE. OR Head-Injuries-Closed#.DE. OR Brain-Injuries#..DE.
2. ((cerebral OR craniocerebral) ADJ trauma OR (head OR brain) ADJ (injury OR injuries OR injured OR trauma)).TI,AB.
3. Skull-Fractures.DE. OR Skull-Fracture-Depressed.DE. OR Skull-Fracture-Basilar.DE.
4. (skull ADJ (fracture OR fractures)).TI,AB.
5. Intracranial-Hemorrhage-Traumatic#.DE.
6. (intracranial ADJ (injury OR injuries) OR (intracranial OR epidural OR subdural OR extradural) ADJ (haematoma OR haematomas OR hematoma OR hematomas OR hemorrhage OR hemorrrhages OR haemorrhages)).TI,AB.
7. ((brain OR intracranial OR neurological) ADJ lesions).TI,AB.
8. ((cerebral OR brain) ADJ (oedema OR oedemas OR edema OR edemas)).TI,AB.
9. 1 OR 2 OR 3 OR 4 OR 5 OR 6 OR 7 OR 8
10. Hospitalization#.W..DE. OR (transfer$4 OR transport$6 OR ambulance OR university ADJ hospital).TI,AB.
11. Referral-and-Consultation.DE. OR refer$4.TI,AB. OR ((tertiary OR neurological OR neurosurgical OR specialist OR trauma) ADJ (centre OR centres OR service$) OR neurosurgery).TI,AB.
12. 10 OR 11
14. Randomized-Controlled-Trial.PT. OR Clinical-Trial.PT. OR Controlled-Clinical-Trial.PT.
15. ((clinical OR control OR controlled) ADJ (study OR trial) OR (single OR double OR triple) ADJ (blind$3 OR mask$3) OR randomi$6 OR (random OR randomly) WITH (assign$5 OR allocat$4 OR group OR groups OR grouped OR patients OR study OR trial OR distribut$4) OR crossover NEXT (design OR study OR trial) OR placebo OR placebos).TI,AB.
16. 13 OR 14 OR 15
17. Case-Reports.PT. NOT Randomized-Controlled-Trial.PT. OR Letter.PT. OR Historical-Article.PT. OR Review-Of-Reported-Cases.PT. OR Animals#.W..DE. NOT Humans.DE.
18. 16 NOT 17
20. Evaluation-Studies.PT. OR Multicenter-Study.PT. OR Validation-Studies.PT.
21. (cohort OR case ADJ control OR prospective OR retrospective OR longitudinal OR cross ADJ sectional OR cross-sectional).TLAB.
22. ((follow ADJ up OR follow-up OR observational OR epidemiology OR epidemiologic OR epidemiological) ADJ (study OR studies)).TLAB.
23. (time ADJ series OR pre-test OR pre ADJ test OR post-test OR post ADJ test OR before ADJ after OR quasirandomised OR quasirandomized OR quasi-randomised OR quasi-randomized OR quasi ADJ (randomised OR
randomized OR randomisation OR randomization) OR quasi-experimental OR quasi-experimental OR quasi ADJ (experimental OR experimentation)).TI,AB.

24. 19 OR 20 OR 21 OR 22 OR 23
25. 9 AND 12 AND (18 OR 24)
26. limit set 25 YEAR > 1990

Embase search

1. Head-Injury.DE. OR Brain-Injury#.DE.
2. ((cerebral OR craniocerebral) ADJ trauma OR (head OR brain) ADJ (injury OR injuries OR injured OR trauma)).TI,AB.
3. Skull-Injury.DE. OR Skull-Fracture.DE. OR Skull-Base-Fracture.DE.
4. (skull ADJ (fracture OR fractures)).TI,AB.
5. Brain-Hematoma#.DE. OR Epidural-Hematoma.DE. OR Brain-Hemorrhage.DE.
6. (intracranial ADJ (injury OR injuries) OR (intracranial OR epidural OR subdural OR extradural) ADJ (haematoma OR haematomas OR hematoma OR hematomas OR hemorrhage OR hemorrhages OR haemorrhage OR haemorrhages)).TI,AB.
7. ((brain OR intracranial OR neurological) ADJ lesions).TI,AB.
8. ((cerebral OR brain) ADJ (oedema OR oedemas OR edema OR edemas)).TI,AB.
9. 1 OR 2 OR 3 OR 4 OR 5 OR 6 OR 7 OR 8
11. Patient-Referral.DE. OR refer$4.TI,AB. OR ((tertiary OR neurological OR neurosurgical OR specialist OR trauma) ADJ (centre OR centres OR service$) OR neurosurgery).TI,AB.
12. 10 OR 11
14. ((clinical OR control OR controlled) ADJ (study OR trial) OR (single OR double OR triple) ADJ (blind$3 OR mask$3) OR randomi$6 OR (random OR randomly) WITH (assign$5 OR allocat$4 OR group OR groups OR grouped OR patients OR study OR trial OR distribut$4) OR crossover NEXT (design OR study OR trial) OR placebo OR placebos).TI,AB.
15. 13 OR 14
17. 15 NOT 16
19. (cohort OR case ADJ control OR prospective OR retrospective OR longitudinal OR cross ADJ sectional OR cross-sectional).TI,AB.

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20. ((follow ADJ up OR follow-up OR observational OR epidemiology OR epidemiologic OR epidemiological) ADJ (study OR studies)).TI,AB.
21. (time ADJ series OR pre-test OR pre ADJ test OR post-test OR post ADJ test OR before ADJ after OR quasirandomised OR quasirandomized OR quasi-randomised OR quasi-randomized OR quasi ADJ (randomised OR randomized OR randomisation OR randomization) OR quasiexperimental OR quasi-experimental OR quasi ADJ (experimental OR experimentation)).TI,AB.
22. 18 OR 19 OR 20 OR 21
23. 9 AND 12 AND (17 OR 22)
24. limit set 23 YEAR > 1990

Diagnostic tool for patients with head injury

Medline search

1. Craniocerebral-Trauma.DE. OR Head-Injuries-Penetrating.DE. OR Head-Injuries-Closed#.DE. OR Brain-Injuries#.DE.
2. ((cerebral OR craniocerebral) ADJ trauma OR (head OR brain) ADJ (injury OR injuries OR injured OR trauma)).TI,AB.
3. Skull-Fractures.DE. OR Skull-Fracture-Depressed.DE. OR Skull-Fracture-Basilar.DE.
4. (skull ADJ (fracture OR fractures)).TI,AB.
5. Intracranial-Hemorrhage-Traumatic#.DE.
6. (intracranial ADJ (injury OR injuries) OR (intracranial OR epidural OR subdural OR extradural) ADJ (haematoma OR haematomas OR hematoma OR hematomas OR hemorrhage OR hemorrhages OR haemorrhage OR haemorrhages)).TI,AB.
7. ((brain OR intracranial OR neurological) ADJ lesions).TI,AB.
8. ((cerebral OR brain) ADJ (oedema OR oedemas OR edema OR edemas)).TI,AB.
9. 1 OR 2 OR 3 OR 4
10. 5 OR 6 OR 7 OR 8
11. 1 OR 2 OR 3 OR 4 OR 5
13. ((computed OR computer OR computerised OR computerized) ADJ (tomograph OR tomography OR tomographies OR tomographic OR tomographical OR tomographically) OR ct).TI,AB.
14. (skull ADJ radiograph$ OR skull ADJ (xray$ OR x-ray$ OR x ADJ (ray OR rays))).TI,AB.
15. Magnetic-Resonance-Imaging#.DE.
16. (MRI OR magnetic ADJ resonance ADJ imaging).TI,AB.
17. 12 OR 13 OR 14 OR 15 OR 16
18. ((glasgow ADJ coma ADJ scale OR gcs) NEXT ('13' OR '14' OR '15') OR mild OR minor OR minimal OR trivial).TI,AB.
19. Animals#.DE. NOT Humans.DE. OR (Biography OR Comment OR Editorial OR Letter OR News).PT.
20. (11 AND 17 AND 18) NOT 19
21. (9 AND 10 AND 17) NOT 19
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22. 20 OR 21
23. (Diagnosis.W..DE. NOT Di.DE.) OR Diagnostic-Errors#.DE. OR Sensitivity-
    and-Specificity#.DE.
24. (diagnostic OR sensitivity OR specificity OR predictive ADJ value$ OR
    accuracy OR likelihood ADJ (ratio OR ratios) OR false ADJ negative$ OR
    false ADJ positive$ OR true ADJ positive$ OR true ADJ negative$).TI,AB.
25. 23 OR 24
26. 22 AND 25
27. limit set 26 YEAR > 2002

Embase search

1. Head-Injury.DE. OR Brain-Injury#.DE.
2. ((cerebral OR craniocerebral) ADJ trauma OR (head OR brain) ADJ (injury
    OR injuries OR injured OR trauma)).TI,AB.
3. Skull-Injury.DE. OR Skull-Fracture.DE. OR Skull-Base-Fracture.DE.
4. (skull ADJ (fracture OR fractures)).TI,AB.
5. 1 OR 2 OR 3 OR 4
6. Brain-Hematoma#.DE. OR Epidural-Hematoma.DE. OR Brain-
    Hemorrhage.DE.
7. (intracranial ADJ (injury OR injuries) OR (intracranial OR epidural OR
    subdural OR extradural) ADJ (haematoma OR haematomas OR hematoma OR
    hematomas OR hemorrhage OR hemorrhages OR haemorrhage OR
    haemorrhages)).TI,AB.
8. ((brain OR intracranial OR neurological) ADJ lesions).TI,AB.
9. ((cerebral OR brain) ADJ (oedema OR oedemas OR edema OR
    edemas)).TI,AB.
10. 6 OR 7 OR 8 OR 9
11. Computer-Assisted-Tomography.DE. OR Brain-Tomography.DE. OR
    Radiography.W..DE. OR Skull-Radiography.DE.
12. ((computed OR computer OR computerised OR computerized) ADJ
    tomography OR tomographic OR tomographies OR tomographic OR
    tomographically OR ct)).TI,AB.
13. (skull ADJ radiograph$ OR skull ADJ (xray$ OR x-ray$ OR x ADJ (ray OR
    rays))).TI,AB.
15. (MRI OR magnetic ADJ resonance ADJ imaging).TI,AB.
16. 11 OR 12 OR 13 OR 14 OR 15
17. ((glasgow ADJ coma ADJ scale OR gcs) NEXT ('13' OR '14' OR '15') OR
    mild OR minor OR minimal OR trivial).TI,AB.
19. (5 AND 16 AND 17) NOT 18
20. (5 AND 10 AND 16) NOT 18
21. 19 OR 20
22. (Diagnosis.W..DE. NOT Di.DE.) OR Diagnostic-Error#.DE. OR Sensitivity-
    and-Specificity#.DE.
23. (diagnostic OR sensitivity OR specificity OR predictive ADJ value$ OR
    accuracy OR likelihood ADJ (ratio OR ratios) OR false ADJ negative$ OR
    false ADJ positive$ OR true ADJ positive$ OR true ADJ negative$).TI,AB.
24. 22 OR 23

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Clinical prediction rule for imaging of patients with head injury

Medline search

1. Craniocerebral-Trauma.DE. OR Head-Injuries-Penetrating.DE. OR Head-Injuries-Closed#.DE. OR Brain-Injuries#.DE.
2. ((cerebral OR craniocerebral) ADJ trauma OR (head OR brain) ADJ (injury OR injuries OR injured OR trauma)).TI,AB.
3. Skull-Fractures.DE. OR Skull-Fracture-Depressed.DE. OR Skull-Fracture-Basilar.DE.
4. (skull ADJ (fracture OR fractures)).TI,AB.
5. Intracranial-Hemorrhage-Traumatic#.DE.
6. (intracranial ADJ (injury OR injuries) OR (intracranial OR epidural OR subdural OR extradural) ADJ (haematoma OR haematomas OR hematoma OR hematomas OR hemorrhage OR hemmorhages OR haemorrhage OR haemorrhages)).TI,AB.
7. ((brain OR intracranial OR neurological) ADJ lesions).TI,AB.
8. ((cerebral OR brain) ADJ (oedema OR oedemas OR edema OR edemas)).TI,AB.
9. 1 OR 2 OR 3 OR 4
10. 5 OR 6 OR 7 OR 8
11. 1 OR 2 OR 3 OR 4 OR 5
13. ((computed OR computer OR computerised OR computerized) ADJ (tomograph OR tomography OR tomographies OR tomographic OR tomographically) OR ct).TI,AB.
14. (skull ADJ radiograph$ OR skull ADJ (xray$ OR x-ray$ OR x ADJ (ray OR rays))).TI,AB.
15. Magnetic-Resonance-Imaging#.DE.
16. (MRI OR magnetic ADJ resonance ADJ imaging).TI,AB.
17. 12 OR 13 OR 14 OR 15 OR 16
18. ((glasgow ADJ coma ADJ scale OR gcs) NEXT ('13' OR '14' OR '15') OR mild OR minor OR minimal OR trivial).TI,AB.
19. Animals#.DE. NOT Humans.DE. OR (Biography OR Comment OR Editorial OR Letter OR News).PT.
20. (11 AND 17 AND 18) NOT 19
21. (9 AND 10 AND 17) NOT 19
22. 20 OR 21
23. Meta-Analysis.DE. OR Review-Literature#.DE.
24. Meta-Analysis.PT. OR ((selection ADJ criteria).AB. OR (data ADJ extraction).AB.) AND Review.PT.
25. (cochrane OR embase OR psychlit OR psychinfo OR psycinfo OR cinahl OR cinhal OR science ADJ citation ADJ index OR bids OR cancerlit).AB.
26. (reference ADJ ('LIST' OR lists) OR bibliograph$ OR hand ADJ search$ OR manual ADJ search$ OR relevant ADJ journals).AB.
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27. meta ADJ (analysis OR analyse OR analyses OR analysed OR analytic$) OR
metaanaly$ OR meta-analy$ OR systematic ADJ (review OR overview)
28. 23 OR 24 OR 25 OR 26 OR 27
29. Comment.PT. OR Letter.PT. OR Editorial.PT. OR (Animals#.DE. NOT Humans.DE.)
30. 28 NOT 29
31. 22 AND 30
32. Guidelines#.W..DE.
33. (guideline$ OR protocol OR consensus OR decision ADJ (rule OR rules)).TI,AB.
34. 32 OR 33
35. 22 AND 34
36. Predictive-Value-Of-Tests.DE.
37. (predict$ OR validate$ OR rule OR rules).TI,AB.
38. 36 OR 37
39. 22 AND 38
40. 31 OR 35 OR 39
41. limit set 40 YEAR > 2002

Embase search

1. Head-Injury.DE. OR Brain-Injury#.DE.
2. ((cerebral OR craniocerebral) ADJ trauma OR (head OR brain) ADJ (injury OR injuries OR injured OR trauma)).TI,AB.
3. Skull-Injury.DE. OR Skull-Fracture.DE. OR Skull-Base-Fracture.DE.
4. (skull ADJ (fracture OR fractures)).TI,AB.
5. 1 OR 2 OR 3 OR 4
7. (intracranial ADJ (injury OR injuries) OR (intracranial OR epidural OR subdural OR extradural) ADJ (haematoma OR haematomas OR hematoma OR hematomas OR hemorrhage OR hemorrhages OR haemorrhage OR haemorrhages)).TI,AB.
8. ((brain OR intracranial OR neurological) ADJ lesions).TI,AB.
9. ((cerebral OR brain) ADJ (oedema OR oedemas OR edema OR edemas)).TI,AB.
10. 6 OR 7 OR 8 OR 9
12. ((computed OR computer OR computerised OR computerized) ADJ (tomograph OR tomography OR tomographies OR tomographic OR tomographically OR ct)).TI,AB.
13. (skull ADJ radiograph$ OR skull ADJ (xray$ OR x-ray$ OR x ADJ (ray OR rays))).TI,AB.
15. (MRI OR magnetic ADJ resonance ADJ imaging).TI,AB.
16. 11 OR 12 OR 13 OR 14 OR 15
17. ((glasgow ADJ coma ADJ scale OR gcs) NEXT ('13' OR '14' OR '15') OR mild OR minor OR minimal OR trivial).TI,AB.
Diagnostic tools for patients with damage to the cervical spine

Medline search

2. Spine-RA.DE.
3. Cervical-Vertebrae-RA#.DE.
4. Neck-RA.DE.
5. (((computed OR computer OR computerised OR computerized) ADJ (tomograph OR tomography OR tomographies OR tomographic OR tomographical OR tomographically) OR ct OR radiograph$ OR xray$ OR x-ray$ OR x ADJ (ray OR rays) OR MRI OR magnetic ADJ resonance ADJ imaging) WITH (neck OR spine OR spinal)).TI,AB.
6. 1 OR 2 OR 3 OR 4 OR 5
7. Spinal-Injuries#.DE.
8. Spinal-Cord-Injuries.DE.
9. Neck-Injuries#.DE.
10. Whiplash.TI,AB.
HEAD INJURY UPDATE FULL GUIDELINE: DRAFT FOR CONSULTATION (FEB 2007)

11. ((trauma OR injury OR injuries OR injured) WITH (neck OR spine OR spinal)).TI,AB.
12. 7 OR 8 OR 9 OR 10 OR 11
13. cervical.TI,AB.
14. Animals#.DE. NOT Humans.DE. OR (Biography OR Comment OR Editorial OR Letter OR News).PT.
15. (6 and 12 and 13) not 14
16. (Diagnosis.W..DE. NOT Di.DE.) OR Diagnostic-Errors#.DE. OR Sensitivity-and-Specificity#.DE.
17. (diagnostic OR sensitivity OR specificity OR predictive ADJ value$ OR accuracy OR likelihood ADJ (ratio OR ratios) OR false ADJ negative$ OR false ADJ positive$ OR true ADJ positive$ OR true ADJ negative$).TI,AB.
18. 16 OR 17
19. 15 AND 18
20. limit set 19 YEAR > 2002

Embase search

1. Cervical-Spine-Radiography.DE.
3. (neck OR spine OR spinal).TI,AB.
5. ((computed OR computer OR computerised OR computerized) ADJ (tomograph OR tomography OR tomographies OR tomographic OR tomographical OR tomographically) OR ct OR radiograph$ OR xray$ OR x-ray$ OR x ADJ (ray OR rays) OR MRI OR magnetic ADJ resonance ADJ imaging).TI,AB.
6. 1 OR ((2 OR 3) AND (4 OR 5))
9. Neck-Injury#.DE.
10. Whiplash.TI,AB.
11. ((trauma OR injury OR injuries OR injured) WITH (neck OR spine OR spinal)).TI,AB.
12. 7 OR 8 OR 9 OR 10 OR 11
13. cervical.TI,AB.
15. (6 AND 12 AND 13) NOT 14
16. (Diagnosis.W..DE. NOT Di.DE.) OR Diagnostic-Error#.DE. OR Sensitivity-and-Specificity#.DE.
17. (diagnostic OR sensitivity OR specificity OR predictive ADJ value$ OR accuracy OR likelihood ADJ (ratio OR ratios) OR false ADJ negative$ OR false ADJ positive$ OR true ADJ positive$ OR true ADJ negative$).TI,AB.
18. 16 OR 17
19. 15 AND 18
20. limit set 19 YEAR > 2002

Clinical prediction rule for imaging of patients with damage to the cervical spine

245
Medline search

2. Spine-RA.DE.
3. Cervical-Vertebrae-RA#.DE.
4. Neck-RA.DE.
5. (((computed OR computer OR computerised OR computerized) ADJ (tomograph OR tomography OR tomographies OR tomographic OR tomographical OR tomographically) OR ct OR radiograph$ OR xray$ OR x-ray$ OR x ADJ (ray OR rays) OR MRI OR magnetic ADJ resonance ADJ imaging) WITH (neck OR spine OR spinal)).TI,AB.
6. 1 OR 2 OR 3 OR 4 OR 5
7. Spinal-Injuries#.DE.
8. Spinal-Cord-Injuries.DE.
9. Neck-Injuries#.DE.
10. Whiplash.TI,AB.
11. ((trauma OR injury OR injuries OR injured) WITH (neck OR spine OR spinal)).TI,AB.
12. 7 OR 8 OR 9 OR 10 OR 11
13. cervical.TI,AB.
14. Animals#.DE. NOT Humans.DE. OR (Biography OR Comment OR Editorial OR Letter OR News).PT.
15. (6 and 12 and 13) not 14
17. Meta-Analysis.PT. OR ((selection ADJ criteria).AB. OR (data ADJ extraction).AB.) AND Review.PT.
18. (cochrane OR embase OR psychlit OR psyclit OR psychinfo OR psycinfo OR cinahl OR cinhal OR science ADJ citation ADJ index OR bids OR cancerlit).AB.
19. (reference ADJ ('LIST' OR lists) OR bibliograph$ OR hand ADJ search$ OR manual ADJ search$ OR relevant ADJ journals).AB.
20. meta ADJ (analysis OR analyse OR analyses OR analysed OR analytic$) OR metaanaly$ OR meta-analy$ OR systematic ADJ (review OR overview)
21. 16 OR 17 OR 18 OR 19 or 20
22. Comment.PT. OR Letter.PT. OR Editorial.PT. OR (Animals#.DE. NOT Humans.DE.)
23. 21 NOT 22
24. 15 AND 23
25. Guidelines#.W..DE.
26. (guideline$ OR protocol OR consensus).TI,AB.
27. 25 OR 26
28. 15 AND 27
29. Predictive-Value-Of-Tests.DE.
30. (predict$ OR validate$ OR rule OR rules).TI,AB.
31. 29 OR 30
32. 15 AND 31
33. 24 OR 28 OR 32
34. limit set 33 YEAR > 2002

Embase search

1. Cervical-Spine-Radiography.DE.
3. (neck OR spine OR spinal).TI,AB.
5. ((computed OR computer OR computerised OR computerized) ADJ (tomograph OR tomography OR tomographies OR tomographic OR tomographical OR tomographically) OR ct OR radiograph$ OR xray$ OR x-ray$ OR x ADJ (ray OR rays) OR MRI OR magnetic ADJ resonance ADJ imaging).TI,AB.
6. 1 OR ((2 OR 3) AND (4 OR 5))
9. Neck-Injury#.DE.
10. Whiplash.TI,AB.
11. ((trauma OR injury OR injuries OR injured) WITH (neck OR spine OR spinal)).TI,AB.
12. 7 OR 8 OR 9 OR 10 OR 11
13. cervical.TI,AB.
15. (6 AND 12 AND 13) NOT 14
16. Meta-Analysis#.DE. OR Systematic-Review.DE.
17. ((selection ADJ criteria).AB. OR (data ADJ extraction).AB.) AND Review.AT.
18. (cochrane OR embase OR psychlit OR psyclip OR psychinfo OR psycinfo OR cinahl OR cinhal OR science ADJ citation ADJ index OR bids OR cancerlit).AB.
19. (reference ADJ ('LIST' OR lists) OR bibliograph$ OR hand ADJ search$ OR manual ADJ search$ OR relevant ADJ journals).AB.
20. meta ADJ (analysis OR analyse OR analyses OR analysed OR analytic$) OR metaanaly$ OR meta-analy$ OR systematic ADJ (review OR overview)
21. 16 OR 17 OR 18 OR 19 OR 20
22. Letter.AT. OR Editorial.AT. OR ((Animal#.DE. OR Nonhuman.DE. OR Animal-Experiment#.DE.) NOT Human#.DE.)
23. 21 NOT 22
24. 15 AND 23
25. Practice-Guideline#.DE.
26. (guideline$ OR protocol OR consensus OR decision ADJ (rule OR rules)).TI,AB.
27. 25 OR 26
28. 15 AND 27
29. Methodology#.W..DE.
30. (predict$ OR validate$).TI,AB.
31. 29 OR 30
32. 15 AND 31
Harm associated with radiation to the head and/or spine

Medline search

1. Tomography-X-Ray-Computed.DE. OR ((computed OR computer OR computerised OR computerized) ADJ (tomograph OR tomography OR tomographies OR tomographic OR tomographical OR tomographically) OR ct).TI,AB.
2. Radiation-Injuries#.DE.
3. Neoplasms#.W..DE.
4. (neoplasm OR neoplasms OR neoplasia OR neoplastic OR cancer OR tumor OR tumors OR tumour OR tumours OR carcinoma OR carcinomas OR adenocarcinoma OR adenocarcinomas).TI,AB.
5. 1 OR 2 OR 3 OR 4
6. Radiation#.W..DE.
7. Radiation-Dosage.DE.
8. (radiation WITH (dose OR dosage OR doses OR exposure OR exposures OR exposed OR expose)).TI,AB.
9. 6 OR 7 OR 8
10. Risk#.W..DE. OR risk.TI,AB.
11. Cohort-Studies#.DE.
12. Odds-Ratio.DE. OR (odds ADJ ratio).TI,AB.
13. Case-Control-Studies.DE. OR (case ADJ control).TI,AB.
14. 10 OR 11 OR 12 OR 13
15. Animals#.DE. NOT Humans.DE. OR (Biography OR Comment OR Editorial OR Letter OR News).PT.
16. (1 AND (2 OR (5 AND 9 AND 14))) NOT 15
17. limit set 16 YEAR > 2002

Embase search

1. Tomography-X-Ray-Computed.DE. OR ((computed OR computer OR computerised OR computerized) ADJ (tomograph OR tomography OR tomographies OR tomographic OR tomographical OR tomographically) OR ct).TI,AB.
2. Radiation#.W..DE.
3. Radiation-Injury#.DE.
4. Radiation-Exposure#.DE.
5. Radiation-Dose.DE.
6. Radiation-Response.DE.
7. (radiation WITH (dose OR dosage OR doses OR exposure OR exposures OR exposed OR expose)).TI,AB.
8. 2 OR 3 OR 4 OR 5 OR 6 OR 7
9. Neoplasm#.W..DE.
10. (neoplasm OR neoplasms OR neoplasia OR neoplastic OR cancer OR tumor OR tumors OR tumour OR tumours OR carcinoma OR carcinomas OR adenocarcinoma OR adenocarcinomas).TI,AB.
HEAD INJURY UPDATE FULL GUIDELINE: DRAFT FOR CONSULTATION (FEB 2007)

11. 9 OR 10
12. Cancer-Risk.DE.
13. Radiation-Carcinogenesis.DE.
14. 12 OR 13
15. Risk.W..DE. OR Risk-Assessment.DE. OR Risk-Factor.DE. OR risk.TI,AB.
16. Cohort-Analysis.DE.
17. (odds ADJ ratio).TI,AB.
18. Case-Control-Study.DE. OR (case ADJ control).TI,AB.
19. 15 OR 16 OR 17 OR 18
21. (1 AND (14 OR (8 AND 11 AND 19))) NOT 20
22. limit set 21 YEAR > 2002

Best tool for identifying the patients who should be referred to rehabilitation services following the initial management of a head injury

Medline search

1. Craniocerebral-Trauma.DE.
2. Head-Injuries-Penetrating.DE.
3. Head-Injuries-Closed#.DE.
4. Brain-Injuries#.DE.
5. ((cerebral OR craniocerebral) ADJ trauma).TI,AB.
6. ((head OR brain) ADJ (injury OR injuries OR injured OR trauma)).TI,AB.
7. Skull-Fractures.DE.
8. Skull-Fracture-Depressed.DE.
9. Skull-Fracture-Basilar.DE.
10. (skull ADJ (fracture OR fractures)).TI,AB.
11. Intracranial-Hemorrhage-Traumatic#.DE.
12. 1 OR 2 OR 3 OR 4 OR 5 OR 6 OR 7 OR 8 OR 9 OR 10 OR 11
13. ((glasgow ADJ coma ADJ scale OR gcs) NEXT ('13' OR '14' OR '15') OR mild OR minor OR minimal OR trivial).TI,AB.
14. Prognosis.W..DE. OR Treatment-Outcome#.DE.
15. Incidence.W..DE. OR Mortality#.W..DE. OR Follow-Up-Studies.DE.
16. Mo.DE.
17. (prognos$ OR predict$ OR course).TI,AB.
18. 14 OR 15 OR 16 OR 17
19. rehabilitat$.DE. OR rehabilitat$.TI,AB.
20. Animals#.DE. NOT Humans.DE. OR (Biography OR Comment OR Editorial OR Letter OR News).PT.
21. (12 AND 13 AND (18 OR 19)) NOT 20
22. limit set 21 YEAR > 2002

Embase

1. Head-Injury.DE.
2. Brain-Injury#.DE.
3. ((cerebral OR craniocerebral) ADJ trauma).TI,AB.
4. ((head OR brain) ADJ (injury OR injuries OR injured OR trauma)).TI,AB.
5. Skull-Injury.DE.
HEAD INJURY UPDATE FULL GUIDELINE: DRAFT FOR CONSULTATION  
(FEB 2007)

6. Skull-Fracture.DE.
7. Skull-Base-Fracture.DE.
8. (skull ADJ (fracture OR fractures)).TI,AB.
9. 1 OR 2 OR 3 OR 4 OR 5 OR 6 OR 7 OR 8
10. ((glasgow ADJ coma ADJ scale OR gcs) NEXT ('13' OR '14' OR '15') OR mild OR minor OR minimal OR trivial).TI,AB.
12. Treatment-Outcome#.DE.
13. Incidence.W..DE. OR Mortality#.W..DE. OR Follow-Up#.DE.
14. (prognos$ OR predict$ OR course).TI,AB.
15. 11 OR 12 OR 13 OR 14
16. rehabilitat$.DE. OR rehabilitat$.TI,AB.
18. (9 AND 10 AND (15 OR 16)) NOT 17
19. limit set 18 YEAR > 2002

Clinical prediction rules for patients with head injury

Medline search

1. Craniocerebral-Trauma.DE. OR Head-Injuries-Penetrating.DE. OR Head-Injuries-Closed#.DE. OR Brain-Injuries#.DE.
2. ((head OR brain) ADJ (injury OR injuries OR injured OR trauma)).TI,AB.
3. 1 OR 2
4. Predictive-Value-Of-Tests.DE.
5. (predict$ OR validat$ OR rule OR rules).TI,AB.
6. 4 OR 5
7. YEAR=2006 OR YEAR=2005 OR YEAR=2004 OR YEAR=2003 OR YEAR=2002
8. Comment.PT. OR Letter.PT. OR Editorial.PT. OR Animals#.DE. NOT Humans.DE.
9. (3 AND 6 AND 7) NOT 8

Embase search

1. Head-Injury.DE. OR Brain-Injury#.DE.
2. ((head OR brain) ADJ (injury OR injuries OR injured OR trauma)).TI,AB.
3. 1 OR 2
4. Methodology#.W..DE.
5. (predict$ OR validat$).TI,AB.
6. 4 OR 5
7. YEAR=2006 OR YEAR=2005 OR YEAR=2004 OR YEAR=2003 OR YEAR=2002
8. Letter.AT. OR Editorial.AT. OR (Animal#.DE. OR Nonhuman.DE. OR Animal-Experiment#.DE.) NOT Human#.DE.
9. (3 AND 6 AND 7) NOT 8

Psycinfo search

1. Head-Injuries#.DE.
2. ((head OR brain) ADJ (injury OR injuries OR injured OR trauma)).TI,AB.

250
3. 1 OR 2
4. Prediction.W..DE.
5. (predict$4 OR validat$4 OR rule OR rules).TI,AB.
6. 4 OR 5
7. YEAR=2006 OR YEAR=2005 OR YEAR=2004 OR YEAR=2003 OR YEAR=2002
8. 3 AND 6 AND 7

**Head injury economic searches**

**NHS Economic Evaluation Database (NHSEED)**

1. MeSH descriptor Craniocerebral Trauma
2. MeSH descriptor Head Injuries, Penetrating
3. MeSH descriptor Head Injuries, Closed explode all trees
4. MeSH descriptor Brain Injuries explode all trees
5. ((cerebral OR craniocerebral) NEXT trauma) OR ((head OR brain) NEXT injur* OR trauma*)) in Record Title
6. ((cerebral OR craniocerebral) NEXT trauma) OR ((head OR brain) NEXT injur* OR trauma*)) in Abstract
7. MeSH descriptor Skull Fractures
8. MeSH descriptor Skull Fracture, Depressed
9. MeSH descriptor Skull Fracture, Basilar
10. skull NEXT fracture* in Record Title
11. skull NEXT fracture* in Abstract
12. MeSH descriptor Intracranial Hemorrhage, Traumatic explode all trees
13. (intracranial NEXT injur*) OR ((intracranial OR epidural OR subdural OR extradural) NEXT (haematoma* OR hematoma* OR haemorrhage* or hemorrhage*)) in Record Title
14. (intracranial NEXT injur*) OR ((intracranial OR epidural OR subdural OR extradural) NEXT (haematoma* OR hematoma* OR haemorrhage* or hemorrhage*)) in Abstract
15. (cerebral OR brain) NEXT (oedema* OR edema*) in Record Title
16. (cerebral OR brain) NEXT (oedema* OR edema*) in Abstract
17. #1 OR #2 OR #3 OR #4 OR #5 OR #6 OR #7 OR #8 OR #9 OR #10 OR #11 OR #12 OR #13 OR #14 OR #15 OR #16
18. MeSH descriptor Spinal Injuries explode all trees
19. MeSH descriptor Spinal Cord Injuries
20. MeSH descriptor Neck Injuries explode all trees
21. whiplash in Record Title
22. whiplash in Abstract
23. (trauma OR injur*) AND (neck OR spine OR spinal) in Record Title
24. (trauma OR injur*) AND (neck OR spine OR spinal) in Abstract
25. #18 OR #19 OR #20 OR #21 OR #22 OR #23 OR #24
26. cervical in Record Title
27. cervical in Abstract
28. #25 AND (#26 OR #27)
29. #17 OR #28 from 2002 to 2006
Health Economic Evaluations Database (HEED)

1. AX='head injury' OR 'head injuries' OR 'head injured' OR 'brain injury' OR 'brain injuries' OR 'brain injured' OR 'intracranial injury' OR 'intracranial injuries' OR 'head trauma' OR 'brain trauma'
2. AX='skull fracture' OR 'skull fractures'
3. CS = 1 OR 2
4. AX=trauma OR injur*
5. AX=spine or spinal or neck
6. AX=whiplash
7. CS = (4 AND 5) OR 6
8. AX=cervical
9. CS = 7 AND 8
10. TE='Applied Study' OR 'Review of Applied Studies'
11. JD>=2002
12. CS = (3 OR 9) AND 10 AND 11

Medline and Embase used the same strategies for each clinical question, the cost papers being filtered from the search using the following cost filters:

**Medline**

4. ((low OR high OR unit OR healthcare OR health ADJ care OR health-care OR hospital OR benefit ADJ (cost OR costs OR costing OR costings)).TI,AB. OR ((cost OR costs OR costing OR costings) ADJ (estimat$ OR variable OR effectiv$ OR benefit$)).TI,AB.
5. fiscal OR funding OR financial OR finance OR economic$ OR pharmacoeconomic$ OR price OR prices OR pricing OR (QALYS OR life-year$ OR costeffectiv$ OR cost-effectiv$ OR costbenefit$ OR cost-benefit$).TI,AB.
6. 1 OR 2 OR 3 OR 4 OR 5

**Embase**

Cost.DE. OR Health-Care-Financing.DE. OR Health-Economics.DE. OR Hospital-Cost.DE. OR Cost-Minimization-Analysis.DE.

2. fiscal OR financial OR finance OR funding OR (cost ADJ (estimate$ OR variable$)).TI,AB. OR (unit ADJ (cost OR costs OR costing OR costings)).TI,AB.

3. 1 OR 2
Appendix E. Suggested written discharge advice card for patients aged over 12 years who have sustained a head injury

We think that it is alright for you to leave hospital now. We have checked your symptoms and you seem well on the road to recovery. When you get home it is very unlikely that you will have any further problems. But, if any of the following symptoms do return, we suggest you come back, or get someone to bring you back to your nearest hospital A&E Department as soon as possible:

- unconsciousness, or lack of full consciousness (e.g. problems keeping eyes open)
- any confusion (not knowing where you are, getting things muddled up)
- any drowsiness (feeling sleepy) that goes on for longer than one hour when you would normally be wide awake
- any problems understanding or speaking
- any loss of balance or problems walking
- any weakness in one or more arms or legs
- any problems with your eyesight
- very painful headache that won’t go away
- any vomiting – getting sick
- any fits (collapsing or passing out suddenly)
- clear fluid coming out of your ear or nose
- bleeding from one or more ears
- new deafness in one or more ears

Things you shouldn’t worry about

You may feel some other symptoms over the next few days which should disappear in the next two weeks. These include a mild headache, feeling sick (without vomiting), dizziness, irritability or bad temper, problems concentrating or problems with your memory, tiredness, lack of appetite or problems sleeping. If you feel very concerned about any of these symptoms in the first few days after discharge, you should go and see your own doctor to talk about them. If these problems do not go away after two weeks, you should go and see your doctor. We would also recommend that you seek a doctor’s opinion about your ability to drive a car or motorbike.

Things that will help you get better

If you follow this advice you should get better more quickly and it may help any symptoms you have to go away:

- DO NOT stay at home alone for the first 48 hours after leaving hospital.
- DO make sure you stay within easy reach of a telephone and medical help.
- DO have plenty of rest and avoid stressful situations
- DO NOT take any alcohol or drugs
• DO NOT take sleeping pills, sedatives or tranquilisers unless they are given by a doctor
• DO NOT play any contact sport (e.g. rugby or football) for at least three weeks without talking to your doctor first
• DO NOT return to your normal school, college or work activity until you feel you have completely recovered
• DO NOT drive a car, motorbike or bicycle or operate machinery unless you feel you have completely recovered

Telephone number to call at the hospital______________________________

Long-term problems

Most patients recover quickly from their accident and experience no long-term problems. However, some patients only develop problems after a few weeks or months. If you start to feel that things are not quite right (e.g. memory problems, not feeling yourself), then please contact your doctor as soon as possible so that we can check to make sure you are recovering properly.
Appendix F.  Suggested written discharge advice card for carers of children who have sustained a head injury

We think that it is alright for your child to leave hospital now. We have checked their symptoms and they seem well on the road to recovery. When you get them home it is very unlikely that they will have any further problems. But, if any of the following symptoms do return, we suggest you bring them back to their nearest hospital A&E Department as soon as possible:

- unconsciousness, or lack of full consciousness (e.g. problems keeping eyes open)
- any confusion (not knowing where they are, getting things muddled up)
- any drowsiness (feeling sleepy) that goes on for longer than one hour when they would normally be wide awake
- difficulty waking the patient up
- any problems understanding or speaking
- any loss of balance or problems walking
- any weakness in one or more arms or legs
- any problems with their eyesight
- very painful headache that won’t go away
- any vomiting – getting sick
- any fits (collapsing or passing out suddenly)
- clear fluid coming out of their ear or nose
- bleeding from one or more ears
- new deafness in one or more ears

Things you shouldn’t worry about

They may feel some other symptoms over the next few days which should disappear in the next two weeks. These include a mild headache, feeling sick (without vomiting), dizziness, irritability or bad temper, problems concentrating or problems with their memory, tiredness, lack of appetite or problems sleeping. If you feel very concerned about any of these symptoms in the first few days after discharge, you should bring the patient to their doctor. **If these problems do not go away after two weeks, you should bring the patient to see their doctor.**

Things that will help the patient get better

If the patient follows this advice it should help them get better more quickly and it may help any symptoms they have to go away:

- DO have plenty of rest and avoid stressful situations
- DO NOT take sleeping pills, sedatives or tranquilisers unless they are given by a doctor
- DO NOT play any contact sport (e.g. football) for at least three weeks without talking to their doctor first
Things you should do to make sure the patient is OK

- DO NOT allow them to return to school until you feel they have completely recovered
- DO NOT leave the patient alone in the home for the first 48 hours after leaving hospital
- DO make sure that there is a nearby telephone and that the patient stays within easy reach of medical help

Telephone number to call at the hospital ____________________________

Long-term problems

Most patients recover quickly from their accident and experience no long-term problems. However, some patients only develop problems after a few weeks or months. If you start to feel that things are not quite right for your child (e.g. memory problems, not feeling themselves), then please contact your doctor as soon as possible so that we can check to make sure they are recovering properly.
Appendix G. Suggested written discharge advice card for carers of adults

We think that it is alright for your friend/relative/client to leave hospital now. We have checked their symptoms and they seem well on the road to recovery. When you get them home it is very unlikely that they will have any further problems. But, if any of the following symptoms do return, we suggest you bring them back to their nearest hospital A&E Department as soon as possible:

- unconsciousness, or lack of full consciousness (e.g. problems keeping eyes open)
- any confusion (not knowing where they are, getting things muddled up)
- any drowsiness (feeling sleepy) that goes on for longer than one hour when they would normally be wide awake
- difficulty waking the patient up
- any problems understanding or speaking
- any loss of balance or problems walking
- any weakness in one or more arms or legs
- any problems with their eyesight
- very painful headache that won’t go away
- any vomiting – getting sick
- any fits (collapsing or passing out suddenly)
- clear fluid coming out of their ear or nose
- bleeding from one or more ears
- new deafness in one or more ears

Things you shouldn’t worry about

They may feel some other symptoms over the next few days which should disappear in the next two weeks. These include a mild headache, feeling sick (without vomiting), dizziness, irritability or bad temper, problems concentrating or problems with their memory, tiredness, lack of appetite or problems sleeping. If you feel very concerned about any of these symptoms in the first few days after discharge, you should bring the patient to their doctor to talk about them. If these problems do not go away after two weeks, you should bring the patient to see their doctor. We would also recommend that they seek a doctor’s opinion about their ability to drive a car or motorbike.

Things that will help the patient get better

If the patient follows this advice it should help them get better more quickly and it may help any symptoms they have to go away:

- DO have plenty of rest and avoid stressful situations
- DO NOT take any alcohol or drugs
- DO NOT take sleeping pills, sedatives or tranquilisers unless they are given by a doctor
• DO NOT play any contact sport (e.g. football) for at least three weeks without talking to a doctor first
• DO NOT return to their normal college or work activity until they feel they have completely recovered.
• DO NOT drive a car, motorbike or bicycle or operate machinery unless they feel they have completely recovered.

**Things you should do to make sure the patient is OK**

• DO NOT leave the patient alone in the home for the first 48 hours after leaving hospital
• DO make sure that there is a nearby telephone and that the patient stays within easy reach of medical help

Telephone number to call at the hospital______________________________

______

**Long-term problems**

Most patients recover quickly from their accident and experience no long-term problems. However, some patients only develop problems after a few weeks or months. **If you start to feel that things are not quite right for your child or friend/relative/client (e.g. memory problems, not feeling themselves), then please contact your doctor as soon as possible so that we can check to make sure they are recovering properly.**
## Appendix H  Abbreviations used in these evidence tables

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>AIS</td>
<td>Abbreviated Injury Score</td>
</tr>
<tr>
<td>BP</td>
<td>Blood pressure</td>
</tr>
<tr>
<td>c-spine</td>
<td>Cervical Spine</td>
</tr>
<tr>
<td>CCHR</td>
<td>Canadian CT Head Rule</td>
</tr>
<tr>
<td>CT</td>
<td>Computed tomography</td>
</tr>
<tr>
<td>DGH</td>
<td>District General Hospital</td>
</tr>
<tr>
<td>ED</td>
<td>Emergency department</td>
</tr>
<tr>
<td>GCS</td>
<td>Glasgow Coma Scale</td>
</tr>
<tr>
<td>HI</td>
<td>Head injury</td>
</tr>
<tr>
<td>HCT</td>
<td>Helical computed tomography</td>
</tr>
<tr>
<td>ICER</td>
<td>Incremental cost-effectiveness ratio</td>
</tr>
<tr>
<td>ICI</td>
<td>Intracranial injury</td>
</tr>
<tr>
<td>ICU</td>
<td>Intensive care unit</td>
</tr>
<tr>
<td>ISS</td>
<td>Injury severity score</td>
</tr>
<tr>
<td>ITT</td>
<td>Intention to treat</td>
</tr>
<tr>
<td>LE</td>
<td>Life expectancy</td>
</tr>
<tr>
<td>LoS</td>
<td>Length of stay (in hospital)</td>
</tr>
<tr>
<td>M/F</td>
<td>Male/female</td>
</tr>
<tr>
<td>MRI</td>
<td>Magnetic resonance imaging</td>
</tr>
<tr>
<td>N</td>
<td>Total number of patients randomised</td>
</tr>
<tr>
<td>NA</td>
<td>Not applicable</td>
</tr>
<tr>
<td>NOC</td>
<td>New Orleans Criteria</td>
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<tr>
<td>NR</td>
<td>Not reported</td>
</tr>
<tr>
<td>NS</td>
<td>Not significant</td>
</tr>
<tr>
<td>QALY</td>
<td>Quality-adjusted life years</td>
</tr>
<tr>
<td>QoL</td>
<td>Quality of life</td>
</tr>
<tr>
<td>RCT</td>
<td>Randomised controlled trial</td>
</tr>
<tr>
<td>SEM</td>
<td>Standard error of the mean</td>
</tr>
<tr>
<td>Sig</td>
<td>Statistically significant at 5%</td>
</tr>
</tbody>
</table>
**Appendix I. Evidence Tables**

**UPDATE 2007:**
In deciding on the most appropriate destination for a patient with severe head injury, what are the benefits of direct transport to a specialist neurosciences centre compared to transport to the nearest acute centre?

<table>
<thead>
<tr>
<th>Study details</th>
<th>Patients</th>
<th>Interventions Details &amp; duration of intervention:</th>
<th>Outcome measures</th>
<th>Effect size</th>
<th>Comments</th>
</tr>
</thead>
</table>
| **Hannan 2005**<sup>16</sup> | **Patient group:** sub group of 2763 Head Injured patients from data set of 5419 trauma patients. | **Group 1** Patients assessed via American Triage system (pre-hospital care) and referred directly to the emergency department of either a regional or area trauma centre | **Mortality (odds ratios)** | **Group 1:** 2272  
**Group 2:** 491  
Odds 0.88, CI (0.64-1.22), NS p value: NR | **Funding:**  
New York State Department of Health. State Trauma Advisory Committee assisted in ‘formulating’ the study.  
**Limitations:**  
Description of head injured population is not detailed. Unclear, for example, what proportion has GCS>8.  
**Additional outcomes:**  
AIS; Injury Severity Score; GCS; BP; pulse rate; breaths per minute. |

**Study design:** Retrospective observational Cohort  
**Evidence level:** 2+  
**Duration of follow-up:**
<table>
<thead>
<tr>
<th>Study details</th>
<th>Patients</th>
<th>Interventions Details &amp; duration of intervention:</th>
<th>Outcome measures</th>
<th>Effect size</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1996-1998</td>
<td>(82.2%)</td>
<td>American Triage system (pre hospital care) and referred directly a non-trauma centre</td>
<td></td>
<td>Crude Mortality: 25.4%</td>
<td>Notes: Data obtained from New York State Trauma Registry from 1996-1998. ‘Regional’, ‘Area’ and ‘Non-trauma’ are not defined in the paper, thus may not be neurosurgical units.</td>
</tr>
<tr>
<td>Study details</td>
<td>Patients</td>
<td>Interventions Details &amp; duration of intervention:</td>
<td>Outcome measures</td>
<td>Effect size</td>
<td>Comments</td>
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</tr>
<tr>
<td>Hannan 2005<a href="#">1</a></td>
<td><strong>Patient group:</strong> sub group data of 2763. Head Injured patients from data set of 5419 trauma patients.</td>
<td><strong>Group 1</strong> Patients assessed via American Triage system (pre hospital care) and referred directly to the emergency department of a regional centre</td>
<td>Mortality (odds ratios)</td>
<td><strong>Group 1</strong>: 1430&lt;br&gt;Mortality: 25.4%&lt;br&gt;<strong>Group 2</strong>: 1333&lt;br&gt;Odds 0.67, CI (0.53-0.85), Significant p value: NR</td>
<td>Funding: New York State Department of Health. State Trauma Advisory Committee assisted in ‘formulating’ the study.</td>
</tr>
<tr>
<td><strong>Study design:</strong> Retrospective observational Cohort</td>
<td>All patients&lt;br&gt;N: 2763/5419&lt;br&gt;Age (mean): NR&lt;br&gt;M/F: NR&lt;br&gt;Drop outs: n/a</td>
<td><strong>Group 2</strong> Patients assessed via American Triage system (pre hospital care) and referred directly to either an area centre or a non-trauma centre</td>
<td></td>
<td>Limitations: Description of head injured population is not detailed. Unclear, for example, what proportion has GCS&gt;8.</td>
<td></td>
</tr>
<tr>
<td><strong>Evidence level:</strong> 2+</td>
<td><strong>Group 1</strong>&lt;br&gt;HI referred to regional trauma centre n = 1430 (51.8%)&lt;br&gt;Age (mean): NR&lt;br&gt;M/F: NR&lt;br&gt;Drop outs: NR</td>
<td><strong>Additional outcomes:</strong>&lt;br&gt;AIS. Injury Severity Score. GCS, BP, pulse rate, breaths per minute.</td>
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<tr>
<td><strong>Duration of follow-up:</strong> 1996-1998</td>
<td><strong>Group 1</strong>&lt;br&gt;HI area non centre n = 1333 (48.2%)&lt;br&gt;Age (mean): NR&lt;br&gt;M/F: NR&lt;br&gt;Drop outs: NR</td>
<td>Crude Mortality: 25.4%</td>
<td></td>
<td>Notes: Data obtained from New York State Trauma Registry from 1996-1998. Included patients from 13yrs.</td>
<td>‘Regional’, ‘Area’ and ‘Non-trauma’ are not defined in the paper, thus may not be neurosurgical units.</td>
</tr>
<tr>
<td>Study details</td>
<td>Patients</td>
<td>Interventions</td>
<td>Outcome measures</td>
<td>Effect size</td>
<td>Comments</td>
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<tr>
<td>Poon 1991(^{241})</td>
<td>Patient group: patients who had an extradural haematoma requiring surgery in the neurosurgical unit between Jan 1985-Dec 1989.</td>
<td>Group 1: primary or direct neurosurgical care&lt;br&gt;Group 2: secondarily transferred from district general hospital. Transfer policy was followed, i.e. patients with skull fractures and impaired conscious level, coma continuing after resuscitation, deterioration of conscious level, confusion and drowsiness for more than 8 hours, depressed fractures and basal skull fractures, are transferred immediately without question to the neurosurgical unit.</td>
<td>Mean delay&lt;br&gt;(hours ± SE)= time interval between deterioration of conscious level and decompressive surgery</td>
<td>Group 1: 0.7±1.0&lt;br&gt;Group 2: 3.2±0.5</td>
<td>Funding: NR&lt;br&gt;Limitations: Possible that the patients in group 2 transferred were more severely injured than those in group 1. Additional outcomes: Traumatic extradural haematoma mainly occurs in young men and the incidence of lucid interval, skull fracture, posterior fossa and intradural lesions were similar between the groups. Majority of the extradural haematomas in the primary group were diagnosed and treated without clinical deterioration (63% vs 33%, (X^2=7.7, P=0.005))</td>
</tr>
<tr>
<td>Study design: Case series</td>
<td></td>
<td></td>
<td>Results using Glasgow Outcome Scale:&lt;br&gt;Mortality:</td>
<td>Group 1: 3 (4%)&lt;br&gt;Group 2: 8 (24%)&lt;br&gt;Group 1: 7 (10%)&lt;br&gt;Group 2: 9 (27%)&lt;br&gt;Group 1 (n=11): 1&lt;br&gt;Group 2 (n=12): 8</td>
<td></td>
</tr>
<tr>
<td>Evidence level: 3</td>
<td>All patients&lt;br&gt;N: 104</td>
<td>Group 1&lt;br&gt;N: 71&lt;br&gt;Age (mean): 22&lt;br&gt;M/F: 49/22</td>
<td>Good recovery:</td>
<td>Group 1: 61 (86%)&lt;br&gt;Group 2: 16 (49%)&lt;br&gt;(X^2=17.2, P&lt;0.0002, DF=2)</td>
<td></td>
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<tr>
<td>Duration of follow-up: 5 yr prospective study</td>
<td>Group 2&lt;br&gt;N: 33&lt;br&gt;Age (mean): 20&lt;br&gt;M/F: 23/10</td>
<td></td>
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</tbody>
</table>

**Notes:**
- Funding: NR
- Limitations: Possible that the patients in group 2 transferred were more severely injured than those in group 1.
- Additional outcomes: Traumatic extradural haematoma mainly occurs in young men and the incidence of lucid interval, skull fracture, posterior fossa and intradural lesions were similar between the groups.
- Majority of the extradural haematomas in the primary group were diagnosed and treated without clinical deterioration (63% vs 33%, \(X^2=7.7, P=0.005\)).
### Study Details

<table>
<thead>
<tr>
<th>Patients</th>
<th>Interventions</th>
<th>Effect size</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Disability:</strong>&lt;br&gt;Group 2(n=12): 4&lt;br&gt;Group 1(n=11): 9&lt;br&gt;X²=16.2, P≤0.0003, DF=2</td>
<td><strong>Outcome measures</strong>&lt;br&gt;Mortality (observed versus expected)&lt;br&gt;Group 1: 16.5%&lt;br&gt;Group 2: 13.3%&lt;br&gt;p value: NR&lt;br&gt;<strong>Probability of Death</strong> (observed versus expected)&lt;br&gt;Group 1: NS&lt;br&gt;Group 2: NS&lt;br&gt;Mortality Stratified by NISS (New Injury Severity Score)&lt;br&gt;Based on graph&lt;br&gt;&lt;15 NISS&lt;br&gt;Group 1: NR&lt;br&gt;Group 2: NR&lt;br&gt;p value: NS&lt;br&gt;15-35 NISS&lt;br&gt;Group 1: NR&lt;br&gt;Group 2: NR&lt;br&gt;p value: NS&lt;br&gt;&gt;35 NISS&lt;br&gt;Group 1: NR&lt;br&gt;Group 2: NR&lt;br&gt;p value: &lt;0.03&lt;br&gt;Mortality Stratified by Degree of Head Injury&lt;br&gt;Based on graph&lt;br&gt;None/Mild&lt;br&gt;Group 1: NR&lt;br&gt;Group 2: NR&lt;br&gt;p value: NS&lt;br&gt;Good recovery&lt;br&gt;Group 2(n=12): 0&lt;br&gt;X²=16.2, P≤0.0003, DF=2</td>
<td><strong>Effect size</strong></td>
<td><strong>Comments</strong></td>
</tr>
<tr>
<td><strong>DiRusso 2005</strong>&lt;br&gt;Study design: Retrospective Cohort Study&lt;br&gt;Evidence level: 2-&lt;br&gt;Duration of follow-up: Data from patients admitted between April 1994 until January 2002</td>
<td><strong>Patients</strong>&lt;br&gt;Patient group: Trauma patients younger than 20 years of age with a primary diagnosis of injury.&lt;br&gt;All patients&lt;br&gt;N: 49,747&lt;br&gt;Age (mean): 8.15±5.2&lt;br&gt;M/F: 3183/17909&lt;br&gt;Dropouts: NR&lt;br&gt;Group 1: Non-trauma centre&lt;br&gt;N: 1647&lt;br&gt;Age (mean): 7.05±5.2&lt;br&gt;M/F: 1110/537&lt;br&gt;Dropouts: NR&lt;br&gt;RHIS score 2 (moderate): 54.1%&lt;br&gt;RHIS score 3 (severe): 15.4%&lt;br&gt;NISS: 24.8±16.4&lt;br&gt;Group 2: Trauma centre&lt;br&gt;N: 1874&lt;br&gt;Age (mean): 8.0±5.4&lt;br&gt;M/F: 1196/678&lt;br&gt;Dropouts: NR</td>
<td><strong>Interventions</strong>&lt;br&gt;Group 1: Patients intubated in a hospital that is not a trauma centre&lt;br&gt;Group 2: Patients intubated in a trauma centre</td>
<td><strong>Funding:</strong>&lt;br&gt;Supported in part by an unrestricted grant from the Institute of Trauma and Emergency Care, New York.&lt;br&gt;Limitations:&lt;br&gt;Little analysis done of results so relationship between variables (causal or otherwise) is not clear. In general not much analysis was done and this makes the results as presented unclear. Also no data is given on attrition.&lt;br&gt;Additional outcomes:&lt;br&gt;To adjust for degree of injury, patients were risk stratified using data on presentation including age, sex, race, ...</td>
</tr>
<tr>
<td>Study details</td>
<td>Patients</td>
<td>Interventions</td>
<td>Outcome measures</td>
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<tr>
<td>---------------</td>
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</tbody>
</table>
| RHISS score 2 (moderate): 50.1%  
RHISS score 3 (severe): 14.6%  
NISS: 24.4±16.1 | | | | Moderate  
Group 1: NR  
Group 2: NR  
p value: NS  
Severe  
Group 1: NR  
Group 2: NR  
p value: Significant | systolic blood patients, respiratory rate, heart rate, New Injury Severity Score (NISS), Revised Trauma Score and Paediatric Trauma Score. The Relative Head Injury Severity Scale (RHISS) was used to stratify the severity of any head injury.  
Notes: Data set derived from National Paediatric Trauma Registry (NTPR) |
| NISS (New Injury Severity Score) of patients who survived to hospital discharge | | | Group 1: 21.4±14.8 (n = 1379)  
Group 2: 21.6±14.4 (n = 1628)  
p value: NR | | |
| RHISS (Relative Head Injury Severity Scale) of intubated patients who survived to hospital discharge | | | RHISS 2  
Group 1: 55.9 (n = 1379)  
Group 2: 52.8 (n = 1628)  
p value: NR  
RHISS 3  
Group 1: 9.1 (n = 1379)  
Group 2: 9.7 (n = 1628)  
p value: NR | | |
| Odds ratios for being intubated (compared with non-intubated patients) | | | Group 1: 5.8  
Group 2: 4.8 | | |
## Update 2007: Economics evidence table for the transport question

<table>
<thead>
<tr>
<th>Study details</th>
<th>Patients</th>
<th>Interventions</th>
<th>Outcome measures</th>
<th>Effect size</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Economic analysis: Not an economic analysis because it only models survival</td>
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<tr>
<td>Study design</td>
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<tr>
<td>Computer simulation</td>
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<td></td>
</tr>
<tr>
<td>Duration of follow-up:</td>
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<tr>
<td>NR</td>
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<tr>
<td>Discount rates:</td>
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<tr>
<td>NA</td>
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</tr>
<tr>
<td>Additional survivors per 100 HI patients compared with intervention 1 ±SEM (Far)</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>1: 0 2: 3.42±0.06 3: 3.54±0.06 4: 3.44±0.06 5: 3.27±0.06 6: 3.44±0.06 7: 2.76±0.05 8: 1.65±0.04 9: 1.32±0.03 10: 1.53±0.04</td>
<td></td>
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</tr>
<tr>
<td>Additional survivors per 100 HI patients compared with intervention 1 ±SEM (near)</td>
<td></td>
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</tr>
<tr>
<td>1: 0 2: 4.47±0.09 3: 4.55±0.07 4: 4.29±0.08 5: 3.99±0.07 6: 4.51±0.06 7: 3.61±0.08 8: 1.91±0.08 9: 1.51±0.09 10: 1.97±0.07</td>
<td></td>
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<tr>
<td>Sensitivity analysis</td>
<td></td>
<td></td>
<td></td>
<td>The results were not sensitive to one-way sensitivity analyses. Even when all of the subjective parameters were set to favour the DGH, strategies 2-6 improved survival compared with 1, by 2-3%.</td>
<td></td>
</tr>
</tbody>
</table>

### Comments

- Funding: NR
- Notes: data were from the Keele University trauma database, Staffordshire ambulance records, published literature and expert opinion
For patients who have suffered a clinically important brain injury that does not require surgical intervention and who have been transported to a non-specialist centre, what are the benefits of the patient continuing on receiving treatment at that acute centre versus being transferred to a neurosciences centre?

<table>
<thead>
<tr>
<th>Study details</th>
<th>Patients</th>
<th>Interventions</th>
<th>Outcome measures</th>
<th>Effect size</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patel 2005[^235]</td>
<td><strong>Patient group</strong>: patients injured by blunt trauma between 1996-2003 who were treated by participating hospitals in the Trauma Audit and Research Network (TARN).</td>
<td><strong>Group 1</strong>: Patients who received care at a neurosurgical centre (including those who had been transferred).</td>
<td><strong>Mortality</strong>: Odds of death adjusted for variations in ISS, RTS and age.</td>
<td><strong>Group 1</strong>: 1624 (35%, 34-37)</td>
<td><strong>Funding</strong>: States that funder had no role in study design, collection, analysis or interpretation or writing of report.</td>
</tr>
<tr>
<td><strong>Study design</strong>: Retrospective Cohort, data collected prospectively.</td>
<td><strong>Group 2</strong>: Patients who received all their care in hospitals without neurosurgical facilities on site.</td>
<td><strong>Standardised observed-expected survival rates for severe head injury (Ws scores)</strong>.</td>
<td><strong>Group 2</strong>: 1406 (61%, 59-63)</td>
<td><strong>p value = 0.000</strong></td>
<td><strong>Additional outcomes</strong>: This was a sub-group of a larger study which looked at mortality outcomes of HI patients compared to patients without HI. Reported trends of odds of death adjusted for case mix for patients with HI. Comparison of mortality for head injured patients and those without head injury.</td>
</tr>
<tr>
<td><strong>Evidence level</strong>: 2+</td>
<td><strong>Mortality among sub-group of patients with isolated, non-surgical severe HI (n=894)</strong>.</td>
<td></td>
<td><strong>Group 1</strong>: +6% (+5% to +8%)</td>
<td>Patients at non-neurosurgical centre were less likely to have isolated HI and to have normal BP at first hospital presentation. Mortality was 26% higher for group 2 than for those treated in neurosurgical centres (p=0.000).</td>
<td></td>
</tr>
<tr>
<td><strong>Duration of follow-up</strong>: Review from 1989-2003</td>
<td></td>
<td><strong>Group 2</strong>: -10 (-9% to -12%)</td>
<td>Case mix adjusted odds of death after injury for patients with severe HI with complete physiological data who were treated in a non-neurosurgical centre was 2.15 (95% CI 1.77-2.60, AROC=0.87) times that of patients who were treated in a neurosurgical centre. Case mix adjusted odds of death was significantly higher 1.92 (1.11-3.30) for subgroup of patients not requiring surgery. These results were limited by that nearly 50% of these patients had a component of the RTS missing.</td>
<td><strong>Group 2</strong>: 118 (34%, 29-40)</td>
<td><strong>p value = 0.005</strong></td>
</tr>
</tbody>
</table>

[^235]: Funding: States that funder had no role in study design, collection, analysis or interpretation or writing of report.

Additional outcomes:
- This was a sub-group of a larger study which looked at mortality outcomes of HI patients compared to patients without HI.
- Reported trends of odds of death adjusted for case mix for patients with HI. Comparison of mortality for head injured patients and those without head injury.

Patients at non-neurosurgical centre were less likely to have isolated HI and to have normal BP at first hospital presentation. Mortality was 26% higher for group 2 than for those treated in neurosurgical centres (p=0.000).
### Hartl 2006

<table>
<thead>
<tr>
<th>Study details</th>
<th>Patients</th>
<th>Interventions</th>
<th>Outcome measures</th>
<th>Effect size</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>ISS (median): 26</td>
<td>GCS (median): 4</td>
<td>Transferred: 302 (13%, 12-14)</td>
<td>Patient mortality, defined as death within two weeks after TBI. A logistic regression analysis predicting mortality is carried out controlling for hypotension status on day one, &lt; or &gt;60yrs old, pupil status on day 1, and initial GCS. Admission time and times by transport status were found not to affect the results.</td>
<td>Odds ratio: 1.48</td>
<td></td>
</tr>
</tbody>
</table>

**Group 1:** Direct transport is defined as the transport of a patient from the scene of an injury directly to one of the study trauma centres.

**Group 2:** Indirect transport is defined as the transport of a patient from the scene of an injury to a non-trauma centre first, and then to one of the study trauma centres.

**Funding:** The New York State Department of Health (contract #C-019600)

**Limitations:** No raw data is given on mortality rates in the different groups.

**Additional outcomes:** Hypotension status on day one, < or >60yrs old, pupil status on day 1, and initial GCS. Admission time and time by transport status, urban vs non-urban centres.

**Notes:** Well designed and reliable study.
**UPDATE 2007:** Which is the most accurate diagnostic tool to determine which patients with head injury require neurosurgical care?

<table>
<thead>
<tr>
<th>Study details</th>
<th>Patients</th>
<th>Interventions</th>
<th>Outcome measures</th>
<th>Effect size</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age (mean):</strong> 36.5</td>
<td>trauma centres.</td>
<td></td>
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<tr>
<td><strong>M/F:</strong> NR</td>
<td></td>
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</tr>
<tr>
<td><strong>Group 2 Indirect transport</strong></td>
<td>N: 254</td>
<td></td>
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</tr>
<tr>
<td><strong>Age (mean):</strong> 34.4</td>
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<tr>
<td><strong>M/F:</strong> NR</td>
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</tbody>
</table>

**Funding:** County Council of Stockholm (Department of Research, Development and Education) and other foundations and societies.

GOS-E was used through a postal questionnaire to assess the outcomes of all randomised patients 3 months after the injury.

Primary end point: Dichotomised GOS-E 3 months after the injury (8 (fully recovered) v 1-7 (not fully recovered)).

Secondary end point: Same scores dichotomised in 6 other possible ways.

**Limitations:** Some patients were lost completely to
<table>
<thead>
<tr>
<th>Study details</th>
<th>Patients</th>
<th>Diagnostic Tool</th>
<th>Outcome measures</th>
<th>Effect size</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>of follow-up: 3 month follow up.</td>
<td>529(40.2) Obs: 752(58.5) / 534(41.5)</td>
<td>Alternative strategy: Patients were admitted for observation strategy as inpatients according to local guidelines. The attending physicians cold decide to perform CT if this seemed to be clinically necessary. Results were reported and interpreted according to local clinical practice.</td>
<td>CT (%)</td>
<td>52 v 1235 (4.0)</td>
<td>follow-up or withdrew, some were randomised twice if they had head injury twice, some had head injury more than 3 months after the first and they were counted twice, some had partial or incomplete follow up data and some randomised patients were not fully eligible. There was an error by the statistician in the preparation of the randomisation sequence for one of the centres. Not all the unused envelopes were returned after the end of the study.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Obs in hospital (%)</td>
<td>56 v 1187 (4.5)</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Difference (95% CI) (%)</td>
<td>-0.5 (-2.0 to 1.1)</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>GOS-E of 1-3 v 4-8 -</td>
<td>12 v 1275 (0.9)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>CT (%)</td>
<td>7 v 1236 (0.6)</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>Obs in hospital (%)</td>
<td>0.4 (-3.0 to 1.0)</td>
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<td></td>
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<td></td>
<td>Difference (95% CI) (%)</td>
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<td></td>
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<td></td>
<td>GOS-E of 1-2 v 3-8 -</td>
<td>3 v 1282 (0.4)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>CT (%)</td>
<td>4 v 1240 (0.3)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Obs in hospital (%)</td>
<td>0.1 (-0.4 to 0.5)</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Difference (95% CI) (%)</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>GOS-E of 1 v 2-8 -</td>
<td>5 v 1306 (0.4)</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>CT (%)</td>
<td>4 v 1275 (0.3)</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Obs in hospital (%)</td>
<td>0.1 (-0.4 to 0.5)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Difference (95% CI) (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Deaths caused by head injury:</td>
<td></td>
<td></td>
<td>CT</td>
<td>1</td>
<td>A complication defined as deterioration due to the head injury that necessitated neurosurgical intervention, medical treatment or intensive care. Also included subsequent readmission because of head injury.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Obs</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Deaths possibly related to head injury:</td>
<td></td>
<td></td>
<td>CT</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Obs</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Deaths from other causes:</td>
<td></td>
<td></td>
<td>CT</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Obs</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Study details</td>
<td>Patients</td>
<td>Diagnostic Tool</td>
<td>Outcome measures</td>
<td>Effect size</td>
<td>Comments</td>
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<td></td>
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<td></td>
<td>Complications on admission to ICU/neurosurgical ward during acute phase:</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>CT</td>
<td>2</td>
<td></td>
</tr>
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<td></td>
<td></td>
<td></td>
<td>Obs</td>
<td>3</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Complications during acute phase of Neurosurgical operations:</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>CT</td>
<td>0</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Obs</td>
<td>0</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Complications during 3mo follow up of Neurosurgical operations:</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>CT</td>
<td>1</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Obs</td>
<td>3</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Readmission due to symptoms of head injury:</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>CT</td>
<td>1</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Obs</td>
<td>1</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>A rank sum test results:</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>CT group was slightly better than in the obs group (p=0.062, two sided). Worst outcomes (1-4 death to severe disability) were similarly distributed in the 2 groups (4% v 4.5%). 2 people in CT group and 1 in obs group died as a probable or possible</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Study details</td>
<td>Patients</td>
<td>Diagnostic Tool</td>
<td>Outcome measures</td>
<td>Effect size</td>
<td>Comments</td>
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<td></td>
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<td></td>
<td>result of head injury (0.2% v 0.1%). There were 4 (0.3%) non fatal complications in the CT group and 7 (0.5%) in the obs group. All 3 patients in the obs group who needed surgery had a considerable delay in diagnosis and treatment (between 43-74 days after the trauma). Although 2 of these patients completely recovered.</td>
<td></td>
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<td></td>
<td>Outcome of not recovering completely at 3 months follow up: CT Obs Difference (%, one sided 95% CI, two sided 95% CI) 275 patients (21.4%) 300 patients (24.2%) -2.8%, ≤0.03%, -6.1%≤0.6% Outcome for CT is not inferior to the outcome with admission for obs.</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Patient satisfaction (satisfied or quite satisfied with the care they had received): CT Obs</td>
<td>92.5% 93.8%</td>
<td></td>
</tr>
</tbody>
</table>

273
<table>
<thead>
<tr>
<th>Study details</th>
<th>Patients</th>
<th>Diagnostic Tool</th>
<th>Outcome measures</th>
<th>Effect size</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wintermark, 2004&lt;sup&gt;339&lt;/sup&gt;</td>
<td><strong>Patient Group:</strong></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Severe Head Trauma (GCS&lt;8)</td>
<td>Un-enhanced CT scan</td>
<td>Sensitivity: <strong>NOTE:</strong> Cerebral contusions were diagnosed in 48 patients. In 19 patients the contusions were detected on the admission un-enhanced CT scan. The contusion on the remaining 29 was detected on the delayed follow-up un-enhanced CT scans.</td>
<td>39.6% 19/48 (P&lt;0.001)</td>
<td></td>
</tr>
<tr>
<td>Study design:</td>
<td></td>
<td></td>
<td>Specificity:</td>
<td>100% (82/82)</td>
<td></td>
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<tr>
<td>Prospective study</td>
<td></td>
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<tr>
<td>Evidence level: 1b</td>
<td></td>
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</tr>
</tbody>
</table>
| Duration of follow up: | | | | | 3 months
| 3 months | | | | | |

**Cause of HI:** Car accident (70%), motorcycle accidents (18%), pedestrians (12%). Others: falls and crushing accidents

**N:** 130

**Age:** 56 (19-86)

**M/F=101/29**

**Funding :**

N/R

**Limitations:** It includes only patients with severe trauma who had a GCS score of 8 or less at admission. This introduces a bias toward an apparent improvement in the sensitivity and specificity of perfusion CT.

**Additional outcomes:**

Ordered logistic regression performed to determine risk factors for an unfavourable GOS score at 3 months.
### Study details

<table>
<thead>
<tr>
<th>Patients</th>
<th>Diagnostic Tool</th>
<th>Outcome measures</th>
<th>Effect size</th>
<th>Comments</th>
</tr>
</thead>
</table>
| **Patient Group:** Children with isolated closed head injury, history of loss of consciousness or amnesia, and GCS 13-15 who were referred for paediatric trauma evaluation and received a head CT as part of this evaluation. | Patients receive (non-contrast) CT as part of the evaluation and standardised physical examination | Correlation (Sensitivity and Specificity) of examination (normal/abnormal) with the absence/presence of CT finding of intracranial injury. Gold standard is CT scan.  
- Sensitivity of positive examination (anything abnormal on the standardised examination including GCS <15):  
  0.69 (9/13) (CI 0.42-0.87)  
- Specificity:  
  0.4 (34/85) (CI 0.30 - 0.51)  
- Negative Predictive Value:  
  0.89 (CI 0.76 - 0.95)  
- Positive Predictive Value:  
  0.15 (CI 0.08-0.26)  | 13 | Funding: N/R  
**Limitations:** limited sample size. 9/98 subjects not contactable. Three of these patients had surgical follow up visits and were noted to be doing well. Two other subjects were observed in the hospital for 24-48hrs before discharge and were stable at the time of discharge. 4/9 subjects were lost to follow up and had no further visits to the institution. Of the 13 subjects with findings of intracranial injury on CT scan, two required neurosurgical intervention. One subject had an intracranial pressure monitor placed when mental status deteriorated on the ITU. 2nd subject had a depressed skull fracture elevated. Both of these subjects had abnormal clinical examinations at the time of enrolment. |
| N: 98  
Age: 2-16  
M/F: 74/26 (%)  
GCS 13: 3 patients  
GCS 14: 19 patients  
GCS 15: 76 patients |  |  |  | |
| Setting: Large, tertiary, paediatric trauma centre in San Diego.  
Evidence level: II+  
Duration of follow up: 4-6 weeks | | | | |
### Update 2007: Economics evidence table for the head imaging question

<table>
<thead>
<tr>
<th>Study details</th>
<th>Patients</th>
<th>Interventions</th>
<th>Outcome measures</th>
<th>Effect size</th>
<th>Comments</th>
</tr>
</thead>
</table>
| Af Geijerstam, 2004<sup>4</sup> | GCS 15, mild head injury, Country: Sweden | **Group1**: CT strategy  
**Group2**: Observation strategy | **Mean cost** (CT, observation, ED visit, neurosurgery, from Swedish national cost database) | **Group 1**: £ 300  
**Group 2**: £ 470 | **Funding**:  
N/R  

**Notes:**  
Costs are calculated according to Swedish national dataset  
Costs are presented in sterling (£) (£1 in 1998 = 13.17 SEK/1.66 US$)  
Cost of in hospital observation £335; Cost of CT scan £140; % of patients admitted despite normal CT findings, 10%; % of patients given a CT scan despite observed in hospital 20% |
| Economic analysis: Cost analysis | | | | | |
| Study design | Decision analysis | | | | |
| Time horizon: | Discharge | | | | |
| Discount rates: | Costs: NA | | | | |

**Sensitivity analysis**  
The CT strategy was only cost increasing when the unit cost of CT was very high and the observation cost very low. The model was not sensitive to other parameters
<p>| Study details                                                                 | Patients                                                                 | Interventions                | Outcome measures | Effect size                                                                 | Comments   |
|------------------------------------------------------------------------------|--------------------------------------------------------------------------|-----------------------------|------------------|----------------------------------------------------------------------------|--|----------------|
| Fiser 1998&lt;sup&gt;94&lt;/sup&gt; USA                                                 | Patient group: patients with TBI undergoing both CT* and MRI             | 1: CT*+MRI                  | Diagnosis        | CT but not MRI: 9/40 MRI but not CT: 24/40                                 | Funding    |
| Economic analysis: Cost analysis                                            |                           | 2: CT*                      |                  |                                                                           | NR         |
| Study design: Case series                                                   |                           | Interventions               | Interventions    | Surgical: 12/40 Surgical (only indicated by MRI): 0/12 Medical: 31/40     | Note       |
| Duration of follow-up: NR                                                   |                           |                             |                  | Medical (only indicated by MRI): 0/31                                      | *          |
| Discount rates: NA                                                          |                           |                             |                  |                                                                           |            |
| N: 40                                                                        | Age 28.9±3.3              |                             |                  |                                                                           |            |
| M/F: 2.8:1                                                                  | Initial GCS: 8.8±0.7      |                             |                  |                                                                           |            |
| Mean cost (imaging charges)                                                 | 1: $3,731                  |                             |                  |                                                                           |            |
| 2: $1,840                                                                   |                             |                             |                  |                                                                           |            |
| p value: NR                                                                 |                             |                             |                  |                                                                           |            |
| Cost-effectiveness (lesions detected)                                       | 1vs2: $3,152 per extra lesion detected                                   |                             |                  |                                                                           |            |
| Cost-effectiveness (change in treatment path)                               | CT+MRI is dominated by CT                                              |                             |                  |                                                                           |            |
| Sensitivity analysis                                                        | NR                         |                             |                  |                                                                           |            |</p>
<table>
<thead>
<tr>
<th>Study details</th>
<th>Patients</th>
<th>Interventions</th>
<th>Outcome measures</th>
<th>Effect size</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hassan 2005[123]</td>
<td><strong>Country:</strong> UK</td>
<td><strong>Economic analysis:</strong> Cost-analysis</td>
<td><strong>Study design</strong> Cohort study</td>
<td><strong>Duration of follow-up:</strong> 1 month (before NICE guideline implementation) and 1 month after (NICE guideline implementation)</td>
<td><strong>Discount rates:</strong> Costs: NA</td>
</tr>
<tr>
<td><strong>Patient group:</strong> patients with head injury presenting to the ED setting</td>
<td><strong>A. On-site Regional Neurosciences Hospital Group 1 (before)</strong> N: 221 Age (mean): 20 M/F: 68/32 % Drop outs: NA</td>
<td><strong>Group 1:</strong> Before implementation of NICE guideline</td>
<td><strong>CT scan</strong> Number, %</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>Mean cost difference (95%CI)</strong>*</td>
<td>-</td>
<td>-</td>
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<tr>
<td></td>
<td></td>
<td><strong>Skull X ray</strong> Number, %</td>
<td>-</td>
<td>-</td>
<td>-</td>
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<td></td>
<td></td>
<td></td>
<td><strong>Mean cost difference (95%CI)</strong>*</td>
<td>-</td>
<td>-</td>
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<tr>
<td></td>
<td></td>
<td><strong>Admission</strong> Number, %</td>
<td>-</td>
<td>-</td>
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<td></td>
<td></td>
<td></td>
<td><strong>Mean cost difference (95%CI)</strong>*</td>
<td>-</td>
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<td></td>
<td><strong>Total cost</strong></td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td><strong>Group 2 (after)</strong> N: 282 Age (mean): 23 M/F: 64/36 % Drop outs: NA</td>
<td><strong>Group 2:</strong> After implementation of NICE guideline</td>
<td></td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>B District General Hospital Group 1 (before)</strong> N: 276 Age (mean): 20 M/F: 66/34 % Drop outs: NA</td>
<td></td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Group 1:</strong> Before implementation of NICE guideline</td>
<td><strong>Group 1:</strong> 7/221, 3%</td>
<td><strong>Mean2-Mean1</strong> £4.91 (0.13, 9.63)</td>
<td><strong>p value:</strong> 0.054</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>Group 2:</strong> 20/282, 7%</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td><strong>Mean cost difference (95%CI)</strong>*</td>
<td><strong>Group 1:</strong> 81/221, 37%</td>
<td><strong>Mean2-Mean1</strong> £-21.94 (-26.94,-17.49)</td>
<td><strong>p value:</strong> &lt; 0.001</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Skull X ray</strong> Number, %</td>
<td><strong>Group 2:</strong> 11/282, 4%</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td><strong>Mean cost difference (95%CI)</strong>*</td>
<td><strong>Group 1:</strong> 52/276, 19%</td>
<td><strong>Mean2-Mean1</strong> £-7.13 (-8.93,-5.27)</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Admission</strong> Number, %</td>
<td><strong>Group 2:</strong> 2/351, 0.6%</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td><strong>Mean cost difference (95%CI)</strong>*</td>
<td><strong>Group 1:</strong> 18/276, 7%</td>
<td><strong>Mean2-Mean1</strong> £-2.79 (-10.22,-4.62)</td>
</tr>
<tr>
<td></td>
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<td></td>
<td></td>
<td><strong>Mean2-Mean1</strong> £-33.81</td>
<td><strong>p value:</strong> &lt; 0.001</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td><strong>Mean2-Mean1</strong> £-2.90</td>
<td><strong>p value:</strong> &lt; 0.001</td>
</tr>
</tbody>
</table>

**Funding**
Trauma audit and research network

**Notes**
* CIs were calculated by the NCC health economist

**Other outcomes**
The study also presented predicted resource use and cost for if the NICE guideline had been applied in the control period.
### Study details
Norlund 2006 Sweden

Economic analysis: Cost analysis

Study design: RCT

Duration of follow-up: 3 months follow up

Discount rates: NA

### Patients

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Age</th>
<th>M/F</th>
<th>Drop outs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group 1</td>
<td>1316</td>
<td>&gt;=6</td>
<td>NR</td>
<td>2%</td>
</tr>
<tr>
<td>Group 2</td>
<td>1286</td>
<td>&gt;=6</td>
<td>NR</td>
<td>5%</td>
</tr>
</tbody>
</table>

### Interventions

- **Group 1**: Immediate CT
- **Group 2**: Admission for observation

### Outcome measures

<table>
<thead>
<tr>
<th>Effect size</th>
<th>Comments</th>
</tr>
</thead>
</table>
| Group 1: 314 (IQR:240-333)  
Group 2: 460 (IQR:369-467) | p value: <0.001 |
| Group 1: 174  
Group 2: 161 | p value: Not signif |
| Group 1: 488  
Group 2: 621 | p value: <0.001 |
| Group 1: 0.98  
Group 2: 0.08 |
| Group 1: 0.14  
Group 2: 1.06 |

### Effect size

- **Group 1**: 314 (IQR:240-333)  
- **Group 2**: 460 (IQR:369-467)

### Comments

- **Funding**: County Council of Stockholm
- **Limitations**: See clinical review of af Geijerstam 2006
- **Additional outcomes**: Follow-up resource use: primary care visits, emergency ward visits, sickness absence. Indirect costs. For Deaths and Glasgow Outcome Scale see clinical review

### Notes
- Costs have been converted from Euros (converting factor: 1€=£0.68).
<table>
<thead>
<tr>
<th>Study details</th>
<th>Patients</th>
<th>Interventions</th>
<th>Outcome measures</th>
<th>Effect size</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shravat 2006 (^{288}) UK</td>
<td>Patients with trauma to the head attending the ED</td>
<td><strong>Group 1</strong>: before implementation of NICE guideline. <strong>Group 2</strong>: after implementation of NICE guideline.</td>
<td>Mean number of skull x-ray scans</td>
<td>Group 1: 0.113 Group 2: 0.004 (p&lt;0.03)</td>
<td>Funding: NR</td>
</tr>
<tr>
<td>Economic analysis: Cost-analysis</td>
<td></td>
<td></td>
<td>Mean number of CT scans</td>
<td>Group 1: 0.02 Group 2: 0.07 (p&lt;0.01)</td>
<td>Additional outcomes: Sensitivity and Specificity of NICE CT scan rule. Cost impact for England &amp; Wales</td>
</tr>
<tr>
<td>Study design</td>
<td>Retrospective cohort study</td>
<td></td>
<td>Mean number of admissions</td>
<td>Group 1: 0.08 Group 2: 0.09 (p=0.42)</td>
<td></td>
</tr>
<tr>
<td>Duration of follow-up:</td>
<td>NR</td>
<td></td>
<td>Mean cost</td>
<td>Group 1: £263 Group 2: £340 (p=0.03)</td>
<td></td>
</tr>
<tr>
<td>Discount rates:</td>
<td>NA</td>
<td></td>
<td>Sensitivity analysis</td>
<td>NR</td>
<td></td>
</tr>
</tbody>
</table>

**Mean number of skull x-ray scans**
- **Group 1**: 0.113
- **Group 2**: 0.004
  - \(p<0.03\)

**Mean number of CT scans**
- **Group 1**: 0.02
- **Group 2**: 0.07
  - \(p<0.01\)

**Mean number of admissions**
- **Group 1**: 0.08
- **Group 2**: 0.09
  - \(p=0.42\)

**Mean cost**
- **Group 1**: £263
- **Group 2**: £340
  - \(p=0.03\)
### Study details

<p>| | |</p>
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<tr>
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<tbody>
<tr>
<td><strong>Stein 2006</strong></td>
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<tr>
<td><strong>USA</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Economic analysis:</strong> Cost-utility</td>
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<tr>
<td><strong>Study design</strong></td>
<td>Decision analysis</td>
</tr>
<tr>
<td><strong>Time horizon:</strong></td>
<td>Lifetime</td>
</tr>
<tr>
<td><strong>Discount rates:</strong></td>
<td>Costs: 3% annual rate</td>
</tr>
<tr>
<td><strong>Effects:</strong></td>
<td>3% annual rate</td>
</tr>
</tbody>
</table>

### Patients

<table>
<thead>
<tr>
<th>Group</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Selective CT and discharge for others based on the Canadian CT head rule: GCS of 14 and GCS of 15 with a high risk factor (suspected open, basilar or depressed skull fracture, multiple episodes of vomiting, age &gt;65)</td>
</tr>
<tr>
<td>2</td>
<td>CT scan for all and ED discharge if normal</td>
</tr>
<tr>
<td>3</td>
<td>Skull radiography for all patients and discharge if no fracture</td>
</tr>
<tr>
<td>4</td>
<td>Prolonged (6 hours) ED observation and discharge if stable</td>
</tr>
<tr>
<td>5</td>
<td>No treatment</td>
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<tr>
<td>6</td>
<td>24-hour hospital admission (admit All)</td>
</tr>
</tbody>
</table>

### Interventions

<table>
<thead>
<tr>
<th>Group</th>
<th>群</th>
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<tbody>
<tr>
<td>1</td>
<td>Selective CT and discharge for others based on the Canadian CT head rule: GCS of 14 and GCS of 15 with a high risk factor (suspected open, basilar or depressed skull fracture, multiple episodes of vomiting, age &gt;65)</td>
<td></td>
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<tr>
<td>2</td>
<td>CT scan for all and ED discharge if normal</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Skull radiography for all patients and discharge if no fracture</td>
<td></td>
</tr>
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<td>Prolonged (6 hours) ED observation and discharge if stable</td>
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<td>6</td>
<td>24-hour hospital admission (admit All)</td>
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</tbody>
</table>

### Outcome measures

<table>
<thead>
<tr>
<th>Group</th>
<th>Mean LE (years)</th>
<th>Effect size</th>
<th>Comments</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>58.6</td>
<td>Group 2: 58.6</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>58.5, Group 4: 58.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>58.4, Group 6: 58.4</td>
<td>p value: NR</td>
<td></td>
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<td>4</td>
<td></td>
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<td>5</td>
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### Effect size

<table>
<thead>
<tr>
<th>Group</th>
<th>Mean QALYs</th>
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<tr>
<td>1</td>
<td>28.85</td>
<td>Group 2: 28.85</td>
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<tr>
<td>2</td>
<td>28.79, Group 4: 28.79</td>
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<td>3</td>
<td>28.76, Group 6: 28.76</td>
<td>p value: NR</td>
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<td>6</td>
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</tbody>
</table>

### False positive

<table>
<thead>
<tr>
<th>Group</th>
<th>False positive (surgical + non-surgical lesion)*</th>
<th>Effect size</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.504</td>
<td>Group 2: 0</td>
<td>p value: NR</td>
</tr>
<tr>
<td>2</td>
<td>0</td>
<td></td>
<td></td>
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<tr>
<td>3</td>
<td>0.05, Group 4: 0.25</td>
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<tr>
<td>4</td>
<td>0.879, Group 6: 0</td>
<td>p value: NR</td>
<td></td>
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<td>5</td>
<td></td>
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</tbody>
</table>

### False negative

<table>
<thead>
<tr>
<th>Group</th>
<th>False negative (surgical + non-surgical lesion)*</th>
<th>Effect size</th>
<th>Comments</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>0.017+0.02, Group 2: 0.017+0</td>
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<tr>
<td>2</td>
<td>0.40+0.61, Group 4: 0.371+0.25</td>
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<tr>
<td>3</td>
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<tr>
<td>4</td>
<td>0.879, Group 6: 0</td>
<td>p value: NR</td>
<td></td>
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<tr>
<td>5</td>
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</tbody>
</table>

### Mean cost per patient

<table>
<thead>
<tr>
<th>Group</th>
<th>Mean cost per patient 2005 US$, direct costs based on Medicare and Medicaid reimbursements: screening + treatment**</th>
<th>Effect size</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>$1,668 (£1046)</td>
<td></td>
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<tr>
<td>2</td>
<td>$1,888 (£1184)</td>
<td></td>
<td></td>
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<tr>
<td>3</td>
<td>$2,201 (£1380)</td>
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<tr>
<td>4</td>
<td>$2,862 (£1795)</td>
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<tr>
<td>5</td>
<td>$3,144 (£1971)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>$4,924 (£3087)</td>
<td>p value: NR</td>
<td></td>
</tr>
</tbody>
</table>

### Cost-effectiveness (cost/QALY)

<table>
<thead>
<tr>
<th>Group</th>
<th>Cost-effectiveness (cost/QALY)</th>
<th>Effect size</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Selective CT is dominant.</td>
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<td>2</td>
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<td>6</td>
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</tbody>
</table>

### Sensitivity analysis

a) One-way sensitivity analysis (within 95% CI)  
   b) Monte Carlo simulation  
   c) ages up to 80

Only a summary was reported. QALYs and costs sensitive to the probability of good outcome of surgery for haematomas. If sensitivity of Selective CT is decreased by 1%, CT All becomes more effective but with an ICER of $1.4m/QALY is not cost-effective. As age increases the results of

### Notes:

* Surgical lesions are intracranial haematomas requiring surgery, non-surgical lesions are subarachnoid haemorrhage, cerebral oedema, or contusions  
** Higher Medicare rates for complicated haematomas and concussions were applied when lesions were initially missed.
<table>
<thead>
<tr>
<th>Study details</th>
<th>Patients</th>
<th>Interventions</th>
<th>Outcome measures</th>
<th>Effect size</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>the selective CT and CT All strategies converge.</td>
<td></td>
</tr>
</tbody>
</table>
### Data extraction for papers describing rules for head CT selection: adults

<table>
<thead>
<tr>
<th>Names and evidence level</th>
<th>Rule description</th>
<th>Participants</th>
<th>Outcomes</th>
<th>Specificity</th>
<th>Sensitivity</th>
<th>CT ordering rate</th>
<th>Prevalence</th>
<th>Derived using primary data</th>
<th>Derived using prospect. data</th>
<th>Validated using primary data</th>
<th>Validated using prospect. data</th>
<th>Multi-variate modelling</th>
<th>Follow-up</th>
<th>Notes</th>
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</table>

284
<table>
<thead>
<tr>
<th>Names and evidence level</th>
<th>Rule description</th>
<th>Participants</th>
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<th>Sensitivity</th>
<th>CT ordering rate</th>
<th>Prevalence Derived using primary data</th>
<th>Derived using prospect. data</th>
<th>Validated using primary data</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Stiell et al (2001) 304</td>
<td>Canadian CT Head Rule (5 and 7 variables)</td>
<td>N = 3121 GCS 13-15, with loss of consciousness/ post-traumatic amnesia and history of trauma, and no signs of penetrating trauma, or seizure Age &gt;16 yrs Patients attending 10 Canadian emergency departments Consecutive</td>
<td>Clinically important brain injury (CIBI) for seven variable rule. Need for neurosurgical intervention for five variable rule.</td>
<td>69.6% (48-51%) for the 7 variable rule. 68.7% (67-70%) for the 5 variable rule.</td>
<td>98.4% (96-99%) for the 7 variable rule. 100% (92-100%) for the 5 variable rule.</td>
<td>54.3% for the 7 variable rule 32.2% for the five variable rule</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes (in a sub-sample)</td>
<td>Yes</td>
<td>67% had CT scan 21% clinical follow-up by telephone at 14 days. 567 patients not followed up (12%)</td>
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<td>Assumption is that ‘trivial injuries’ are discharged (no loss of consciousness, amnesia, disorientation); all GCS&lt;13 would receive immediate CT, even though rules not developed for this group; clinical follow-up is not as sensitive as CT (estimated that up to 13% of CIBI could have been missed). These rules are in the process of being validated. The large sample size gives greater confidence in the preliminary validation carried out on the derivation sample. 1358 eligible patients were not enrolled (logistics) Note: this rule does not include headache as a variable, which some UK clinicians may find unacceptable. This was due to the fact that their data collection only recorded presence or absence of headache and did not divide this category into mild, moderate and severe headache, therefore significance was not found.</td>
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</tr>
<tr>
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<tr>
<td>Duus et al (1994)(^8)</td>
<td>Admit the following for observation: Collision or aggression, impaired consciousness, focal neurological signs, skull fracture suspected. History of convulsions, amnesia before impact &gt; 15 mins, loss of consciousness more than 15 mins, &lt;3 yrs old, with headaches and vomiting. Nobody at home for observation. CT scan performed when a decline in consciousness or neurological signs is observed.</td>
<td>N=2204 attenders at A&amp;E able to talk and walk even if unclear speech. No information on GCS.</td>
<td>Death, Need for neuro intervention.</td>
<td>98% (all those that did not need observation received it)</td>
<td>0.2% needed neuro intervention</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes in 1993 paper</td>
<td>100% Used routine data sources (ICD codes) to detect late ICH. Skull radiographs not used at all.</td>
<td>Participants seem to have very low prevalence of ICH.</td>
<td></td>
</tr>
<tr>
<td>Level 1 evidence</td>
<td>Well constructed derivation and validation of rule</td>
<td></td>
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<tr>
<td>Miller et al (1997)(^1)</td>
<td>This paper tests rule for CT scanning in children and adults: GCS 15, with loss of consciousness and/or post-traumatic amnesia and one or more of: Severe headache, nausea, vomiting, clinically depressed skull fracture.</td>
<td>N=2143 GCS 15 and history of loss of consciousness. Children and adults. Presenting to single USA trauma centre.</td>
<td>Positive CT scan.</td>
<td>65% spec for excluding neurosurgery. 62% spec in excluding any CT abnormal.</td>
<td>100% for neurosurgery, but only 65% (90/138) for any CT abnormal.</td>
<td>Reduces CT ordering by 61%</td>
<td>6.4% abnormal CT</td>
<td>Yes = 1996 paper</td>
<td>Yes = 1996 paper</td>
<td>Yes</td>
<td>Not in this paper</td>
<td>No. All patients monitored for 3 hours after injury and then discharged.</td>
<td>Paper validates a 4-point decision rule. Unfortunately their definition of positive CT was very wide so the rule's sensitivity to any positive CT is low. Also no follow up for those discharged, and patients without loss of consciousness not included.</td>
</tr>
<tr>
<td>Names and evidence level</td>
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<td>Sensitivity</td>
<td>CT ordering rate</td>
<td>Prevalence derived using primary data</td>
<td>Derived using prospect. data</td>
<td>Validated using primary data</td>
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<tr>
<td>Haydel et al (2000) (FEB 2007)</td>
<td>CT for one of the following: Short-term memory deficit, Intoxication, Trauma, Age &gt; 60 yrs, Seizure, Headache, Vomiting Discharge if none of these present</td>
<td>N=520 in derivation phase, N=909 in validation phase GCS = 15 Age 3 years and over. Attendees at a trauma centre in the USA</td>
<td>Abnormal CT-scan findings</td>
<td>25% (22-28%)</td>
<td>100% (95-100%)</td>
<td>76.7%</td>
<td>6.3%</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>100% - CT diagnosis</td>
</tr>
<tr>
<td>Richless et al (1993) (FEB 2007)</td>
<td>This study validated the Masters criteria for use of CT in the over 2 age group Low-risk: observation Moderate-risk: extended observation, consider CT, skull series may be helpful High-risk: Neurosurgical consult, emergency CT</td>
<td>N=967 GCS 15 Adults and Children over 2 years Single USA community hospital Consecutive patients</td>
<td>Abnormal CT Not clear</td>
<td>99.6%</td>
<td>14 CT scans were performed (1.4%) and 23 skull X-rays (2.4%) Only 1 CT abnormality was found Masters criteria = yes Masters criteria = yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>93%</td>
<td>They do not specify the severity of injury of their population i.e. any GCS&lt;15. They only had one negative outcome, but Masters criteria was used safely for these thousand patients. Serious questions about the severity of the population recruited</td>
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<tr>
<td>Livingston et al (2000)</td>
<td>Rule was standard physical and neurologic exam for all patients, followed by 100% CT-scan. In this study all patients were admitted for observation, but this was for the purposes of ensuring 100% follow-up. Objective was to establish safety of early discharge.</td>
<td>N=2152 GCS 14-15 and minor head injury with loss of consciousness/ post-traumatic amnesia Adults over 15 years old.</td>
<td>Need for neurosurgery Intracranial injury</td>
<td>0% (all those who did not need a test got a test)</td>
<td>Negative predictive value was 99.9-100% for need for a craniotomy</td>
<td>100%</td>
<td>13% positive CT scans</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>This is an excellent paper that demonstrates the NPV of CT-scan. A large number of in-patient bed days could possibly be saved.</td>
</tr>
<tr>
<td>Level 1 evidence</td>
<td>Well constructed validation of rule</td>
<td>Livingston, Loder &amp; Hunt (1991)179 and Livingston, Loder, Koizel &amp; Hunt (1991)180 are papers with much smaller sample sizes (N=111 and 138) that reach the same conclusions</td>
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<td>Livingston, Loder &amp; Hunt</td>
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<td>(1991)179 and Livingston,</td>
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<tr>
<td>Stein and Ross (1992)(^{17})</td>
<td>CT-scan for all patients with any loss of consciousness or amnesia</td>
<td>N=1538</td>
<td>Intracranial lesions on CT</td>
<td>0%</td>
<td>100%</td>
<td>100%</td>
<td>13%</td>
<td>No (routine practice)</td>
<td>No (routine practice)</td>
<td>Yes</td>
<td>No (review of notes)</td>
<td>No</td>
<td>100% CT-diagnosis</td>
</tr>
</tbody>
</table>

An earlier paper by Stein and Ross\(^{12}\) appears in 1990 – seems to be the same patients
Level 1 evidence
Well constructed validation of rule
<table>
<thead>
<tr>
<th>Names and evidence level</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Stein et al (1995)⁴⁶</td>
<td>Paediatric Retrospective Cohort study.</td>
<td>N = 2,533 fully reviewed from a population of 12,809 from whom some data was obtained</td>
<td>Intracranial lesion, Neurosurgery</td>
<td>81% sensitivity of rule</td>
<td>High sensitivity if you use 12559 as a denominator. To use this denominator we must be satisfied that the follow up of the 10,276 minimal head injury patients was adequate (see notes)</td>
<td>100%</td>
<td>Proposed rule would lead to 7% CT ordering rate.</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
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<td>Level 2 evidence</td>
<td>DERIVED RULE: Minimal closed head injury (CHI):</td>
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<td>2.6% of mild head injuries needed neurosurgery. (1.9% of GCS 15)</td>
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<td>Well constructed derivation of rule</td>
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<td></td>
<td>0.01% neurosurgery for Minimal head injury (1 case in 11,907)</td>
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<tr>
<td>Stein et al (1996)⁴⁷</td>
<td>Discharge with no CT if none of the following risk factors: -Extracranial injuries -Age&lt;2 with repeated vomiting -No reliable transportation or reliable observation at Home -Anticoagulations or medical condition increasing risk -Palpable depressed skull fracture -1 or more seizures Suspected child abuse Persistent headache, nausea, vomiting etc.</td>
<td>Children under 19 years old</td>
<td>Glasgow Outcome Score at 6 months</td>
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<tr>
<td>This is a review and data extraction of past papers</td>
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<td>N = 2,533 fully reviewed from a population of 12,809 from whom some data was obtained</td>
<td>All GCS scores</td>
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<td>Discharge with no CT if none of the following risk factors: -Extracranial injuries -Age&lt;2 with repeated vomiting -No reliable transportation or reliable observation at Home -Anticoagulations or medical condition increasing risk -Palpable depressed skull fracture -1 or more seizures Suspected child abuse Persistent headache, nausea, vomiting etc.</td>
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<td>If risk factor present admit and CT if symptoms persist.</td>
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<td>Mild CHI: GCS14 or GCS15 and LOC &lt;5 mins, event amnesia</td>
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<td>- CT scan all patients. If neg and none of above high risk factors discharge.</td>
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<td>Moderate CHI: loss of consciousness &gt; 5mins, GCS 9-13 or focal neurology.</td>
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<table>
<thead>
<tr>
<th>Names and evidence level</th>
<th>Rule description</th>
<th>Participants</th>
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<th>Specificity</th>
<th>Sensitivity</th>
<th>CT ordering rate</th>
<th>Prevalence derived using primary data</th>
<th>Derived using prospect. data</th>
<th>Validated using primary data</th>
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<tr>
<td>Stein and Spettel (1993)²⁹</td>
<td>Concludes that neurological assessment either by GCS or by Reaction Level Scale (RLS85) is not adequate to determine risk of ICH. Recommends CT for all patients with loss of consciousness / post-traumatic amnesia.</td>
<td>N=685 GCS 13-15. Age range not stated? Adults only. Patients who had CT at single trauma centre. USA. Consecutive patients.</td>
<td>Intracranial abnormality on CT scan</td>
<td>No rule evaluated</td>
<td>No rule evaluated</td>
<td>100%</td>
<td>18% ICH</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Retrospective study with 100% CT rate reporting the inability of neurological assessment to predict ICH. No other symptoms or signs were extracted from case records. Study is of limited use in constructing a comprehensive rule for CT scanning.</td>
</tr>
<tr>
<td>Hsiang et al (1997)³⁰</td>
<td>Derived rule: High-risk mild head injury is GCS 13-14 and GCS 15 with acute radiographic abnormalities. (Including CT findings) Mild head injury is the remaining GCS 15 patients.</td>
<td>N=1360 GCS 13-15 admitted to hospital. Patients over 11 years old. Single Hong Kong Hospital Consecutive</td>
<td>Abnormal CT Skull fracture 6 month GOS</td>
<td>72% specificity for neurosurgery after radiographic imaging that includes skull X-ray and/or CT scan</td>
<td>100% sensitivity for neurosurgery</td>
<td>62%</td>
<td>6% of patients had bad outcome</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Unfortunately this rule is to predict outcome. It requires all patients to undergo CT scanning before categorising them.</td>
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<td>Jeret et al (1993)¹⁵</td>
<td>This is an exploratory cohort study that looks at a number of prognostic variables. The paper reports that 4 variables predict abnormal CT: older than 60 years, white race, basal skull fracture signs and motor vehicle or assault cause. No item or combinations could classify 95% of patients correctly. Authors conclude that CT may be indicated for all types of patients.</td>
<td>N=712 GCS 15, with loss of consciousness or amnesia. Adults 18 and over 2 USA hospitals Consecutive</td>
<td>Neurosurgery, abnormal CT Abnormal neurology assessed by a neurologist for all patients</td>
<td>No rule evaluated</td>
<td>No rule evaluated</td>
<td>100%</td>
<td>9.4% abnormal CT rate 0.3% had neurosurgery</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>100%</td>
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<tr>
<td>Nagy et al (1999)²⁰</td>
<td>Rule: All GCS 15 patients presenting with loss of consciousness/post-traumatic amnesia should undergo CT scanning. If this is normal then they are safe to be discharged</td>
<td>N=1,170 GCS 15 with loss of consciousness/post-traumatic amnesia Adults USA level 1 trauma centre Consecutive</td>
<td>Intracranial abnormality on CT</td>
<td>100% of discharge excluding ICH after negative CT</td>
<td>No positive outcomes for admission and deterioration</td>
<td>100%</td>
<td>3.3% (39 patients) abnormal CT 0.4% (4 patients) had neurosurgery</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>All patients with a normal CT were then observed for 24 hours. No other follow up after discharge</td>
</tr>
<tr>
<td>Names and evidence level</td>
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<td>Sensitivity</td>
<td>CT ordering rate</td>
<td>Prevalence Derived using primary data</td>
<td>Derived using prospect data</td>
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<td>Gomez et al (1996)&lt;sup&gt;19&lt;/sup&gt;</td>
<td>Level 3 evidence</td>
<td>Participants: N=2484 GCS 13-15 Age over 15 Attendance at single Spanish hospital Consecutive</td>
<td>Outcomes: CT abnormality Neurosurgery or death</td>
<td>Specificity: No rule evaluated</td>
<td>Sensitivity: No rule evaluated</td>
<td>CT ordering rate: 7.5%</td>
<td>Prevalence: 0.8% of patients had neurologic deterioration 7 patients had surgery (0.2%) 11 patients died (0.3%)</td>
<td>Derived using primary data: Yes</td>
<td>Derived using prospect data: No</td>
<td>Validated using primary data: No</td>
<td>Validated using prospect data: No</td>
<td>Multi-variate modelling: Yes</td>
<td>Follow-up: No</td>
</tr>
<tr>
<td>Dunham et al (1996)&lt;sup&gt;83&lt;/sup&gt;</td>
<td>Level 3 evidence</td>
<td>Participants: N=2587 GCS13-15 Age over 14 Patients attending single USA trauma centre Consecutive</td>
<td>Outcomes: ICH on CT</td>
<td>Specificity: No rule evaluated</td>
<td>Sensitivity: No rule evaluated</td>
<td>CT ordering rate: 91.3%</td>
<td>Prevalence: 7.2%</td>
<td>Derived using primary data: Yes</td>
<td>Derived using prospect data: Yes</td>
<td>Validated using primary data: No</td>
<td>Validated using prospect data: No</td>
<td>Multi-variate modelling: No</td>
<td>Follow-up: No</td>
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<td>Harad et al (1992)(^1)(^8) Level 3 evidence Non-consecutive study.</td>
<td>They recommend CT for all patients with minor head injury.</td>
<td>N=1875 patients that attended only 497 who had CT were included in the study (Criteria for CT was loss of consciousness, GCS&gt;13 focal deficits, skull fracture, pupils) All GCS 13-15 Age of patients not described – probably adults only Patients scanned at a level 1 USA trauma centre. Non-consecutive</td>
<td>Outcome: abnormal CT neurosurgery</td>
<td>No rule evaluated</td>
<td>No rule evaluated</td>
<td>100% Focus is only on those with CT</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No follow up of non-CT patients Study of limited relevance.</td>
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<tr>
<td>Names and evidence level</td>
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<tr>
<td>Servadei et al (1993)279</td>
<td>Level 3 evidence</td>
<td>Servadei et al (1995)276 reports similar results – same design problems</td>
<td>Servadei, Vergoni et al (1995)280 reports a case series</td>
<td>Servadei et al (1989 – reports a case series)277</td>
<td>Level 3 evidence as unclear reference standards</td>
<td>N=423 adults and 83 children in protocol free period</td>
<td>N=859 adults and 191 children in period with protocol</td>
<td>Adults included if GCS 13-15. And brief loss of consciousness, or skull fracture</td>
<td>Children included if symptomatic but not if in stupor, coma or focal neurology. Asymptomatic children not included</td>
<td>Attendance at single Italian Hospital</td>
<td>Probably non consecutive</td>
<td>Not possible to produce for this design</td>
<td>Positive CT-scan. Mortality (followed up through routine sources)</td>
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</table>

This is a review on behalf of the WHO Neurotrauma Collaborating Center. Their recommendations are as follows:

Low-risk mild injury patients are those with a Glasgow Coma Score (GCS) of 15 and without a history of loss of consciousness, amnesia, vomiting, or diffuse headache. The risk of intracranial hematoma requiring surgical evacuation is definitively less than 0.1:100. These patients can be sent home with written recommendations.

Medium risk mild injury patients have a GCS of 15 and one or more of the following symptoms: loss of consciousness, amnesia, vomiting, or diffuse headache. The risk of intracranial hematoma requiring surgical evacuation is in the range of 1-3:100. Where there is one computed tomography (CT) scanner available in an area for 100,000 people or less, a CT scan should be obtained for such patients. If CT scanning is not so readily available, adults should have a skull x-ray and, if this shows a fracture, should be moved to the 'high-risk' category and undergo CT scanning.

High-risk mild head injury patients are those with an admission GCS of 14 or 15, with a skull fracture and/or neurological deficits. The risk of intracranial hematoma requiring surgical evacuation is in the range 6-10:100. If a CT scan is available for 500,000 people or less, this examination must be obtained. Patients with one of the following risk factors - coagulopathy, drug or alcohol consumption, previous neurosurgical procedures, pretrauma epilepsy, or age over 60 years - are included in the high-risk group independent of the clinical presentation.


Exploratory Cohort study but patients were not a consecutive cohort of head injured patients.

9 variables yield high rate of abnormal CT: alcohol, amnesia, loss of consciousness, pupils, Babinski, focal lesion, GCS<15, cranial nerve lesion, basilar fracture.

N= 264

All GCS grades (51 patients under GCS 15, 17 +ve CT)

Patients, all ages, 2 USA hospitals.

Not consecutive attenders only those undergoing CT

Abnormal CT scan – as decided by 2 radiologists, if either feel that there is an abnormality.

No rule evaluated

No rule evaluated

100%

32 positive CT, 12%

Yes

Yes

No

No

Yes

No

Identifies 9 high yield criteria for CT scan. Does not provide data on what the sensitivity and specificity of this rule would be. 10% of patients had none of their high risk criteria.
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<tr>
<td>Nelson et al (1992)²¹²²</td>
<td>This paper looks at Head CT, Thoracic CT and Abdominal CT so Head CT is a sub analysis. Rule is that GCS 15 pts can have their CT safely delayed (but must be done) Does not provide data for the non-CT patients.</td>
<td>N= 374</td>
<td>Abnormal CT</td>
<td>All GCS scores</td>
<td>Adults only</td>
<td>Level 1 USA trauma centre</td>
<td>Consecutive blunt trauma patients of all causes</td>
<td>No rule evaluated</td>
<td>No rule evaluated</td>
<td>71%</td>
<td>Not possible to calculate</td>
<td>Yes</td>
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<tr>
<td>Murshid et al (1994)²³²³</td>
<td>Conclude that skull X-ray is unnecessary and after careful examination CT should be performed. Criteria for CT not given.</td>
<td>N= 566</td>
<td>Abnormal CT, skull fracture on skull X-ray, neurosurgery and death</td>
<td>All ages</td>
<td>Single Saudi Arabian Hospital</td>
<td>Selected cases as its only those who were admitted and admission criteria are unclear.</td>
<td>No rule evaluated</td>
<td>No rule evaluated</td>
<td>Not possible to calculate</td>
<td>Not possible to calculate</td>
<td>Yes</td>
<td>No</td>
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<td>Holmes et al (1997)</td>
<td>Their conclusion is the Miller criteria, which aims to stratify the GCS 14 group into high and low risk is unsafe. The Miller criteria imply that GCS 14 patients with no soft-tissue injury and neurologic improvement can be released. They imply that all GCS 14 should be scanned.</td>
<td>N=264 GCS 14 only Adults Level 1 USA trauma centre Non-consecutive patients receiving CT Consecutive patients – only CT patients were studied</td>
<td>No rule evaluated</td>
<td>No rule evaluated</td>
<td>100% CT rate in this study</td>
<td>13.2% abnormal CT</td>
<td>1.5% required neurosurgery</td>
<td>Yes (Miller)</td>
<td>Yes (Miller)</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
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<td>Borczuk et al (1995)&lt;sup&gt;35&lt;/sup&gt;</td>
<td>Identified high risk factors to be: Cranial soft tissue injury</td>
<td>1448</td>
<td>GCS 13-15</td>
<td>CT scan Neurosurgical intervention</td>
<td>96.25% for rule as applied to derivation set</td>
<td>91.6% for rule as applied to derivation set</td>
<td>100%</td>
<td>8.2% abnormal CT, 0.8% neurosurgery</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
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<td></td>
<td>Focal neurology</td>
<td>Level 1 USA trauma centre Consecutive patients who had undergone CT</td>
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<td></td>
<td>Basal skull fracture signs Age &gt;60</td>
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<td>Moran et al (1994)&lt;sup&gt;20&lt;/sup&gt;</td>
<td>Immediate CT-scan for all GCS13-15 with loss of consciousness or suspected skull fracture.</td>
<td>200</td>
<td>GCS 13-15</td>
<td>Positive CT-scan</td>
<td>No rule evaluated</td>
<td>No rule evaluated</td>
<td>46%</td>
<td>4%</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
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<td>Adults and children over 6 years</td>
<td>Single USA hospital Non-consecutive Only study of patients who were transferred to them by air-ambulance</td>
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<td>Arienta et al (1997)(^1)</td>
<td>4 different groups: 1. GCS=15, no loss of consciousness, currently alert and no neurologic problems, absent or minimal subgaleal swelling (this seems like a definition of ‘trivial’). Patient is released into care of a family member with written instructions. 2. GCS=15, transitory loss of consciousness, patient awake, oriented and without neurologic deficits. Amnesia, one episode of vomiting, significant subgaleal swelling. Neurologic evaluation and CT-scan. If not CT available, skull x-ray and observation for 6 or more hours if x-ray negative. CT-scan if positive skull x-ray. 3. GCS 9-15, impaired consciousness, uncooperative, neurologic deficits, otorrhagia/otorrhea, rhinorrhea, signs of basal fracture, seizures, penetrating or perforating wounds, patients in anticoagulant therapy, affected by coagulopathy, previous intracranial operations, epileptic or alcoholic patients. CT-scan and neurologic evaluation. 4. GCS 3-8, resuscitate and CT-scan.</td>
<td>N=10,000 Intracranial lesions</td>
<td>90% specificity in their derivation set, not tested in a validation cohort</td>
<td>100% sensitivity in their derivation set, not tested in a validation cohort</td>
<td></td>
<td></td>
<td>59.2%</td>
<td>1.5%</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
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<td>Shackford et al (1992)²⁸³</td>
<td>No rule stated – the paper is more of an audit of current practice, although they do estimate the sensitivity and specificity of a CT alone strategy. They recommend 100% CT.</td>
<td>2766 N=2766 GCS 13-15 Adults and children 7 USA trauma centres</td>
<td>Relevant positive CT (excluding fracture) Craniotomy</td>
<td>Not possible to produce for this design</td>
<td>Not possible to produce for this design</td>
<td>78.3%</td>
<td>17% relevant positive CT (468/2766) 9% intervention rate (256/2766)</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
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<td>Mohanty et al (1991)²⁰¹</td>
<td>No rule stated – this is a retrospective study of CT only patients. They state that “low-risk” patients require observation alone. Low-risk seems to be: history of head trauma, 18 years or older, GCS 14-15, no decline in neurologic status, absence of any focal, sensory or motor neurologic deficit, absence of any obvious signs of basal skull fracture.</td>
<td>N=348</td>
<td>Abnormal CT</td>
<td>No rule evaluated</td>
<td>No rule evaluated</td>
<td>Not possible to calculate</td>
<td>3.4% = abnormal CT</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
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</tr>
<tr>
<td>Rosenorn et al (1991)²⁵⁵</td>
<td>Audit of practice – describes the utility of skull x-ray</td>
<td>N=1876</td>
<td>ICH development</td>
<td>No rule evaluated</td>
<td>No rule evaluated</td>
<td>0.5%</td>
<td>Not applicable</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
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<td>Viola et al (2000)³²</td>
<td>Group 0: GCS 15, no loss of consciousness/amnesia/headache/vomiting, no other risk factors should be discharged</td>
<td>N=4536</td>
<td>Abnormal CT scan</td>
<td>86% (3864/4492)</td>
<td>100%</td>
<td>19%</td>
<td>1.9%</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>4078 patients were clinically observed for 6 to 12 hours and then discharged, without any further follow up.</td>
<td>Admitted patients were reviewed within 6 months</td>
</tr>
<tr>
<td>Tomei et al (1996)³³</td>
<td>Group 1: GCS 15 one or more from loss of consciousness/amnesia/headache/vomiting, no other risk factors need radiology and clinical observation</td>
<td>Group 1: GCS 15 one or more from loss of consciousness/amnesia/headache/vomiting and with or without other risk factors need radiology and clinical observation</td>
<td>GCS 14-15 Adults and over 12 years old Single Italian Hospital Consecutive</td>
<td>Abnormal CT scan</td>
<td>86% (3864/4492)</td>
<td>100%</td>
<td>19%</td>
<td>1.9%</td>
<td>No</td>
<td>Yes</td>
<td>4078 patients were clinically observed for 6 to 12 hours and then discharged, without any further follow up.</td>
<td>Admitted patients were reviewed within 6 months</td>
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<td>Derived using prospect. data</td>
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<td>Uchino et al (2001)³⁵⁷</td>
<td>No rule evaluated. This paper examines the utility of GCS in classifying patients. All patients had CT or MRI.</td>
<td>N=90 GCS 13-15, Adults aged &gt;13 years Single Japanese Hospital Consecutive</td>
<td>Abnormal CT</td>
<td>No rule evaluated</td>
<td>No rule evaluated</td>
<td>100% 14%</td>
<td>Yes Yes No No No No</td>
<td>This is a small study that attempts to demonstrate that GCS alone cannot rule out ICH. They also conclude that MRI should be performed on patients with GCS 14, as parenchymal lesions cannot be imaged with CT. Study is underpowered for these conclusions.</td>
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<tr>
<td>Gutman et al (1992)¹³⁹</td>
<td>This is an exploratory cohort study, which looks at a number of prognostic variables. They conclude that age, GCS, injury due to a fall, injury due to motor-vehicle occupant, pupil inequality are best ICH predictors.</td>
<td>N=1039 patients admitted with head injury All GCS scores Adults &gt;15 years old Single Canadian regional trauma centre Non-consecutive as 2/3rds of patients had been referred by other hospitals Therefore preselcted</td>
<td>Operable ICH</td>
<td>No rule evaluated</td>
<td>No rule evaluated</td>
<td>100% 27%</td>
<td>Yes Yes No No Yes No</td>
<td>A prognostic study that indicates age, GCS, injury due to a fall, injury due to motor-vehicle occupant, pupillary inequality are the best ICH predictors. Results influenced by the more serious patient profile. Results presentation is problematic. 2/3rds of patients in their study had been referred from other hospitals No follow up described after discharge</td>
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<tr>
<td>Taheri et al (1993)</td>
<td>Exploratory cohort study designed to identify those patients with minor head injuries that can be safely discharged from A&amp;E. They state that: GCS 15, no deficit except amnesia, no signs of intoxication, no evidence of basal skull fracture on clinical exam, no linear fracture on skull x-ray.</td>
<td>N=310 fully assessed out of 407 who were reviewed GCS 15 Adults over 14 years old Single USA trauma centre Consecutive</td>
<td>ICH</td>
<td>No rule evaluated</td>
<td>No rule evaluated</td>
<td>55%</td>
<td>23%</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
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<tr>
<td>Vilke et al (2000)</td>
<td>Exploratory Cohort study 3 Patients had ICH, 2 Had abnormal neurology but one Had no neurology. Conclusion is that full neurological examination is not adequate to exclude ICH.</td>
<td>N=58. GCS 15 with loss of consciousness post-traumatic amnesia Sober adults Single Canadian hospital Non-consecutive</td>
<td>Acute intracranial injury on CT</td>
<td>61%</td>
<td>66% sensitivity of neurological exam in predicting ICH</td>
<td>100%</td>
<td>5% ICH</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
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<tr>
<td>Porchet et al (1998)</td>
<td>This is a review, no original data</td>
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### Names and evidence level

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<tr>
<td>Retrospective cohort study to validate the Masters criteria in a Dutch setting. Rule: The Master's criteria are safe in the low risk category. In the high and moderate category CT scanning should be used rather than skull X-ray.</td>
<td>N=1218 All GCS groups Adults 1 University hospital in Holland Consecutive</td>
<td>Intracranial haematoma</td>
<td>57% of Low vs (moderate or High risk) in the rule</td>
<td>100%</td>
<td>It is unclear as to what rate of CT scanning the proposed rule produces</td>
<td>1.6% intracranial haematoma</td>
<td>Yes (the Masters criteria)</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No patients followed up after discharge. The patients in this study did not actually undergo management by the Masters criteria. Thus only 70% of patients in the moderate group received a skull X-ray. Also there was no follow up after discharge. In the moderate group they found 1 patient with an ICH but without skull fracture. They thus state that CT is superior to skull X-ray but do not then recommend a CT for all in the moderate category (which would give a CT ordering rate of 33%).</td>
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<td>Pasman et al (1992)</td>
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### HEAD INJURY UPDATE FULL GUIDELINE: DRAFT FOR CONSULTATION (FEB 2007)

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<tbody>
<tr>
<td>Hung et al (1996)&lt;sup&gt;141&lt;/sup&gt;  &lt;br&gt; Level 3 evidence  &lt;br&gt; Not clear that a gold standard was universally applied and cohort consists only of those admitted for head injury, not whole head injury population seen by the hospitals</td>
<td>Rule: Patients who have either lost consciousness or have a skull fracture are at increased risk of surgically significant intracranial haematoma  &lt;br&gt; N=28,500  &lt;br&gt; All GCS scores  &lt;br&gt; Average age 35. No further details given  &lt;br&gt; Patients admitted to hospitals in Taipei city and Hualien county 1988-1992  &lt;br&gt; Consecutive hospital inpatients</td>
<td>Surgically significant Intracranial haematoma  &lt;br&gt; Neurosurgery</td>
<td>Specificity of loss of consciousness and absence of skull fracture in excluding ICH is 77%</td>
<td>Sensitivity of loss of consciousness or Skull fracture in detecting ICH is 75%</td>
<td>Does not give advice for CT scanning</td>
<td>9,038 (31.9%) had intracranial haematoma on CT.  &lt;br&gt; 3,348 (11.7%) had a craniotomy.</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No follow up protocol was described</td>
<td>A patient without loss of consciousness or a skull fracture still had a risk of 5.5% for surgically significant intracranial haematoma.  &lt;br&gt; In GCS 13-15 group skull fracture increases the risk of ICH by 5.5 times  &lt;br&gt; Paper of limited value</td>
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<td>Mikhail et al (1992)&lt;sup&gt;194&lt;/sup&gt;  &lt;br&gt; Level 3 evidence  &lt;br&gt; Small study with non universal gold standard,  &lt;br&gt; Prospective Exploratory Cohort study  &lt;br&gt; Concludes that Age &gt;40, and headache are associated with intracranial injury in the GCS 13-15 group.  &lt;br&gt; No rule proposed</td>
<td>Prospective Exploratory Cohort study  &lt;br&gt; N=113  &lt;br&gt; GCS 13-15  &lt;br&gt; Adults only  &lt;br&gt; Single USA level 1 trauma centre consecutive</td>
<td>Intracranial injury on CT scan  &lt;br&gt; Neurosurgery</td>
<td>No rule proposed</td>
<td>No rule proposed</td>
<td>35 scans performed in this study</td>
<td>8 patients with ICH on CT (7%)  &lt;br&gt; 3 patients had neurosurgery</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>83% follow up at 4 weeks by telephone</td>
<td>Underpowered study.  &lt;br&gt; Entry criteria of ‘complaint of head injury and GCS 13-15’, look very unlikely to produce a prevalence of 7% ICH. Likely that further criteria e.g. loss of consciousness/post-traumatic amnesia were used to exclude trivial injury, but these were not mentioned.</td>
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<tr>
<td>Teasdale et al (1990)</td>
<td>Fully conscious patients without any indication for skull x-ray: discharged (criteria for a Skull X-ray are not given)</td>
<td>A&amp;E PATIENTS: N=8406 All GCS scores Adults, and children under 14 compared as 2 groups 3557 from all hospitals in Scotland in a 2 week period in 1974, 768 pts from Glasgow, 710 pts from Teesside, 3371 pts from Monklands Non-consecutive NEUROSURGERY PATIENTS: N=1007 All GCS scores Adults, and children under 14 compared as 2 groups Patients from Glasgow neuro-surgical unit from 1974-1984 Consecutive patients with evacuation of haematoma</td>
<td>Need for neurosurgery</td>
<td>No rule evaluated</td>
<td>No rule evaluated</td>
<td>Proposed rule would lead to 7% CT ordering rate</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Not relevant</td>
<td>This retrospective design is a case-control comparison. The authors indicate that historical data point to the role of skull fracture and history of altered consciousness as key risk factors. In fully conscious adults they state that the risk goes from 1 in 31,370 for someone with neither skull fracture nor history of loss of consciousness to 1 in 29 for someone with both risk factors. Risk factors are said to be the same for children.</td>
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<tr>
<td>Teasdale et al (1990)</td>
<td>Patients with impaired consciousness or neurologic signs: urgent CT</td>
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<td>Teasdale et al (1990)</td>
<td>Negative CT patients: observed in hospital until they have recovered</td>
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<td>Tsai et al (1994) Level 4 evidence Retrospective exploratory cohort study with inconsistent reference standards</td>
<td>Rule proposed: CT scan for loss of consciousness/ post-traumatic amnesia. Progressive neurologic abnormality, GCS &lt;13. People with normal CT can go home.</td>
<td>N=186 GCS 13-15 Adults Attending 1 Taiwanese Hospital, Non-consecutive,</td>
<td>Abnormal CT scan Neurosurgery</td>
<td>Unable to calculate as paper states that there were asymptomatic and delayed onset haematomas but did not give any further details of numbers</td>
<td>Unable to calculate as paper states that there were asymptomatic and delayed onset haematomas but did not give any further details of numbers</td>
<td>4%</td>
<td>22% abnormal CT 6.5% neurosurgery</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes – but no details given other than stating: “This recommendation is not foolproof as asymptomatic and delayed onset haematomas did occur”</td>
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The Patient group was highly selected: from 4760 records, 186 patients were found who were GCS 13-15 and had a CT scan requested. Criteria for CT were loss of consciousness/post-traumatic amnesia, focal neurology, depressed or open skull fracture, pupil inequality, deterioration in mental status. The reporting of results is incomplete with regard to the total number of haematomas found in the study period.
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<tr>
<td>Sharma et al (1994) Level 3 evidence</td>
<td>Retrospective validation cohort study. Management Protocol: Admission: History of trauma and, loss of consciousness, bleeding from ear, nose or mouth, vomiting or skull fracture on skull X-ray. CT scan: GCS&lt;8 with no eye opening for 6 hours, deteriorating sensorium, focal pupil or limb signs, coma, unresponsive to verbal commands for &gt;24 hours, seizures, hyperpyrexia and neck rigidity.</td>
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<td>Cummins (1992) Paper not relevant to this review</td>
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<td>Frush et al (1998) Paper not relevant to this review</td>
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<tr>
<td>Otte et al (1998) This is a case report of disability after head injury</td>
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<td>Herbert et al (2000) Paper not relevant to this review</td>
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<tr>
<td>N=312</td>
<td>Abnormality on CT scan</td>
<td>Not reliably obtainable</td>
<td>16% of the 87 children</td>
<td>22 of 87 abnormal CT</td>
<td>25% ICH or cerebral oedema</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>All patients with ‘residual deficits’ or on anti convulsants seen.</td>
<td>None of those admitted or discharged were followed up if asymptomatic at discharge. Only 83 scans out of 312 were performed in total so no reliable gold standard.</td>
</tr>
<tr>
<td>Names and evidence level</td>
<td>Rule description</td>
<td>Participants</td>
<td>Outcomes</td>
<td>Specificity</td>
<td>Sensitivity</td>
<td>CT ordering rate</td>
<td>Prevalence Derived using primary data</td>
<td>Derived using prospect. data</td>
<td>Validated using primary data</td>
<td>Validated using prospect. data</td>
<td>Multi-variate modelling</td>
<td>Follow-up</td>
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</table>
| Finizio et al (1992)
| This is a non-consecutive case series of 21 operated Extradural Haematomas in children, reporting fracture rate and location of haematoma. Therefore not relevant to the review. | | | | | | | | | | | | |
| Review of post-concussion syndrome, 1860's to present day. Paper not relevant to the review. | | | | | | | | | | | | |
| Reinus et al (1994)
| This is not exclusively a head injury paper. | | | | | | | | | | | | |
| Cigada et al (1999)
| Level 3 evidence: unclear patient selection policies. Inadequate sample size. Paper examines the impact of guidelines on minor head injuries in a small cohort of patients Paper is in Italian | First Cohort N=257 GCS 14-15 Adults Single Spanish hospital Consecutive Second cohort N=221 GCS 14-15 Adults Single Spanish hospital Consecutive | | | | | | | | | | | |
| Sturloni et al (1997)
<p>| Paper not relevant to the review. | | | | | | | | | | | |</p>
<table>
<thead>
<tr>
<th>Names and evidence level</th>
<th>Rule description</th>
<th>Participants</th>
<th>Outcomes</th>
<th>Specificity</th>
<th>Sensitivity</th>
<th>CT ordering rate</th>
<th>Prevalence Derived using primary data</th>
<th>Derived using prospect. data</th>
<th>Validated using primary data</th>
<th>Validated using prospect. data</th>
<th>Multi-variate modelling</th>
<th>Follow-up</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ciccarese et al (1998) Level 2 evidence: unclear patient selection policies</td>
<td>Rule implemented in this study: Group 0: GCS 15, no symptoms or risk factors and the possibility of being monitored at home. Group 1: GCS 15 and one or more symptoms Group 2: GCS 14 Group 0 may be discharged without investigations Group 1 and 2 should have a CT scan</td>
<td>N= 6,600 All GCS Adults Single Italian Hospital Consecutive</td>
<td>Intracranial lesions on CT</td>
<td>No positive cases after normal CT</td>
<td>No positive cases after normal CT</td>
<td>67% in the study</td>
<td>189 lesions found</td>
<td>Yes-derived from other authors reports</td>
<td>unclear</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
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<tr>
<td>Ingebrigtsen et al (1995) Level 3 evidence No universally applied gold standard.</td>
<td>Rule: Inpatients presenting with GCS14-15 and no neurological deficits and normal CT, these patients can safely be discharged</td>
<td>N= 146 GCS 14-15 and no neurological deficits. 128 loss of consciousness Adults Single Swedish Hospital Consecutive</td>
<td>Intracranial lesions on CT</td>
<td>No positive cases after normal CT</td>
<td>No positive cases after normal CT</td>
<td>5% intracranial lesions</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>unclear</td>
<td></td>
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<tr>
<td>Names and evidence level</td>
<td>Rule description</td>
<td>Participants</td>
<td>Outcomes</td>
<td>Specificity</td>
<td>Sensitivity</td>
<td>CT ordering rate</td>
<td>Prevalence Derived using primary data</td>
<td>Derived using prospect data</td>
<td>Validated using primary data</td>
<td>Validated using prospect data</td>
<td>Multi-variate modelling</td>
<td>Follow-up</td>
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<tr>
<td>Savastio et al (1991)³⁹⁴</td>
<td>High risk criteria: Basilar fractures (otorrhea, rhinorrhea, focal neurology, retroauricular haematoma), loss of consciousness Moderate risk: loss of consciousness, Amnesia, multiple trauma, possible skull penetration.</td>
<td>N=4262 All GCS grades Adults 1 Italian hospital Consecutive</td>
<td>Intracranial sequelae on CT Skull fracture</td>
<td>High risk criteria 100% sensitive for intracranial sequelae</td>
<td>0.7% Yes Yes No No No</td>
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<tr>
<td>Culotta et al (1996)²⁶</td>
<td>This is a study of neurobehavioural outcome rather than risk of Intracranial pathology and therefore not relevant to this review</td>
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<td>Hofman et al (2000)¹⁵⁵</td>
<td>This is a meta-analysis of a single variable – skull fracture, and it’s value as a prognostic variable for intracranial pathology.</td>
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<tr>
<td>Kelly et al (2000)¹⁰⁹</td>
<td>Not relevant to this review</td>
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<tr>
<td>Lucchi et al (1995)⁵³</td>
<td>Not relevant to this review</td>
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<tr>
<td>Shaabat et al (2001)²⁸</td>
<td>Not relevant to this review</td>
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<tr>
<td>Kelly et al (1988)¹⁰⁸</td>
<td>This Is a paper comparing a cohort of 100 patients who had CT and MR scanning. Only 3 patients had both within 3 days of injury. Conclusions are that CT are superior in the acute situation but MR scanning is superior thereafter. This paper is of interest but largely irrelevant to our clinical question regarding guidelines for acute head injury.</td>
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<td>Names and evidence level</td>
<td>Rule description</td>
<td>Participants</td>
<td>Outcomes</td>
<td>Specificity</td>
<td>Sensitivity</td>
<td>CT ordering rate</td>
<td>Prevalence</td>
<td>Derived using primary data</td>
<td>Derived using prospect. data</td>
<td>Validated using primary data</td>
<td>Validated using prospect. data</td>
<td>Multivariate modelling</td>
<td>Follow-up</td>
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<tr>
<td>Hahn et al (1993)(^{114})</td>
<td>Advise CT in all children with minor head injury, i.e. non trivial, patient has loss of consciousness, headache, vomit reduced GCS and hospital observation. They also recommend follow up CT 12–24 hrs after injury.</td>
<td>N=791 CCS 13-15 (children’s coma score) Children age 0-16 Single level 1 USA children’s trauma centre Consecutive patients</td>
<td>Abnormal CT, Skull fracture on skull X-ray, neurosurgery death</td>
<td>No rule evaluated</td>
<td>No rule evaluated</td>
<td>80%</td>
<td>13% required neurosurgery</td>
<td>Yes</td>
<td>Not clear</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
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<tr>
<td>Greenes et al (1999)(^{105})</td>
<td>All infants under 3 months need radiographic imaging (CT or skull X-ray for haematoma only). 3 mths to 2 years, if asymptomatic and no scalp haematoma discharge</td>
<td>N=608 All GCS scores Infants under 2 years old - patients Single USA paediatric trauma centre Consecutive patients</td>
<td>ICI defined on CT</td>
<td>No rule evaluated</td>
<td>No rule evaluated</td>
<td>31%</td>
<td>5% had ICH</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes all followed up by telephone</td>
</tr>
</tbody>
</table>
| Greenes et al (2001) | Exploratory Cohort study of consecutive asymptomatic infants attending single paediatric trauma centre. Patients excluded if any of the following: loss of consciousness lethargy, irritability, depressed mental status, bulging fontanel, focal neurology, reduced GCS, Palpable skull fracture | Derived Rule: Imaging required if score below is 3 or above: (Imaging means skull X-ray for all asymptomatic patients followed by CT for all skull fractures.)

0 risk points for any of:
Over 12 mths, no scalp haematoma, frontal location.
1 risk point for each of:
6-11 mths, small scalp haematoma, occipital location.
2 risk points for each of:
3-5 months, Medium scalp haematoma, Temporal/parietal location.
3 risk points for each of:
0-2 months, large scalp haematoma,
Range of scores is 0-8 points | N= 422 All GCS scores Age 0-24 months Single USA paediatric trauma centre Consecutive patients Intracranial Injury, defined as cerebral contusion, cerebral oedema, or intracranial haematoma. Skull fracture on skull X-ray or CT. 40% for excluding ICI amongst the 172 who had imaging. 100% for detecting ICI 3% ICI 11% Skull fractures. Only 1 patient had a neurosurgical intervention. Yes Yes No No Yes 99% of patients successfully received a F/U telephone call at 2 weeks 40% for excluding ICI amongst the 172 who had imaging. 100% for detecting ICI 3% ICI 11% Skull fractures. Only 1 patient had a neurosurgical intervention. Yes Only 172 of the 422 patients had a CT or a skull X-ray. The rest were not imaged at all. (41 CT and 96 skull X-rays).
Specificity only obtainable for those 172 patients who had imaging. 250 patients excluded from this calculation. Non accidental injury patients were included in their study.

Intracranial Injury, defined as cerebral contusion, cerebral oedema, or intracranial haematoma. Skull fracture on skull X-ray or CT. 40% for excluding ICI amongst the 172 who had imaging. 100% for detecting ICI 3% ICI 11% Skull fractures. Only 1 patient had a neurosurgical intervention. Yes Only 172 of the 422 patients had a CT or a skull X-ray. The rest were not imaged at all. (41 CT and 96 skull X-rays).
Specificity only obtainable for those 172 patients who had imaging. 250 patients excluded from this calculation. Non accidental injury patients were included in their study.
Chan, Yue et al (1990)  
Chan, Mann et al (1990)

Level 2 evidence 
Well conducted exploratory study. 
Prospective cohort does not have universally applied gold standard

<table>
<thead>
<tr>
<th>RETROSPECTIVE COHORT:</th>
<th>N=12072</th>
<th>All GCS scores</th>
<th>Children under 16 years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single Hong Kong university hospital</td>
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<tr>
<td>Consecutive</td>
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</table>

<table>
<thead>
<tr>
<th>PROSPECTIVE COHORT</th>
<th>N=1178</th>
<th>Adolescents (11-15 years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>All GCS scores but only 21pts less than GCS 15 (6 ICH)</td>
<td></td>
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<tr>
<td>Single Hong Kong university hospital</td>
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<td>Consecutive</td>
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</table>

ICH development | No rule evaluated | No rule evaluated | Not clear | 1.3% = ICH in retrospective cohort | 1.1% in prospective cohort |
|----------------|--------------------|--------------------|-----------|---------------------------------|--------------------------|

Yes | No | Yes | Yes | Yes | In retrospective cohort 100% admission rate, then no follow up after discharge. Prospective cohort: 35% admitted and followed up at 3 months – others not followed up. This study follows the same lines as the Teasdale study -- indicating the importance of skull fracture and loss of consciousness. Validation study has low follow-up rate. The prevalence rate is very low – leading to large confidence intervals.
<table>
<thead>
<tr>
<th>Study</th>
<th>Rule Description</th>
<th>N</th>
<th>Delayed ICH Presence</th>
<th>No positive outcomes</th>
<th>No positive outcomes in the study</th>
<th>100%</th>
<th>0%</th>
<th>Yes</th>
<th>No</th>
<th>No</th>
<th>No</th>
<th>All patients were followed up until discharge. No further follow up thereafter.</th>
<th>From 277 children admitted in the study period, 62 met the strict entry criteria. Low power study that tries to exclude late deterioration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roddy et al (1998)⁴</td>
<td>Patients following minimal head trauma with normal CNS exam and normal CT scan may be safely discharged</td>
<td>62</td>
<td></td>
<td></td>
<td>100%</td>
<td>0%</td>
<td></td>
<td>Yes</td>
<td>no</td>
<td>no</td>
<td>no</td>
<td>All patients were followed up until discharge. No further follow up thereafter.</td>
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<tr>
<td>Gruskin et al (1999)¹⁰</td>
<td>Low risk: Fall&lt;0.9m, no history of neurologic symptoms, normal scalp examination. May be safely discharged without investigation</td>
<td>278</td>
<td>Presence of skull fracture or Intracranial injury</td>
<td>10%</td>
<td>100%</td>
<td>94%</td>
<td></td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Protocol not described but states that 4 returned to hospital, one had haemotympanum but normal repeat CT and the other 3 were discharged after re-evaluation.</td>
<td>This study identifies a small set of patients (43 out of 278) who may be safely discharged.</td>
</tr>
<tr>
<td>Author(s)</td>
<td>Study Details</td>
<td>Results</td>
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<tr>
<td>Levi et al (1991)</td>
<td>Level 3 evidence</td>
<td>This study is not a consecutive study of the population of all patients presenting with head injury. The study is a single departmental neurosurgery study in Israel. The study included children under 14 years of age and was not a consecutive cohort of all patients presenting with head injury. Age and severity of injury affect outcome and the presence of a skull fracture is unrelated to the presence of intracranial pathology. N=653 All GCS scores (41% GCS under 12) Children under 14 years Single Dept neurosurgery Israel. Consecutive cohort of patients admitted to the dept of neurosurgery. But non consecutive cohort of all patients presenting with a head injury. Presence of Skull fracture. Any CT abnormality Disability outcome at 3 months 24% specificity in skull X-ray predicting ICH 48% sensitivity in skull X-ray predicting ICH No rule given 17.5% craniotomy rate 34.6% abnormal CT rate 43 deaths</td>
<td>Paper concludes that age and severity of injury affect outcome and that the presence of a skull fracture is unrelated to the presence of intracranial pathology. N=653 All GCS scores (41% GCS under 12) Children under 14 years Single Dept neurosurgery Israel. Consecutive cohort of patients admitted to the dept of neurosurgery. But non consecutive cohort of all patients presenting with a head injury. Presence of Skull fracture. Any CT abnormality Disability outcome at 3 months 24% specificity in skull X-ray predicting ICH 48% sensitivity in skull X-ray predicting ICH No rule given 17.5% craniotomy rate 34.6% abnormal CT rate 43 deaths</td>
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<td>Murgio (2001)</td>
<td>Level 3 Evidence</td>
<td>Multicentre Exploratory cohort study. Concludes that skull X-ray is unwarranted but no rule for the management of head injuries in children is proposed. N=4690 GCS 13-15 Children 0-15 years Patients attending hospitals in Argentina, Brazil, France, Hong Kong, and Spain. Non-consecutive Abnormality on CT scan Neurosurgical Intervention Glasgow outcome score on follow up No rule proposed No rule proposed 14% CT rate in study 7 deaths 81 had neurosurgical intervention 5.6% pathological CT scan rate</td>
<td>Multicentre Exploratory cohort study. Concludes that skull X-ray is unwarranted but no rule for the management of head injuries in children is proposed. N=4690 GCS 13-15 Children 0-15 years Patients attending hospitals in Argentina, Brazil, France, Hong Kong, and Spain. Non-consecutive Abnormality on CT scan Neurosurgical Intervention Glasgow outcome score on follow up No rule proposed No rule proposed 14% CT rate in study 7 deaths 81 had neurosurgical intervention 5.6% pathological CT scan rate</td>
<td>Yes Yes No No No High follow up rate at 3 months (&gt;98%) This is a selected group in that only patients who were selected for admission were studied. No data is given on whether any patients not admitted had a negative outcome.</td>
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<td>Lloyd, Carty, et al (1997)&lt;sup&gt;181&lt;/sup&gt;</td>
<td>Level 3 evidence</td>
<td>The application of the gold standard of CT scan was dependent on whether the patient had a skull fracture on skull X-ray or was admitted</td>
<td>N=883</td>
<td>Abnormal CT, skull fracture on skull X-ray, neurosurgery and death</td>
<td>No rule evaluated</td>
<td>No rule evaluated</td>
<td>156 CT scans (possibly 1.7%)</td>
<td>Not clear as results for total population not reported</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
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<td>All GCS scores who were admitted or had skull fracture</td>
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<td>Yes</td>
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<td>Children under 16</td>
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<td>Single UK paediatric trauma centre</td>
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| Adams et al (2001)<sup>2</sup> | Level 3 evidence | Patients identified from a trauma database, no universal gold standard of CT or follow up | N=1033 | Abnormal CT-scan | No rule evaluated | No rule evaluated | 37.4% | No neurosurgical interventions out of 1033 patients | Yes | No | No | No | No | No | No |
| | | | GCS 15 and admitted for head injury | | | | | | Yes | | | | | | |
| | | | Children under 18 | | | | | | No | | | | | | |
| | | | Patients entered in the National Pediatric Trauma registry USA | | | | | | No | | | | | | |
| | | | Non-consecutive | | | | | | No | | | | | | |

<sup>181</sup> They did not test their rule of no skull X-ray and only CT. Rules for CT not explicitly derived.
<table>
<thead>
<tr>
<th>Study</th>
<th>Evidence Level</th>
<th>Evidence Type</th>
<th>Study Design</th>
<th>Patient Selection</th>
<th>CT Recommendation</th>
<th>CT Evaluation</th>
<th>CT Results</th>
<th>Rule Evaluation</th>
<th>Rule Validity</th>
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<tbody>
<tr>
<td>Wang et al (2000)</td>
<td>3</td>
<td>Evidence</td>
<td>Highly selective prospective exploratory cohort study</td>
<td>N=209 Children age under 15 Attending 13 trauma centres serving Los Angeles USA Non-Consecutive in the sense that this cohort was selected from a cohort of 8488 patients.</td>
<td>Recommend CT scan for all GCS 13 and 14 patients</td>
<td>Abnormal CT, neurosurgery</td>
<td>Overall population results not reported. This cohort had 86% CT rate</td>
<td>Yes</td>
<td>Yes</td>
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<td>Dietrich et al (1993)</td>
<td>3</td>
<td>Evidence</td>
<td>Only patients selected for CT were included in this study, therefore non-consecutive.</td>
<td>N=322 All GCS scores (50 under GCS 15) Children aged 0-16 years Single USA children’s trauma centre Non-consecutive patients</td>
<td>Recommends CT for all GCS&lt;15, and all GCS 15 if there are any symptoms (i.e. loss of consciousness, nausea, vomiting, seizures etc)</td>
<td>CI on CT scan</td>
<td>Overall population results not reported. 27.4% abnormal CT rate</td>
<td>Yes</td>
<td>Yes</td>
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<tr>
<td>Quayle et al (1997)</td>
<td>Study found association with skull fracture, loss of consciousness for 5 mins, altered mental status, and focal neurology. But absence of any of these factors does not exclude ICH.</td>
<td>N=322</td>
<td>Positive CT scan</td>
<td>No rule evaluated</td>
<td>No rule evaluated</td>
<td>98%</td>
<td>8% = ICH</td>
<td>Yes</td>
<td>Yes</td>
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<tr>
<td>Level 3 evidence</td>
<td>Consecutive Exploratory cohort study but see notes for details of study weakness</td>
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| Simon et al (2001) \[29\] | Exploratory cohort study designed to establish the incidence and identify risk factors for intracranial injury in children aged less than 16 years. Retrospective review, not consecutive patients. | N=429 GCS 14-15 with No suspicious neurologic symptoms, but high risk mechanism Children under 16 years. Single USA paediatric level 1 trauma centre Non-consecutive, 569 eligible patients but only 429 had reliable records | Intracranial injury | No rule evaluated | No rule evaluated | 100% | 14% | Yes | No | No | No | Yes | None |Authors conclude that a normal neurologic exam and maintained consciousness does not rule out ICI in children who have had a high-risk mechanism of injury. The sample is highly selective, with no follow-up and retrospective data collection.
| Mandera et al (2000) | Exploratory cohort study, retrospective study. No rule is evaluated. | N=166 GCS 13-15 Children under 18 years old Single Polish neurosurgical unit Non-consecutive as this is a selected population sent to the neurosurgical unit (reflected in the prevalence of ICH) | Intracranial pathology | No rule evaluated | No rule evaluated | 100% | 83% | Yes | No | No | No | No | None | The sample is highly selective with little detail about inclusion criteria. High prevalence rate makes it very difficult to interpret. |
| Schunk et al (1996)²⁷ | Study does not evaluate a rule — looks at CT-scan patients only. 100% was not the rule. Retrospective review. N=313 GCS 15 and no focal neurology Children under 18 years old. Single USA paediatric level 1 trauma centre Non-consecutive. Only patients who had CT included, no criteria for CT ordering was in place. Intracranial injury Need for neurosurgery. No rule evaluated No rule evaluated 100% 28% ICI Yes No No No No None Small series of CT-scans. |  |
| Shane et al (1997)²⁸ | Conclusions is that the presence of any symptoms or signs as well as a skull fracture is 100% sensitive but not specific for ICH. N= 102 Awake infants only GCS not used Infants under 13 months of age Single USA children’s paediatric trauma centre Non-Consecutive as only patients with a skull fracture studied ICI 35 % specificity for excluding ICI in children with a fracture but no symptoms or signs (Only calculated for the 32 children who had CT scan). 100% sensitivity for finding ICI amongst those with skull fracture and symptoms or signs. If the rule is any child with symptoms or signs should have CT scan the ordering rate would be 76% as 76 patients in the whole study had symptoms signs. 15% had ICI 2% neurosurgery. Yes No No No No Retrospectivel from neurosurgical review clinics Half of the children were tertiary referrals. Very small numbers in this retrospective study and this rule is not validated. Only applicable to a very small subset of patients under 13 mths of age with a Skull fracture. |  |
| Lorini et al (1996) | Validation cohort study with historical control cohort. | Rule: CT scan and admission if: Coma, depressed consciousness, disorientation, focal neurology. | Admission if: Transient loss of consciousness, Amnesia, Vomiting, restlessness, Diffuse headache, suspect basal skull fracture, large scalp haematoma, or depressed fracture, coagulation disorders, previous craniotomy and shunt. | For skull X-ray if: large scalp haematoma, Injury from violent impact with a small object, suspect penetrating injury, suspect base fracture, previous craniotomy with shunt. | Skull fracture Intracranial complications | 84% specificity in validation of rule in 2nd cohort. | 100% | 33 CT scans in 2nd cohort, 4% ordering rate. | No. Of skull X-rays dropped from 81 % to 30 % in asymptomatic patients. Admission is dropped from 16% to 9%. | Incidence of intracranial complications 1.27% in 2nd cohort, 1.28% in 1st cohort. | Yes | No | Yes | No | No | 'Complicated' patients were followed up but this number was not reported. In period A states that no patients re-attended. In period B states that 4 re-attended but no intracranial complications. | Unknown number of minor head injuries followed up. No gold standard to exclude intracranial injuries applied except checking that patients had not re-attended to same hospital. |
| Keskill et al (1995) | N=257 GCS 14-15 with full recovery after loss of consciousness | Intracranial complications | No rule evaluated | No rule evaluated | Liberal CT proposed | 49 patients (19%) had a mass lesion, 7 patients with an intracranial lesion had no symptoms or signs of head injury and no skull fracture. | Yes | No | No | No | Yes | No follow up beyond discharge. | Patients group selected from 1600 patients on review of case histories. |
|---------------------|-------------------------------------------------------------|-----------------------------|------------------|------------------|---------------------|-------------------------------------------------|-----|-----|-----|-----|-----|---------------------------------|
| Level 3 evidence, not a consecutive cohort of all children with GCS 14-15. | Children under 16 years Single Turkish Hospital Consecutive series of patients admitted to the neurosurgery department. Not consecutive series of all children with minor head injury. | | | | | | | | | | | |
| Keskill et al (1995) | N=1,128 GCS 14-15. | Traumatic intracranial abnormalities on CT. | No rule evaluated | No rule evaluated | 1% ICH (11 patients) 4 required surgery. 4 GCS 15 children had ICH. | Yes | Yes | No | No | No | | |
| Level 3 evidence, inconsistent reference standards | Children aged 0-14, Single Spanish centre Consecutive. | | | | | | | | | | | |

Paper concludes that there are no combinations of symptoms or signs that will accurately predict the risk of intracranial injury. They recommend the liberal use of admission and CT.

<table>
<thead>
<tr>
<th>Study</th>
<th>Age/Criteria</th>
<th>N</th>
<th>CT Rate</th>
<th>CT Indicated</th>
<th>Rule Evaluated</th>
<th>CT Rate Evaluated</th>
<th>Methodological Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Davis et al (1994)</td>
<td>N=185, retrospective children in 1994 paper.</td>
<td>185</td>
<td>100%</td>
<td>Yes in 1994 paper</td>
<td>No</td>
<td>No</td>
<td>Not possible to evaluate – focus is on cases.</td>
</tr>
<tr>
<td>Davis, Hughes et al</td>
<td>N=400 children</td>
<td>400</td>
<td>73%</td>
<td>No in 1994 paper</td>
<td>No</td>
<td>No</td>
<td>Rule says 73% ordering rate</td>
</tr>
<tr>
<td>Roupin et al (1995)</td>
<td>Audit of practice – describes reduction in x-ray rate and states that no complications were missed. Looks at children only.</td>
<td></td>
<td></td>
<td>Yes in 1994 paper</td>
<td>No</td>
<td>No</td>
<td>No</td>
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</table>

Methodological error: 2235 patients notes were looked through to find the 185 patients used for the study - highly selected group.
### Update2007: Evidence tables for clinical prediction rule for selecting adults with HI for the imaging technique selected in question 2?

<table>
<thead>
<tr>
<th>Study details</th>
<th>Patients</th>
<th>Interventions</th>
<th>Outcome measures</th>
<th>Effect size</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>STIELL 2005</strong>&lt;sup&gt;2&lt;/sup&gt;</td>
<td><strong>Consecutive adult patients who had sustained acute minor head injury in 9 Canadian tertiary care teaching hospital emergency departments. Inclusion depended on the patients having all of the following:</strong>&lt;br&gt;1) blunt trauma to the head resulting in witnessed loss of consciousness, definite amnesia or witnessed disorientation, (2) initial emergency department GCS score of 13 or greater as determined by treating physician and (3) injury within the previous 24 hours.</td>
<td><strong>Need for neurosurgical intervention</strong>&lt;br&gt;Sensitivity</td>
<td><strong>CCHR (n=1822)</strong>&lt;br&gt;100% (95% CI 63% to 100%)&lt;br&gt;76.3% (95% CI 74% to 78%)&lt;br&gt;8 (0.4%)&lt;br&gt;</td>
<td><strong>Funding:</strong> Peer reviewed grants from Canadian Institutes of Health Research and Ontario Ministry of Health Emergency Health Services Committee.</td>
<td><strong>Additional outcomes:</strong> Interobserver agreement for each variable and for interpretation of the two rules was measured with the weighted k coefficient. Weighted k value for physician interpretation of the overall rules in 49 cases was 0.85 (95% CI 0.58-0.92) for CCHR and 0.47 (95% CI 0.13-1.0) for the NOC. Physician’s theoretical comfort and perceived ease of use of the rules was reported. Length of time spent in the hospital was calculated for patients that did and did not undergo a CT scan. <strong>Notes:</strong> CT scans were interpreted by qualified staff neuroradiologists who were blinded to the information on the data collection sheet. Potential impact on CT ordering evaluated by estimating the proportion of patients who would require CT imaging according to the rules. For entire cohort the CT imaging rate according to CCHR would have been 62.4% (95% CI 61-64); the actual CT rated for these cases was 80.2% at the 9 study sites. Sensitivity and specificity of patients calculated for all brain injury including the...</td>
</tr>
<tr>
<td><strong>Study design:</strong> Prospective Diagnostic Cohort Study</td>
<td><strong>Patient group:</strong> Consecutive adult patients who had sustained acute minor head injury in 9 Canadian tertiary care teaching hospital emergency departments. Inclusion depended on the patients having all of the following:**&lt;br&gt;1) blunt trauma to the head resulting in witnessed loss of consciousness, definite amnesia or witnessed disorientation, (2) initial emergency department GCS score of 13 or greater as determined by treating physician and (3) injury within the previous 24 hours.</td>
<td><strong>Need for neurosurgical intervention</strong>&lt;br&gt;Sensitivity</td>
<td><strong>NOC (n=1822)</strong>&lt;br&gt;100% (95% CI 63% to 100%)&lt;br&gt;12.1% (95% CI 11% to 14%)&lt;br&gt;8 (0.4%)&lt;br&gt;</td>
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<tr>
<td><strong>Evidence level:</strong> 2+</td>
<td><strong>Intervention:</strong> The Canadian CT Head Rule (CCHR) and the New Orleans Criteria (NOC) were assessed on patients who presented with a GCS score of 15. In addition the Canadian rule was assessed for all patients in the study (those presenting with scores of 13-15).</td>
<td><strong>Clinically important brain injury</strong>&lt;br&gt;Sensitivity</td>
<td><strong>CCHR (n=1822)</strong>&lt;br&gt;100% (95% CI 96 to 100)&lt;br&gt;50.6% (95% CI 48-53)&lt;br&gt;97 (5.3%)&lt;br&gt;</td>
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<td><strong>Duration of follow-up:</strong> 14 day follow up by telephone for patients that did not receive CT imaging.</td>
<td><strong>Diagnostic test:</strong> NOC and CCHR prediction rule tests</td>
<td><strong>Clinically important brain injury</strong>&lt;br&gt;Sensitivity</td>
<td><strong>NOC (n=1822)</strong>&lt;br&gt;100% (95% CI 96% to 100%)&lt;br&gt;12.7% (95% CI 11-14)&lt;br&gt;97 (5.3%)&lt;br&gt;</td>
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<td><strong>Reference standard:</strong> CT scan</td>
<td><strong>Clinically important brain injury</strong>&lt;br&gt;Sensitivity</td>
<td><strong>CCHR (n=2707)</strong>&lt;br&gt;100% (95% CI 91% to 100%)&lt;br&gt;65.6% (95% CI 64% to 67%)&lt;br&gt;41 (1.5%)&lt;br&gt;</td>
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<td><strong>CCHR (n=2707)</strong>&lt;br&gt;100% (95% CI 98 to 100)&lt;br&gt;41.1% (95% CI 39 to 43)&lt;br&gt;231 (8.5%)&lt;br&gt;</td>
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<tr>
<td>Study details</td>
<td>Patients</td>
<td>Interventions</td>
<td>Outcome measures</td>
<td>Effect size</td>
<td>Comments</td>
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<tr>
<td><strong>Patients:</strong></td>
<td>GCS score of 15</td>
<td></td>
<td>CT Ordering Rates for patients with GCS of 15 (n=1822)</td>
<td>CCHR=52.1% (95% CI 50-54) NOC= 88.0% (95% CI 86-89) P&lt;0.001</td>
<td>unimportant brain injury. CCHR: Sensitivity 93.1% and 51.4% specificity. NOC: sensitivity was 98.6% and specificity 12.9%.</td>
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<tr>
<td><strong>N:</strong> 1822</td>
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<td><strong>Age (mean):</strong></td>
<td>37.7 (SD 18)</td>
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<td><strong>M/F:</strong></td>
<td>1246/576</td>
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<tr>
<td><strong>All patients:</strong></td>
<td>GCS: 13-15</td>
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<td><strong>N:</strong> 2707</td>
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<tr>
<td><strong>Age (mean):</strong></td>
<td>38.4 (SD 18)</td>
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<tr>
<td><strong>M/F:</strong></td>
<td>1884/823</td>
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<th>Outcome measures</th>
<th>Effect size</th>
<th>Comments</th>
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</thead>
<tbody>
<tr>
<td>Smits 2005</td>
<td>Patient group: Consecutive patients in 4 Dutch university hospitals. Inclusion criteria: 1) presented within 24 hours after blunt head injury 2) older than 16 years 3) GCS score of</td>
<td>Neurosurgical Intervention: Sensitivity Specificity Neurocranial traumatic CT findings: Sensitivity Specificity Important CT Finding: Sensitivity Specificity</td>
<td>% (95% CI)</td>
<td>Funding: Grant from college voor Zorgverzekeringen</td>
<td></td>
</tr>
<tr>
<td>Study design: External Validation Prospective Cohort Study (diagnostic test)</td>
<td></td>
<td></td>
<td>100.0 (34.2-100.0) 5.3 (2.5-8.3) 98.3 (94.0-99.5) 5.6 (2.7-8.8) 97.7 (92.1-99.4) 5.5 (2.6-8.7)</td>
<td></td>
<td>Limitations: Adaptations to rules as described below in notes.</td>
</tr>
<tr>
<td>Evidence</td>
<td>Intervention under investigation: NOC and CCHR decision rules Reference standard: All patients received CT scan</td>
<td>Original NOC (n=1307)</td>
<td></td>
<td>Additional outcomes: CT reduction was also reported. GCS evaluated at 1 hour after presentation instead of after two hours (Steill study found GCS of less that 15 at 2 hours was a risk factor).</td>
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<td>Notes: The decision rules were designed for specific</td>
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<tr>
<td>Study details</td>
<td>Patients</td>
<td>Interventions</td>
<td>Outcome measures</td>
<td>Effect size</td>
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<tr>
<td>level: 2+</td>
<td>13 to 14</td>
<td>Neurosurgical</td>
<td>Sensitivity</td>
<td>3.0 (1.2-4.8)</td>
<td>patient populations, which were more restricted than investigators patient population. They performed validation analyses in subgroup of patients for whom the decision rule as designed (original decision rules). They then adjusted the original decision rules for use in entire study population, which also included patients without a history of loss of consciousness, by adding the exclusion criteria of original rules as additional risk factors, referred to as the adapted decision rules. Therefore, adapted NOC included risk factors neurological deficit and a GCS score of 13 or 14, and adapted CCHR include risk factors anticoagulation, posttraumatic seizure, and neurological deficit in addition.</td>
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<tr>
<td>Duration of follow-up: 30 days</td>
<td>4</td>
<td>GCS score of 15 with 1 of following risk factors: history of loss of consciousness, short-term memory deficit, amnesia for traumatic event, posttraumatic seizure, vomiting, severe headache, clinical evidence of intoxication, use of anticoagulants, physical evidence of injury above clavicles and neurological deficit.</td>
<td>Neurocranial traumatic CT findings:</td>
<td>Specificity</td>
<td>99.9 (97.7-99.8)</td>
</tr>
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<td>Neurocranial traumatic CT findings:</td>
<td>Neurocranial traumatic CT findings:</td>
<td>Sensitivity</td>
<td>3.2 (1.4-5.2)</td>
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<td>Important CT findings</td>
<td>Important CT findings</td>
<td>Specificity</td>
<td>99.2 (97.1-99.8)</td>
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<td></td>
<td></td>
<td></td>
<td>Specificity</td>
<td>3.1 (1.3-5.1)</td>
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<tr>
<td>Original CCHR (n=1307)</td>
<td>Neurosurgical intervention</td>
<td>Neurosurgical intervention</td>
<td>Sensitivity</td>
<td>100.0 (64.6-100)</td>
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<td></td>
<td>Neurocranial traumatic CT findings:</td>
<td>Neurocranial traumatic CT findings:</td>
<td>Specificity</td>
<td>37.2 (34.1-40.4)</td>
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<tr>
<td></td>
<td>Important CT findings</td>
<td>Important CT findings</td>
<td>Sensitivity</td>
<td>83.4 (77.7-87.9)</td>
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<td></td>
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<td></td>
<td>Specificity</td>
<td>39.4 (36.0-42.8)</td>
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<tr>
<td>Adapted CCHR (n=3181)</td>
<td>Neurosurgical intervention</td>
<td>Neurosurgical intervention</td>
<td>Sensitivity</td>
<td>100.0 (81.6-100.0)</td>
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<tr>
<td></td>
<td>Neurocranial traumatic CT findings:</td>
<td>Neurocranial traumatic CT findings:</td>
<td>Specificity</td>
<td>37.5 (34.9-40.0)</td>
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<tr>
<td></td>
<td>Important CT findings</td>
<td>Important CT findings</td>
<td>Sensitivity</td>
<td>85.0 (80.5-88.5)</td>
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<td></td>
<td></td>
<td></td>
<td>Specificity</td>
<td>39.7 (37.0-42.4)</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Sensitivity</td>
<td>87.2 (82.5-90.9)</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Specificity</td>
<td>39.3 (36.6-42.0)</td>
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<tr>
<td>Study details</td>
<td>Patients</td>
<td>Interventions</td>
<td>Outcome measures</td>
<td>Effect size</td>
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<td>M/F: 2244 / 937</td>
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</table>
### Study Details

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<tr>
<th>Mower200</th>
<th>5&lt;sup&gt;th&lt;/sup&gt;</th>
</tr>
</thead>
</table>

**Study design:** Derivation study – prospective cohort

**Evidence level:** 2+

**Duration of follow-up:** NR

### Patients

**Patient group:** All blunt trauma patients that underwent head CT in 21 participating centres.

**All patients**

| N: 13728 | age (median): 37 yrs | M/F: 8988/4718 |

### Interventions

**Development of NEXUS II prediction rule for CT imaging of patients with head injury**

**Intervention under investigation:** NEXUS II

**Reference standard:** CT

### Outcome measures

Recursive partitioning identified eight criteria that were independently and highly associated with intracranial injuries: 8 criteria form decision model

### Effect size

1. Evidence of significant skull fracture
2. Scalp hematoma
3. Neurologic deficit
4. Altered level of alertness
5. Abnormal behaviour
6. Coagulopathy
7. Persistent vomiting
8. Age 65 years or more

### Comments

**Funding:** Grant from Agency for Healthcare research and quality

**Limitations:** Derivation study (not validated).

Patients with blunt head trauma that did not receive CT scan were excluded from study.

**Additional outcomes:** NR

2397 patients had sustained blunt head trauma but were not included in study as did not have CT scanning. Assessed potential of verification bias by follow up of 1,266 of these patients that agreed: CT scanning was ultimately performed in 27 patients (2.1%), MRI in 29 (2.3%) and skull radiography in 14 (1.1%). No significant injuries were found in any of these excluded patients.

**Notes:** Includes patients that had not experienced loss of consciousness unlike other prediction rules (CCHR).
Update Evidence tables for clinical prediction rule for selecting children with HI for the imaging technique selected in question 2?

<table>
<thead>
<tr>
<th>Study details</th>
<th>Patients</th>
<th>Interventions</th>
<th>Outcome measures</th>
<th>Effect size</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oman2006$^{25}$</td>
<td><strong>Patient group:</strong> Children presenting with blunt head trauma (under 18 years) that underwent CT scanning from NEXUS II cohort of 21 emergency departments.</td>
<td><strong>Intervention under investigation:</strong> NEXUS II on children NEXUS rules: 8 criteria: evidence of significant skull fracture, altered level of alertness, neurologic deficit, persistent vomiting, presence of scalp hematoma, abnormal behaviour, coagulopathy and age over 65 years (age criteria excluded as all under 18yrs)</td>
<td>Clinically important ICI</td>
<td>All subjects (n=1666)</td>
<td><strong>Funding:</strong> Grant from the Agency for Healthcare Research and Quality. <strong>Limitations:</strong> Derivation study – not validated. <strong>Additional outcomes:</strong> NR <strong>Notes:</strong> Clinically important intracranial injury (ICI) defined as patient that requires neurosurgical intervention. ICI’s were missed in two children. Authors suggest that the specificity could be underestimated due to the fact that the study only enrolled children that had been selected for CT scanning.</td>
</tr>
<tr>
<td><strong>Study design:</strong> Diagnostic-Prospective Cohort</td>
<td><strong>Evidence level:</strong> 2+</td>
<td><strong>Duration of follow-up:</strong> NR</td>
<td><strong>Sensitivity</strong></td>
<td>98.6% (95% CI, 94.9-99.8)</td>
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<td><strong>Specificity</strong></td>
<td>15.1% (95% CI, 13.3-16.9)</td>
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<td><strong>NPV</strong></td>
<td>99.1% (95% CI, 96.9-99.9)</td>
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<td><strong>Prevalence</strong></td>
<td>138 (8.3%)</td>
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<td></td>
<td><strong>All patients</strong></td>
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<td>N: 1666</td>
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<td></td>
<td>Age (median): 11.3 (4.4-15.9) years</td>
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<td>M/F: 1072/594</td>
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<td><strong>Reference standard:</strong> CT scan</td>
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<tr>
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<td><strong>Patient group:</strong> Children under 3yrs (n=309)</td>
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<td>Diagnostic tools</td>
<td>Measure of Disorders</td>
<td>Results</td>
<td>Comments</td>
</tr>
<tr>
<td>--------------</td>
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<tr>
<td>Haydel2003</td>
<td>Patient group: consecutive 5-17 year old patients presenting at a large inner-city Level I trauma centre presenting with minor head injury (defined as blunt head trauma with loss of consciousness with a normal GCS score, or modified coma scale for infants and children and normal brief neurologic examination). Patients included if presenting within 24 hours of injury. Only included patients with nontrivial mechanisms of injury.</td>
<td>Assessment tool under investigation: NOC on children</td>
<td>Intercranial injury or depressed skull fracture</td>
<td>100% (95% CI 73% to 100%) 25.5% (95% CI 19.1% to 33%) 14 (8%; 95% CI 4.6% to 13.3%)</td>
<td></td>
</tr>
<tr>
<td>Study design: Prospective diagnostic study</td>
<td></td>
<td>Reference standard: CT scan</td>
<td>Reduction in ordering rates</td>
<td>23.4% (95% CI 17.7 to 30.2%)</td>
<td></td>
</tr>
<tr>
<td>Evidence level: 2+</td>
<td></td>
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<tr>
<td>Duration of follow-up: study over 30 month period but not followed up after left hospital.</td>
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<tr>
<td>All patients</td>
<td>N: 175</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Age (mean): 12.8 years</td>
<td>M/F(%): 67:33</td>
<td></td>
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<tr>
<td>Assessment tool under investigation: NOC on children</td>
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<tr>
<td>Reference standard: CT scan</td>
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<td></td>
</tr>
<tr>
<td>Intercranial injury or depressed skull fracture</td>
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<td></td>
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<tr>
<td>Sensitivity</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Specificity</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prevalence</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Reduction in ordering rates</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(n=14)</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Operative: 1 (7.1%)</td>
<td></td>
<td></td>
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<tr>
<td>Medical: 5 (36%)</td>
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<tr>
<td>Observed: 8 (57%)</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Funding: Authors report this study did not receive any outside funding or support. Additional Outcomes: Intracranial injury reported in sub age groups of 5-10 yrs and 11-17 yrs. Limitations: Pilot study so sample size small and underpowered to produce narrow confidence intervals. Notes: There were two isolated skull fractures in addition to 14 intercranial injuries. The set of 6 criteria was significantly associated with an abnormal CT scan result on x2 analysis (p&lt;0.05).</td>
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</tbody>
</table>

334
### Study details

**Patient group:** All children (under 16 years) with any severity of head injury presenting at ten ED hospitals in Northwest of England.

**Head Injury defined as:**
- a history of a blow to the head, with or without a period of unconsciousness or amnesia;
- external evidence of injury to the head;
- simple laceration to the face and neck without a history of a blow to the head is not considered to be a HI.

**All patients**
- N: 22,772
- Age < 5 yrs: 56%
- M/F: 65%/35%

**Prevalence:**
- Positive CT: 281 (1.2%)
- Neurosurgical op: 137

### Diagnostic tools

**Assessment tool under investigation:**
- CHALICE prediction rule for children.
- Recursive partitioning to construct clinical guidelines from 40 clinical variables that were significantly associated to intracranial pathology.

**Reference standard:**
- CT and clinical follow-up

### Outcomes

**CHALICE prediction rule**

### Results

A CT scan is required if any of the following criteria are present:

**HISTORY**
- Witnessed loss of consciousness (LOC) of over 5 minutes in duration
- History of amnesia of over 5 minutes in duration
- Presence of abnormal drowsiness
- Three or more vomits after head injury
- Suspicion of Non-Accidental Injury
- Seizure after head injury in a non-epileptic patient

**EXAMINATION**
- GCS <14, or GCS <15 if under 1yr old
- Suspicion of penetrating or depressed skull injury or tense fontanelle
- Signs of a basal skull fracture
- Positive focal neurology
- Presence of bruise/swelling or laceration over 5cms in a child under 1 year

**MECHANISM**
- High speed road traffic accident either as pedestrian, cyclist or occupant (defined as accident over 40mph)
- Fall of over 3m in height
- High speed injury from a projectile or object

If none of above correlates are present, the patients are at low risk of intracranial pathology.

### Comments

**Funding:**
- RCS for Enid Linder Foundation research Fellowship, Child Brain Injury Trust, Dickinson Trust.

**Limitations:**
- Rule not yet validated.

**Other outcomes:**
- SR and meta-analysis of existing studies to determine significant predictors of intracranial haemorrhage. These risk factors were used in a pilot study to create a clinical record form.
- Interobserver variability of clinical variables collected in the study was assessed. Good correlation found hours since injury, LOC, amnesia, vomiting and laceration. Relatively poor for speed of agent, agent category, headache, number of injuries, bruising and swelling.
<table>
<thead>
<tr>
<th>Study details</th>
<th>Patients</th>
<th>Diagnostic tools</th>
<th>Outcomes</th>
<th>Results</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>(0.6%) Died: 15 (0.1%)</td>
<td></td>
<td></td>
<td>Significant intracranial pathology:</td>
<td>CHALICE</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Sensitivity</td>
<td>98.6% (95% CI, 96.4-99.6)</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Specificity</td>
<td>86.9% (95% CI, 86.5-87.4)</td>
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<td></td>
<td></td>
<td></td>
<td>Prevalence</td>
<td>281 (1.2%)</td>
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</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>CT scan rate</td>
<td>14% (95% CI, 13.6-14.6)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Missed cases</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Significant intracranial pathology:</td>
<td>NICE guidance (CCHR)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Sensitivity</td>
<td>94% (95% CI, 91-97)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Specificity</td>
<td>89% (95% CI, 89-90)</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Prevalence</td>
<td>281 (1.2%)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>CT scan rate</td>
<td>12%</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Missed cases</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>Study details</td>
<td>Patients</td>
<td>Diagnostic tools</td>
<td>Outcomes</td>
<td>Results</td>
<td>Comments</td>
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<tr>
<td>Palchak 2003</td>
<td>Patient group: children (&lt;18 years) with blunt head trauma at a paediatric ED of level 1 trauma centre from July 1998 to September 2001.</td>
<td>Assessment tool under investigation: Patient examined by faculty emergency physicians and clinical findings recorded on standardised data sheet before CT scan (if CT obtained). CT scans ordered at discretion of treating faculty physicians. Recursive partitioning to construct clinical decision rules.</td>
<td>Traumatic brain injury (presence of intracranial haemorrhage, haematoma or cerebral edema)</td>
<td>Presence of any of the predictors - Abnormal mental status - Clinical signs of skull fracture - History of vomiting - Scalp hematoma in children aged 2 yrs or younger. - headache</td>
<td>Funding: supported by a Hibbard E. Williams Grant, University of California–Davis School of Medicine; Faculty Research Grant, University of California–Davis School of Medicine; and A Children’s Miracle Network Grant. Limitations: 77.4% of eligible children enrolled. Study not yet validated. Other outcomes: Decision rules for TBI identified on CT and TBI requiring intervention were formed. The resulting decision rule is a combination of the two. Sub-analysis performed on patients that required a neurosurgical procedure as outcome. Two faculty emergency physicians independently</td>
</tr>
<tr>
<td>Study design: prospective cohort study</td>
<td>Included: Presenting after a history of nontrivial blunt head trauma with historical or physical examination findings consistent with head trauma. These findings included a history of loss of consciousness, amnesia, seizure, vomiting, current head ache, dizziness, nausea, or vision change or physical examination findings of abnormal mental status, focal neurologic deficits, clinical signs of skull fracture, or scalp trauma. This included children with head injuries of all severities. Excluded: trivial head trauma defined by falls from ground level or trauma resulting from walking or running into stationary objects if the only abnormal finding was a scalp laceration or abrasion. Also children transferred to the site if CT scan previously performed before transfer.</td>
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<tr>
<td>Evidence level: 2+</td>
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<tr>
<td>Duration of follow-up: NR</td>
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<tr>
<td></td>
<td>All patients</td>
<td>N: 2043 Age: mean 8.3 years (10days to 17.9 years) N&lt;2 yrs: 327 (16%) M/F: 65%/35%</td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>
Study details | Patients | Diagnostic tools | Outcomes | Results | Comments
---|---|---|---|---|---
**Median GCS: 15**
N that had CT: 1271 (62.2%) | registry | | | | evaluated a convenience sample of 5% of patients to assess inter-observer agreement.
**Notes:** Isolated skull fractures not considered traumatic brain injuries.

Update Evidence Tables for diagnostic tool to determine which patients have sustained damage to the cervical spine and require assessment of cervical spine?

<table>
<thead>
<tr>
<th>Study details</th>
<th>Patients</th>
<th>Diagnostic Tool</th>
<th>Outcome measures</th>
<th>Effect size</th>
<th>Comments</th>
</tr>
</thead>
</table>

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### Holmes2005

**Study design:** Meta-analysis

**Evidence level:** 2+

**Duration of follow-up:** NR

<table>
<thead>
<tr>
<th>Study details</th>
<th>Patients</th>
<th>Diagnostic Tool</th>
<th>Outcome measures</th>
<th>Effect size</th>
<th>Comments</th>
</tr>
</thead>
</table>
| **Patient group:** 7 different studies included (Nunez, Berne, Schenarts, Bach, Griffen, Diaz and Widder) Of which 5 were level 3 and 2 studies were level 4. | | Medline search: studies included either RCT or cohort study consisting of patients undergoing plain radiography and helical CT of c-spine for the detection of blunt c-spine injury. Assessment tool under investigation: Plain radiography and CT scan | Pooled results of Plain Radiography Patients with C-spine injury: Sensitivity Heterogeneity for sensitivity Specificity | Pooled results of CT Patients with C-spine injury: Sensitivity Heterogeneity for sensitivity Specificity | Funding: NR

**Limitations:** Specificity of these two tests could not be calculated due to limitations of the data. The authors reported that none of the studies included an independent gold standard test, instead patients with an abnormality identified on c-spine CT scan were considered to have an injury present.

**Additional outcomes:** Due to heterogeneity identified in the sensitivity of plain radiography they performed sensitivity analysis by eliminating the two level 4 studies. Pooled sensitivity for c-spine plain radiography was 54% (95% CI 48-59%) and for CT was 98% (95% CI 95-99%).

**Notes:** 2 reviewers worked on this meta-analysis and extracted data.
<table>
<thead>
<tr>
<th>Study details</th>
<th>Patients</th>
<th>Diagnostic Tool</th>
<th>Outcome measures</th>
<th>Effect size</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nguyen2005²¹</td>
<td><strong>Patient group:</strong> All patients with blunt trauma who underwent imaging over 70 days from a level 1 trauma centre hospital. <strong>All patients</strong> N: 219 <strong>Age (mean):</strong> Range 2-96 <strong>M/F:</strong> 128/91 <strong>High risk patients:</strong> N: 34 <strong>Age:</strong> 11-88 yrs <strong>M/F:</strong> 22/12 <strong>Patients with plain radiography and CT:</strong> 112</td>
<td><strong>Intervention:</strong> All major trauma patients were automatically screened with standard three-view cervical spine radiography and CT. Very low risk patients only had a CT scan as ordered by treating physicians at their own discretion. <strong>Patients retrospectively divided into three categories:</strong> - very low risk (N=107), - low risk (N=78) and - high risk (N=34). <strong>Assessment tool under investigation:</strong> Plain radiographs (3-view) <strong>Reference standard:</strong> CT</td>
<td><strong>High risk group (n=34)</strong> Outcome: fracture <strong>Plain radiography</strong></td>
<td><strong>Sensitivity</strong> 93.3% <strong>Specificity</strong> 95.0% <strong>Prevalence Identified</strong> 15 (6.8%) 14/15</td>
<td><strong>Funding:</strong> NR <strong>Limitations:</strong> <strong>Additional outcomes:</strong> The very low risk group only had CT scans and no fractures were found. The low risk group had no fractures seen by CT and plain radiographs. The high risk group had 15 fractures in the group of 34 patients. X-ray missed one of these fractures. It was a nondisplaced fracture through the C7 left facet. This injury had no soft tissue abnormality and no misalignment. <strong>Notes:</strong> CT and Radiographs performed on low risk and high risk categories only (n=112). <strong>High risk patients:</strong> major trauma patients, high clinical suspicion, abnormal neurological exam, intoxication or unresponsiveness or inadequate x-rays</td>
</tr>
<tr>
<td>Study details</td>
<td>Patients</td>
<td>Diagnostic Tool</td>
<td>Outcome measures</td>
<td>Effect size</td>
<td>Comments</td>
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<tr>
<td>Brohi200544</td>
<td>Patient group: Consecutive unconscious intubated blunt trauma patients underwent hospitals new protocol for spinal evaluation. Protocol: -Lateral cervical spine plain film, -Risk of thoracic and lumbar spine injury had anteroposterior and lateral views, -CT scan, -MRI if previous results show suspicion of ligamentous injury or</td>
<td>Assessment tools under investigation: Helical CT scan (single slice) and single cross table lateral film. Consultant trauma radiologist reported images.</td>
<td>Helical CT scan: Cervical spine injuries:</td>
<td>n=381</td>
<td>Funding: NR</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Sensitivity</td>
<td>98.1%</td>
<td>Limitations: CI not reported.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Specificity</td>
<td>98.8%</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Negative predictive value</td>
<td>99.7%</td>
<td>Additional outcomes: Does not discuss blinding of results of different imaging results.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Prevalence</td>
<td>61 (14%)</td>
<td>Notes: 381 patients had CT scan that was followed up by MRI or patient follow-up.</td>
</tr>
<tr>
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<td></td>
<td>421 patients had cross table lateral film. 21 patients went straight to CT without a lateral radiograph for reasons of clinical priority.</td>
</tr>
<tr>
<td></td>
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<td></td>
<td>Unstable C-spine injuries:</td>
<td>100.0%</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Sensitivity</td>
<td>99.0%</td>
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</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Specificity</td>
<td>100.0%</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Negative predictive value</td>
<td>31 (7.0%)</td>
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<td></td>
<td></td>
<td></td>
<td>Prevalence</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Reference standard: Clinical outcome and/or MRI. Follow up of patients</td>
<td>Cross-table Lateral Film</td>
<td>n=421</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Sensitivity</td>
<td>72.1</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Specificity</td>
<td>94.2</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Negative predictive value</td>
<td>95.2</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Prevalence</td>
<td>59 (14%)</td>
<td></td>
</tr>
<tr>
<td>Study details</td>
<td>Patients</td>
<td>Diagnostic Tool</td>
<td>Outcome measures</td>
<td>Effect size</td>
<td>Comments</td>
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<tr>
<td></td>
<td>abnormal neurology prior to intubation.</td>
<td></td>
<td>Adequate lateral films</td>
<td>Sensitivity: 53.3%</td>
<td>CT identified 60/61 c-spine injuries. One false negative was an undisplaced fractured of the anterior inferior body of C3, which was visible on cross-table lateral film. MRI confirmed injury was stable with no ligamentous disruption.</td>
</tr>
<tr>
<td>All patients</td>
<td>N: 442</td>
<td></td>
<td>Specificity: 91.7%</td>
<td>91.7%</td>
<td>Lateral film identified 24 of 59 with spine injuries and 15 of the 29 with unstable fractures.</td>
</tr>
<tr>
<td></td>
<td>Age (median): 34</td>
<td></td>
<td>Prevalence: 29 (7%)</td>
<td>87.0%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>IQR: 25-50</td>
<td></td>
<td></td>
<td>29 (7%)</td>
<td></td>
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<tr>
<td></td>
<td>M:F ratio: 2.6:1</td>
<td></td>
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<td></td>
<td>Drop outs: 63 died before completion – but 2 had received MRI scan and could be included in HCT outcomes.</td>
<td></td>
<td>Adequate, Unstable lateral films</td>
<td>Sensitivity: 75.0%</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Specificity: 91.7%</td>
<td>91.7%</td>
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<td></td>
<td></td>
<td></td>
<td>Prevalence: 95.1%</td>
<td>95.1%</td>
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</tbody>
</table>
# Update 2007 Economics Evidence table on the cervical spine imaging question

<table>
<thead>
<tr>
<th>Study details</th>
<th>Patients</th>
<th>Interventions</th>
<th>Outcome measures</th>
<th>Effect size</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adelgais 2004 USA</td>
<td><strong>Patient group</strong>: patients aged 0-14 presenting at a level 1 paediatric trauma centre who required cervical spine radiographic evaluation in addition to cranial CT</td>
<td><strong>Group 1</strong>: Conventional Radiography (ConvRad)</td>
<td>Mean emergency department length of stay (minutes)</td>
<td><strong>Group 1</strong>: 183  <strong>Group 2</strong>: 259  <em>p value</em>: NR</td>
<td><strong>Funding</strong>: NR</td>
</tr>
<tr>
<td>Economic analysis: Cost consequences</td>
<td><strong>Group 2</strong>: HCT</td>
<td>Mean cervical spine radiation exposure (Grays)</td>
<td><strong>Group 1</strong>: 294  <strong>Group 2</strong>: 389  <em>p value</em>: NR</td>
<td><strong>Limitations</strong>: 1. Not a complete economic analysis (only diagnostic costs and no health outcomes), 2. high crossover rate, 3. lack of assignment blinding (clinician bias)</td>
<td></td>
</tr>
</tbody>
</table>
| Study design | **All patients**  
N: 136  
**Group 1**  
N: 64 (36 received group 2's protocol)  
**Mean age**: 6.9  
M/F: 38/26  
**Drop outs**: 0 | Mean imaging resources use (relative value unit RVU) | **Group 1**: 4  **Group 2**: 5.5  *p value*: <0.0001 | 4. lack of age stratification due to the small size of sample |
| Duration of follow-up: Diagnosis only | **Group 2**  
N: 72 (11 received group 1's protocol)  
**Mean age**: 6.8  
M/F: 45/27  
**Drop outs**: 0 | Mean cost per patient (1999 US$; radiography costs including follow-up tests) | **Group 1**: $152 (£98)  **Group 2**: $207 (£133)  *p value*: NR | **Additional outcomes**: Medications. Outcomes were reported for actual treatment as well as intention to treat (ITT). They estimate the number of extra cases of thyroid cancer in the USA associated with HCT. |
<p>| Discount rates: NA | Cost-effectiveness | NA |  | <strong>Notes</strong>: The actual differences were considerably greater than the ITT results presented here. |
|  | Sensitivity analysis | NR |  |  |  |</p>
<table>
<thead>
<tr>
<th>Study details</th>
<th>Patients</th>
<th>Interventions</th>
<th>Outcome measures</th>
<th>Effect size</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Antevil 2006® USA</td>
<td><strong>Patient group:</strong> all trauma patients undergoing spinal imaging</td>
<td><strong>Group 1:</strong> between April 1 and June 30 of 1999 when the X-ray was the preferred technique</td>
<td><strong>Sensitivity</strong> (cases of spine fractures detected)</td>
<td><strong>Subgroup 1:</strong> 71% (17/24)</td>
<td><strong>Funding:</strong> NR</td>
</tr>
<tr>
<td>Economic analysis: cost consequences</td>
<td><strong>All patients</strong></td>
<td><strong>Mean age:</strong> 38 ± 1.10</td>
<td><strong>Subgroup 1:</strong> (c-spine X-ray)</td>
<td><strong>Group 1:</strong> 100% (319/319)</td>
<td><strong>Limitations:</strong> - it’s not clear whether costs were adjusted for inflation</td>
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<td>Study design: Retrospective cohort study (same interval in two different years)</td>
<td><strong>Group 1:</strong> N: 254</td>
<td><strong>Mean age:</strong> 37 ± 1.01</td>
<td><strong>Subgroup 1:</strong> (c-spine CT)</td>
<td><strong>Group 2:</strong> 100% (52/52)</td>
<td>- substantial cross-over</td>
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<td>Duration of follow-up: 48 hours after admission</td>
<td><strong>Group 2:</strong> N: 319</td>
<td><strong>Mean age:</strong> 37 ± 1.01</td>
<td><strong>Subgroup 2:</strong> (c-spine CT)</td>
<td><strong>p value:</strong> &lt;0.001</td>
<td>- not all the outcomes refer to the same groups</td>
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<td>Discount rates: NA</td>
<td><strong>Subgroup 1:</strong> N: 231 (from group 1) + 21 (group 2)</td>
<td><strong>Mean time required for X-ray + mean time for HCT</strong> (total time) (minutes)*</td>
<td><strong>Subgroup 1:</strong> 100% (52/52)</td>
<td><strong>Group 1:</strong> 48 (n=252) + 66 (n=126) = 114</td>
<td>- sensitivity is difficult to interpret because half of the patients had X-ray of the thoracic and lumbosacral spine in addition to c-spine and the reference standard is vague</td>
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<td><strong>Subgroup 2:</strong> N: 297 (group 2) + 20 (group 1)</td>
<td><strong>Mean time required for X-ray + mean time for HCT</strong> (total time) (minutes)*</td>
<td><strong>Group 2:</strong> 100% (52/52)</td>
<td><strong>Group 2:</strong> 18 (n=319) + 42 (n=319) = 60</td>
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<td><strong>Subgroup 1:</strong> X-ray: two-view of the thoracic and lumbosacral spine and three-view cervical spine films.</td>
<td><strong>p value:</strong> &lt;0.001</td>
<td><strong>Group 2:</strong> 100% (52/52)</td>
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<td><strong>Subgroup 2:</strong> Spiral computed tomographic scanning.</td>
<td><strong>Mean Charges</strong> (US $) obtained from the hospital’s charge master list and the professional fee charge list.</td>
<td><strong>Subgroup 1:</strong> $1,462 (£923) (n=20+297)</td>
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<td><strong>Reference standard:</strong> Review of all available outpatient records which identified delayed or missed diagnosis of clinical significance.</td>
<td><strong>Mean Charges</strong> (US $) obtained from the hospital’s charge master list and the professional fee charge list.</td>
<td><strong>Subgroup 2:</strong> $1,462 (£923) (n=20+297)</td>
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<td><strong>Subgroup 2:</strong></td>
<td><strong>Subgroup 1:</strong> $1,462 (£923) (n=20+297)</td>
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<td><strong>Subgroup 1:</strong></td>
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<td>Study details</td>
<td>Patients</td>
<td>Interventions</td>
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<td>Effect size</td>
<td>Comments</td>
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<td><strong>Frank 2002</strong>&lt;sup&gt;95&lt;/sup&gt; USA</td>
<td><strong>Patient group:</strong> children (age 0-17) with suspected cervical spine injury who were intubated at the time of hospital admission and who remained in the intensive care unit for at least 3 days.</td>
<td><strong>Group 1:</strong> Not defined. MRI was performed at an average of 6.8 days after admission (before 1993).</td>
<td><strong>Mean time to cervical spine clearance (days)</strong></td>
<td><strong>Group 1:</strong> 5.1 (n=46)</td>
<td>Funding: none</td>
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<td><strong>Economic analysis:</strong> Cost</td>
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<td><strong>Group 2:</strong> MRI if cervical spine cannot be cleared within 72 hours of hospital admission. MRI was performed at an average of 2.5 days after admission (after 1993).</td>
<td><strong>Group 2:</strong> 3.2 (n=47)</td>
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<td><strong>Study design</strong></td>
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<td>p value: 0.003</td>
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<td>Notes:</td>
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<td>Cohort study (retrospective with historical control)</td>
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<td><strong>Mean intensive unit stay (days)</strong></td>
<td><strong>Group 1:</strong> 9.2</td>
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<td><strong>Duration of follow-up:</strong></td>
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<td><strong>Group 2:</strong> 7.3</td>
<td>p value: 0.122</td>
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<td><strong>NA</strong></td>
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<td>0.106</td>
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<td><strong>Mean hospital stay (days)</strong></td>
<td><strong>Group 1:</strong> 20.1</td>
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<td>N: 51 (31 requiring MRI)</td>
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<td><strong>Group 2:</strong> 15.5</td>
<td>p value: 0.106</td>
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<td>Age (mean): 7.2</td>
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<td>M/F: 37/14</td>
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<td><strong>Positive yield rate of MRI (detection of cervical spine injury)</strong></td>
<td><strong>Group 1:</strong> 3/19 (15.8%)</td>
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<td>Drop outs: 0</td>
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<td><strong>Group 2:</strong> 4/31 (12.9%)</td>
<td>p value: 1</td>
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<td><strong>Group 2:</strong></td>
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<td>N: 51 (31 requiring MRI)</td>
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<td><strong>Mean cost per patient (2000 US$)</strong></td>
<td><strong>Group 1:</strong> $37,400 (£23,674)</td>
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<td>Age (mean): 7.2</td>
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<td><strong>Group 2:</strong> $29,700 (£18,800)</td>
<td>p value: NR</td>
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<td>Drop outs: 0</td>
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<td><strong>Cost-effectiveness</strong></td>
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<td><strong>Grogan 2005</strong>&lt;sup&gt;107&lt;/sup&gt;</td>
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<td></td>
<td><strong>Patient group:</strong></td>
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<td></td>
<td>Group 1: Paralysis due to</td>
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<tr>
<td></td>
<td>Group 1: 0.405%</td>
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</tr>
<tr>
<td>Study details</td>
<td>Patients</td>
<td>Interventions</td>
<td>Outcome measures</td>
<td>Effect size</td>
<td>Comments</td>
</tr>
<tr>
<td>---------------</td>
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</tbody>
</table>
| USA Economic analyses: Cost-effectiveness & Cost-benefit | High risk patients: focal neurological deficit, severe head injury (skull fracture, intracranial haemorrhage, or injury causing unconscious state) or high-energy mechanism (high speed motor vehicle accident or pedestrian struck by car) and age over 50 and Moderate risk patients: high-energy mechanism and age 50 or less, or moderate-energy mechanism (motor vehicle accident of low or unknown speed, motorcycle accident of unknown speed, fall, or bicycle accident) and age over 50. | Plain Radiograph Group 2: Helical CT Scan | undetected cervical spine injuries. | **Group 2:** 0.045%  
*p value:* NR | Office of Academic Affiliations, Department of Veterans Affairs and Vanderbilt University Medical Center.  
**Limitations:**  
1. It did not model the institutional costs of healthcare services related to paralysis.  
2. It did not include the cost of an additional CT scan after plain radiography that would commonly occur among patients with positive films.  
**Notes:**  
The initial indirect costs are assumed to be comparable for the two procedures because they were performed in the same department.  
*Same model as Blackmore (1999)*  
31 |
| Study design Decision analysis* | | | Mean cost per patient US $ | With litigation costs  
**Group 1:** $2,142 (£1,353)  
**Group 2:** $554 (£350)  
P value: NR | |
| Time horizon: Not defined | | | **Without litigation costs**  
**Group 1:** $120 (£76)  
**Group 2:** $329 (£208)  
P value: NR | |
| Discount rates: NA | | | **Cost-effectiveness**  
Cost-benefit analysis (imaging and litigation costs):  
Helical CT is cost-beneficial (direct plus indirect costs are lower)  
Cost-effectiveness analysis (imaging costs only):  
$58,056 (£36,660) per paralysis averted | |
| | | | **Sensitivity analysis**  
One-way sensitivity analysis (probabilities and costs were varied).  
Threshold analysis | CT scan is the least costly strategy if a) threshold values exceed $58,180 for institutional settlement costs, b) there is only a 0.9% probability of c-spine fracture, or c) there is only a 1.7% probability of paralysis from a missed cervical fracture.  
Plain radiograph is the least costly if CT scan costs surpass $1,918 or if plain radiograph sensitivity exceeds 90%.  
*Same model as Blackmore (1999)* | 31 |
<table>
<thead>
<tr>
<th>Study details</th>
<th>Patients</th>
<th>Interventions</th>
<th>Outcome measures</th>
<th>Effect size</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>McCulloch 2005&lt;sup&gt;188&lt;/sup&gt; USA</td>
<td><strong>Patient group:</strong> Adult patients presenting to a level I trauma centre because of either priority I or II high-energy trauma.</td>
<td><strong>Intervention 1:</strong> Standard plain three-view radiographs of the cervical spine</td>
<td>Specificity in identifying any fracture, subluxation, or dislocation in the occiput, cervical spine, or T1 vertebra (excluding inadequate plain x-rays)</td>
<td>Intervention 1: 97% (98%) Intervention 2: 98% p value: p &gt; 0.99</td>
<td>Funding: John Michael Moore Trauma Center, West Virginia University.</td>
</tr>
<tr>
<td>Economic analysis: Cost-accuracy</td>
<td></td>
<td><strong>Intervention 1b:</strong> Standard plain three-view radiographs of the cervical spine (and then HCT if radiograph is inadequate)</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Study design</td>
<td><strong>All patients</strong> N: 407 Mean age (Range): 40 (18-91) M/F: 273/134 Drop outs: 0</td>
<td><strong>Intervention 2:</strong> HCT scan of the cervical spine</td>
<td></td>
<td></td>
<td>Limitations: 1. Patients in the sample were not consecutive. 2. Possible selection bias: it was reported that ISS scores were higher than the usual caseload 3. The reference standard incorporates the results of the two diagnostic tools. 4. Proportion of patients with HI not reported</td>
</tr>
<tr>
<td>Duration of follow-up: NA</td>
<td>Reference standard: Two radiologists independently reviewing both the HCT and plain x-ray results plus reference to hospital case notes (e.g. results of MRI)</td>
<td></td>
<td></td>
<td></td>
<td>Additional outcomes: Mean minutes in the radiology suite: HCT was faster than plain radiography. * Estimated by NCC from study data</td>
</tr>
<tr>
<td>Discount rates: NA</td>
<td></td>
<td>Sensitivity</td>
<td>Intervention 1: 45% (52%) Intervention 2: 98% p value: p &lt; 0.001</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Positive predictive value</td>
<td>Intervention 1: 74% (81%) Intervention 2: 89% p value: p &lt; 0.001</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Negative predictive value</td>
<td>Intervention 1: 91% (93%) Intervention 2: 99.7% p value: p &lt; 0.001</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Number of cases detected</td>
<td>Intervention 1: 26/58 Intervention 1b: 46/58* Intervention 2: 57/58</td>
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<tr>
<td></td>
<td></td>
<td>Mean cost per patient</td>
<td>Radiology charges 2004 US$ including charge for the radiologist’s review.</td>
<td>Intervention 1: $ 268 Intervention 1b: $ 870 Intervention 2: $ 1151 p value: NR</td>
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<tr>
<td></td>
<td></td>
<td>Cost-effectiveness Incremental cost per case detected*</td>
<td>1b vs 1: $12,251 (£7,736) 2 vs 1b: $10,397 (£6,565) 1b is excluded due to extended dominance 2 vs 1: $11,593 (£7,320)</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Sensitivity analysis</td>
<td>NR</td>
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</tbody>
</table>
# Data extraction for papers describing rules for diagnosis of cervical spine injury

<table>
<thead>
<tr>
<th>Names and evidence level</th>
<th>Rule description</th>
<th>Participants</th>
<th>Outcome measures</th>
<th>Specificity</th>
<th>Sensitivity</th>
<th>Investigatio n ordering rate</th>
<th>Prevalence</th>
<th>Derived using primary data</th>
<th>Derived using prospect. data</th>
<th>Validated using primary data</th>
<th>Validated using prospect. data</th>
<th>Multi-variate modelling</th>
<th>follow-up</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Panacek et al for NEXUS group (2001)</td>
<td>Sub-study of NEXUS database to look at each of the 5 criteria identified in the NEXUS study</td>
<td>N=34,069</td>
<td>Any C-spine fracture on plain radiography</td>
<td>12.9% (95% CI: 12.8 - 13.0%)</td>
<td>99.6% (95% CI: 98.6% - 100%)</td>
<td>87% of patients require 3 view imaging</td>
<td>818 (2.4%) patients had a cervical spine injury</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>As for NEXUS study Paper is a sub-study of NEXUS study further demonstrating that their 5 criteria are the optimal tool for detecting C-spine injury</td>
<td></td>
</tr>
</tbody>
</table>
Prospective multicentre observational cohort study. Absence of the 5 criteria are identified to classify the patient as low risk: No midline cervical tenderness, No focal neurologic deficit, Normal alertness, No intoxication, No painful distracting injury. 

N=34,069 patients who underwent imaging.

Findings as diagnosed after 3 view plain radiography (lateral view, antero-posterior and odontoid peg views):

- Cervical spine injury
- Significant cervical spine injury

Gold standard: Results of plain radiography and absence of injury on follow up.

12 participants had a cervical spine injury: 818 (2.4%) patients had a cervical spine injury. 578 (1.7%) patients had a clinically significant cervical spine injury.

87% of patients require 3 view imaging. 

818 (2.4%) patients had a cervical spine injury: 

- 578 (1.7%) patients had a clinically significant cervical spine injury.

Yes Yes Yes Yes Yes 

Records of all centres were reviewed to find any evidence of missed fractures in patients who had not been imaged. 

557 plain radiographs had inadequate views. Radiographs interpreted by a designated radiologist at each site. 

Power study performed – 737 cervical injuries to require confidence intervals of 0.5% or less. This study did not achieve this number in significant cervical spine injuries. 

Of the two clinically significant missed fractures: 

1 had an extension-teardrop fracture and self discharged. He was well at 6 months. 

1 had fracture of right lamina of 6th cervical vertebra requiring open fixation, but may have been incorrectly classified by the institution as he had loss of consciousness and neurology. 

2 patients were categorised by rule as high risk but fractures were initially missed on plain radiography. 

Only 498 of the 818 cervical spine abnormalities were found by plain radiographs. 

Stiell et al investigated the NEXUS criteria in their population of 8924 patients and found 10 of 148 important injuries were missed giving a sensitivity of 93%. 

They also critique the NEXUS rule for the...
Mower et al for NEXUS group (2001)\(^2\)

<table>
<thead>
<tr>
<th>Level of evidence</th>
<th>Well conducted study</th>
</tr>
</thead>
</table>

436 missed injuries in 237 patients were in cases where plain radiography was abnormal or inadequate. But 23 patients were missed with adequate films. Only 498 of the 818 cervical spine injuries were found on plain radiographs. N=34,069 patients who underwent imaging. All levels of alertness. Symptomatic and asymptomatic. Adults and children. 21 USA hospitals. Consecutive. Findings as diagnosed after 3 view plain radiography (lateral view, antero-posterior and odontoid peg views): Cervical spine injury. Significant cervical spine injury. Gold standard: Results of plain radiography and absence of injury on follow up. Not appropriate in this paper. Not appropriate in this paper. Not appropriate in this paper. 23 patients had injuries that were not visualised on adequate plain film imaging including 3 potentially unstable injuries. Yes. Yes. Yes. Yes. No. Records of all centres were reviewed to find any evidence of missed fractures in patients who had not been imaged. Paper illustrating a major weakness in the NEXUS study.
Prospective exploratory cohort study

Level 2 evidence

Well conducted exploratory study

4 factors were identified that could predict the presence of cervical fracture in alert patients:

- Midline neck tenderness
- Evidence of intoxication
- Altered level of alertness
- Severely painful injury elsewhere

No combinations of symptoms and signs predicted all C-spine injuries but altered level of alertness and midline tenderness identified 25 of 27 fractures.

<table>
<thead>
<tr>
<th>C-spine fracture on plain radiography</th>
<th>Gold standard: Results of plain radiography and absence of injury on follow up</th>
</tr>
</thead>
<tbody>
<tr>
<td>57.3% 95% CI: 34-40%</td>
<td>100% 95% CI: 87-100%</td>
</tr>
</tbody>
</table>

Rate with this rule would be 63%.

| Yes | Yes | No | No | No |

2.7% 27 fractures

Hospital records of radiology reports were checked.

Risk management records of potential missed fractures were searched.

All final discharge diagnoses were searched.

26 incomplete records were excluded from analysis (no fractures in this group).

1,342 c-spine films were taken during the study period, and there were 31 cervical fractures of which 27 were in this study. 2 of the missed C-spine fractures were not seen in A&E and 2 were not entered into the study-retrospectively reviewed and deemed to have one of the risk factors.

Paper criticizes itself in the discussion for low rate of C-spine fractures leading to wide confidence intervals. They suggest that their power study indicated a number of 7000 patients.

Number of views taken is not clear.

No comment on quality of films or if C7/T1 junction always visualised.

He describes his intent to set up the NEXUS study.
### Head Injury Update Full Guideline: Draft for Consultation (Feb 2007)

<table>
<thead>
<tr>
<th>Pollack et al (2001) For NEXUS&lt;sup&gt;239&lt;/sup&gt;</th>
<th>Prospective multi-centre observational cohort study secondary analysis: to assess the utility of flexion extension views.</th>
<th>Flexion/extension views should be delayed until 10-14 days after injury and MRI should be used to evaluate possible ligamentous instability.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Level 2 evidence</strong></td>
<td>Well conducted observational study</td>
<td></td>
</tr>
<tr>
<td><strong>N=818 patients with a fracture</strong></td>
<td>Cervical injury diagnosed on flexion extension views that were not seen on plain imaging.</td>
<td>Gold standard: Results of all types of radiography and absence of injury on follow up.</td>
</tr>
<tr>
<td>All levels of alertness</td>
<td>All levels of alertness</td>
<td></td>
</tr>
<tr>
<td>Symptomatic and asymptomatic adults and children</td>
<td>Symptomatic and asymptomatic adults and children</td>
<td></td>
</tr>
<tr>
<td>21 USA trauma centres</td>
<td>21 USA trauma centres</td>
<td></td>
</tr>
<tr>
<td>This sub analysis is non-Consecutive in that it is only the fracture patients.</td>
<td>This sub analysis is non-Consecutive in that it is only the fracture patients.</td>
<td></td>
</tr>
</tbody>
</table>

| Not applicable | Not applicable | 66 of 818 patients with a fracture had F/E views | 0.7% of 818 patients who had a cervical spine injury had an injury seen only on the flexion extension views. 86 F/E views had been requested in this group. All these (4) fractures were stable. | Yes | Yes | No | No | No | No | Hospital records of radiology reports were checked | Risk management records of potential missed fractures were searched | All final discharge diagnoses were searched | The number of negative F/E views performed in the whole population of 34,000 patients was not assessed | 4 of 16 subluxations were also only seen on F/E views, but the plain imaging had other abnormalities that required imaging by CT/MRI which would therefore have resulted in their detection. |

---

352
Stiell et al (2001)^353

Level 2 evidence

N.B. validation study is in press

Well conducted derivation cohort study

3 questions were derived for categorisation of patients:

1. This there any high risk factor present that mandates radiography: age >65, dangerous mechanism, or paraesthesia in the extremities?

2. Is there a low risk factor present that allows the safe assessment of range of motion (i.e. simple rear-end motor vehicle collision, sitting position in ED, ambulatory at any time since injury, delayed onset of neck pain, absence of midline C-spine tenderness?  

3. Is the patient able to actively rotate neck to 45 degrees to the left and right?

| N= 8924 patients who underwent imaging | Important cervical spine injury on 3 view plain radiography | 42.5% | 95% CI: 40-44% | 100% | 95% CI: 98-100% | 151 (1.7%) had clinically important cervical spine injury. | Yes | Yes | No | No | Yes |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Alert, GCS 15 and cardiovascular stability | Symptomatic and asymptomatic | 42.5% | 95% CI: 40-44% | 100% | 95% CI: 98-100% | 151 (1.7%) had clinically important cervical spine injury. | Also 28 unimportant injuries were found | Yes | Yes | No | No | Yes |
| Adults over 16 years old | 10 large community and university hospitals | Consecutive | In addition the rule would find 27 of the 28 unimportant cervical spine injuries | Gold standard: Results of plain radiography and absence of injury on follow up | 4.5% of patients that were not traced by telephone were not further investigated. Coroners records or the records of other hospitals could have been checked. If you assume that this group has the same incidence of fracture as the study cohort then 577 x 1.7% = 10 patients would have been missed. If the incidence was actually 10 times less than the cohort 1 patient would still have been missed. |

100% 95% CI: 98 - 100%

In addition the rule would find 27 of the 28 unimportant cervical spine injuries

100% 95% CI: 98 - 100%

In addition the rule would find 27 of the 28 unimportant cervical spine injuries

100% 95% CI: 98 - 100%

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100% 95% CI: 98 - 100%

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100% 95% CI: 98 - 100%

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100% 95% CI: 98 - 100%

In addition the rule would find 27 of the 28 unimportant cervical spine injuries
<table>
<thead>
<tr>
<th>Author et al.</th>
<th>Study Design</th>
<th>Patient Population</th>
<th>Cervical Spine Injury</th>
<th>Rule</th>
<th>Follow-up</th>
<th>Conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roberge et al (1988)</td>
<td>Prospective observational cohort study</td>
<td>Alert trauma victims with no complaints of neck discomfort upon questioning and with no tenderness on neck palpation need not undergo Cervical Spine radiography.</td>
<td>N=467</td>
<td>45%</td>
<td>89%</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>All levels of alertness</td>
<td>Cervical spine injury</td>
<td>Gold standard: 5 view cervical spine radiographs interpreted by radiographer, or positive follow up</td>
<td>95% CI: 45-50%</td>
<td>95% CI: 55-100%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Symptomatic and asymptomatic Adults over 16 years old</td>
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<td></td>
<td></td>
<td>Single USA level 1 trauma centre</td>
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<td></td>
<td></td>
<td>Consecutive</td>
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<tr>
<td>Roth et al (1994)</td>
<td>Prospective observational study</td>
<td>Rule Blunt trauma patients do not require cervical imaging if they have: Absence of mental status changes, intoxication, neck pain or tenderness, neurologic signs or symptoms, or simultaneous major distracting injury.</td>
<td>N=682 (96 Alert and Asymptomatic patients presumed to be adults)</td>
<td>11%</td>
<td>2%</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Single Hawaiian military hospital</td>
<td>Cervical spine injury</td>
<td>Gold standard: All patients received plain 3 view imaging and follow up (see later)</td>
<td>100%</td>
<td>100% of patients were imaged in this study.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Consecutive</td>
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</tbody>
</table>

Well-conducted study but low number of positive patients has resulted in an underpowered conclusion.
<table>
<thead>
<tr>
<th>Study</th>
<th>Design</th>
<th>Population</th>
<th>Outcome</th>
<th>Sensitivity</th>
<th>Specificity</th>
<th>False Positive Rate</th>
<th>False Negative Rate</th>
<th>Follow-up</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Edwards et al (2001)</td>
<td>Prospective observational cohort study</td>
<td>N=599 low risk patients out of a population of 1757 GCS &gt;13</td>
<td>Cervical spine injury after 3 view radiography</td>
<td>31% (537/1719)</td>
<td>100%</td>
<td>0%</td>
<td>0%</td>
<td>3 to 6 months after discharge by clinic visit or telephone. Success of follow up not stated</td>
<td>1/3rd of the total population group was excluded from the low-risk study group from finding on history or examination. This group contained 50% of cervical spine injuries. Success of follow-up not given.</td>
</tr>
<tr>
<td>Ptak et al (2001)</td>
<td>Retrospective cohort study</td>
<td>N= 676</td>
<td>Fracture on helical CT scanning</td>
<td>100%</td>
<td>98.3</td>
<td>100%</td>
<td>0%</td>
<td>Yes, there was note review of on ward progress</td>
<td>1 patient had a negative CT but had further neck pain and repeat imaging found an undisplaced type II fracture of the odontoid peg</td>
</tr>
<tr>
<td>Reference</td>
<td>Study Design</td>
<td>Setting</td>
<td>Methods</td>
<td>Patients</td>
<td>Control</td>
<td>Follow-up</td>
<td>Findings</td>
<td>Notes</td>
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<tr>
<td>Fischer et al (1984)</td>
<td>Retrospective cohort study</td>
<td>Alert patients after head injury with class 1 level of consciousness but without signs or symptoms of cervical injury do not require cervical radiographic evaluation.</td>
<td>N=333 with blunt head trauma Class 1 level of consciousness Symptomatic and asymptomatic Children and adults (22mths to 77yrs) Single USA hospital Consecutive</td>
<td>Cervical spine injury Gold standard: Cervical spine injury on plain radiographs or cervical injury on follow up</td>
<td>Not evaluated Not evaluated</td>
<td>5 of 333 had cervical injury (1.5%) all were symptomatic</td>
<td>Yes No No No No</td>
<td>3 year follow up of all patients Note the protocol in their department was for C-spine imaging for all people with head injury that are admitted for observation. But only 68% of patients had this protocol followed in this study. The exact number of followed up patients were not described.</td>
<td></td>
</tr>
<tr>
<td>Macdonald et al (1990)</td>
<td>Retrospective observational cohort study</td>
<td>Single lateral C-spine radiograph is not adequate to exclude cervical injury in patients after Motor Vehicle Accidents. Cervical clearance can be obtained by 3-view plain radiography, but there is still a 1% chance of missing significant injury</td>
<td>N=775 patients post MVA All levels of alertness Symptomatic and asymptomatic Adults over 18 years old Single USA regional trauma unit Consecutive</td>
<td>Cervical injury on 3-view radiography Gold standard: Cervical injury on all radiography performed And clinical follow up</td>
<td>97% 85% Not applicable</td>
<td>92 out of 775 (12%)</td>
<td>Yes No No No No</td>
<td>All patients are routinely followed up by neurosurgeons. Although they do not state the number of patients that were verified as asymptomatic Minimal clinical details were taken regarding the patient’s history and examination even though 50% of these patients were GCS 15.</td>
<td></td>
</tr>
</tbody>
</table>
### Gonzalez et al (1999)<sup>103</sup>

**Level 2 evidence**  
Well conducted derivation cohort study

| Prospective observational cohort study | Derived rule: Clinical examination of the neck can reliably rule out significant cervical injury in the awake and alert blunt trauma patient. The addition of a lateral Cervical spine X-ray is of no use. Elevated ethanol level is not a contraindication to this rule. | N=2176 | Results of clinical examination and lateral C-spine radiograph  
Gold Standard: Results of all imaging. Other investigations were only ordered if the lateral image was inadequate. Results of follow up | 82% (1765/2143) | 91% (30/33) | 18% | 33 of 2176 (1.6%)  
3 had negative clinical examination  
Elevated ethanol level is not a contraindication to this rule. | Yes | Yes | No | No | No | All patients admitted for 24 hours. Had repeat neck examination prior to discharge, and outpatient follow up was also performed. |
|---|---|---|---|---|---|---|---|---|---|---|---|

### Ross et al (1992)<sup>256</sup>

**Level 2 evidence**  
Well conducted observational study

| Prospective observational study  
Immediate radiographic investigation of the cervical spine is mandatory in all patients with: Loss or defect in conscious level, neurological deficit, neck tenderness. Imaging is not necessary in the absence of these signs. | N=410 | Cervical injury on 3 view plain radiography  
Gold standard: Positive radiological findings or positive findings at follow up | 49% (196/397) | 100% | 51% (13/25) | 13 out of 410 (6%) had unstable injuries. | Yes | Yes | No | No | No | All patients were followed up for at least 2 weeks after discharge  
Number of patients successfully followed up not stated |
Hanson et al (2000) evidence

Level 3 evidence

No universally applied gold standard

Retrospective validation study

Decision rule:

High risk patients for Helical CT scanning:

1. High-speed (>35mph combined impact) motor vehicle accident.
2. Crash with death at scene of motor vehicle accident
3. Fall from height >3m
4. Significant closed head injury (of ICH on CT)
5. Neurologic symptoms or signs referred to the cervical spine.
6. Pelvic or multiple extremity fractures.

Note all patients receive plain radiography even if prior to Helical CT

Patients only have Helical CT if also undergoing Head CT

N=4285
All levels of alertness
Symptomatic and asymptomatic
Adults over 16 years old
Single USA trauma centre
Consecutive

C-spine fracture on helical CT
Cervical Spine fracture on plain radiography

87% 92%
601 underwent helical CT
the remainder had Plain radiography, 462 of 4146 direct presentations

47 of 4146 1%
Yes
No – article states that rule derived by published and retrospective data
Yes
No – the discussion states that the extraction of clinical data from the notes was retrospective
No

Patient data was obtained retrospectively. No attempts at follow up of those not undergoing Helical CT are documented

107 (23%) had helical CT without an indication by their criteria

Abnormality rate in the low risk group was 0.2% (all low risk patients had plain imaging)

7 out of the 3684 who only had plain radiography had a cervical spine injury. But these patients were not followed up and no gold standard was applied to them to exclude a missed fracture.

The additional fractures revealed by CT were 11 upper thoracic spine fractures 32 proximal rib fractures 12 skull base fractures 1 mandibular fracture and Hyoid fracture.
### Study Admits to Being Underpowered

- **Level 3 evidence**
- Prospective observational study
- The absence of neck discomfort, tenderness or neurological deficits does not exclude cervical spine injury.

<table>
<thead>
<tr>
<th>Study Details</th>
<th>N</th>
<th>All levels of alertness (considered separately)</th>
<th>Symptomatic Adults over 16 years</th>
<th>Asymptomatic Adults over 16 years</th>
<th>Single USA trauma centre Consecutive</th>
<th>Cervical spine injury</th>
<th>Gold standard: Cervical spine injury as diagnosed by a radiologist after 5 view plain radiography</th>
<th>17 had cervical spine injury (3.5%)</th>
<th>Yes</th>
<th>Yes</th>
<th>No</th>
<th>No</th>
<th>No</th>
<th>No</th>
<th>Discharged patients were scheduled for follow up by their own private physician or surgery clinic. Their good outcome was not verified by this study.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Bayless et al (1989)</strong></td>
<td>N=176</td>
<td>All levels of alertness</td>
<td>Symptomatic Adults and children over 12 years old</td>
<td>Asymptomatic Adults and children over 12 years old</td>
<td>Single USA county hospital Consecutive</td>
<td>Cervical spine injury on plain radiography</td>
<td>Gold standard: injury on plain radiography or abnormality after 24 hours admission</td>
<td>3 cervical spine injury (1.7%)</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>All patients admitted for 24 hours. Clinical records were reviewed to look for readmission. Only 3 fractures found in this study. No power study is presented and therefore the null findings are not supported by the authors statistical confidence in these findings.</td>
</tr>
<tr>
<td>Study</td>
<td>Design</td>
<td>N=216</td>
<td>Asymptomatic and alert</td>
<td>Method for identifying cases</td>
<td>Gold standard</td>
<td>Radiography</td>
<td>Fractures</td>
<td>Subluxations</td>
<td>Retrospective analysis of case notes to determine the presence of clinical symptoms and signs on presentation to the emergency department. However these 'asymptomatic' patients still had further imaging after plain radiography so there must have been clinical indications for these.</td>
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<tr>
<td>Woodring et al (1993)</td>
<td>Retrospective cohort</td>
<td>87%</td>
<td></td>
<td>Cervical spine injury Method</td>
<td></td>
<td></td>
<td>33%</td>
<td>55%</td>
<td>85% of fractures deemed to be present on the plain films retrospectively.</td>
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<td></td>
<td>Cervical radiography</td>
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<td>cannot be relied upon</td>
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<td>High risk patients</td>
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<td>Gold standard: 100% of</td>
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<td>and all those with</td>
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<td>positive or</td>
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<td>lateral AP and</td>
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<td>inconclusive plain</td>
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<td>odontoid views.</td>
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<td>films should all have</td>
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<td>100% received CT scanning.</td>
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<td>CT scanning</td>
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<td>Films assessed independently by two radiologists</td>
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</table>

360
**Harris et al. (2000)**

Level 3 evidence

This study acknowledges that it is underpowered

<table>
<thead>
<tr>
<th>Study Design</th>
<th>N=153</th>
<th>Cervical Injury</th>
<th>Gold standard?</th>
<th>Patients who could not be cleared due to altered sensorium, significant distracting injuries, or intubation.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prospective validation cohort study</td>
<td></td>
<td>Patients who could not be cleared due to altered sensorium, significant distracting injuries, or intubation.</td>
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<tr>
<td>Protocol for patients with polytrauma, closed head injury or distracting injuries: C-spine trauma series, lateral, AP, Dens.</td>
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<td>No surgery indicated: Remain in collar until MRI performed.</td>
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<tr>
<td>If normal:</td>
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<td>Single USA trauma centre</td>
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<tr>
<td>SURGERY indicated</td>
<td></td>
<td>CT scan of C-spine. If C7-T1 junction not visualised: Fluoroscopic intra-operative stretch test, followed by F/E views if stretch test negative</td>
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<tr>
<td>Only 3 occult spinal injuries were found.</td>
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<td>No questionnaires of 550 surgeons in USA</td>
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</tbody>
</table>
| All were inpatients. No outpatient follow up described |  | No

The study states that their protocol has not yet recruited enough patients to validate this protocol. Therefore this paper is acknowledged to be underpowered.
| Holliman et al (1991) | Retrospective cohort study | Non-consecutive | N=148 | All levels of alertness | Symptoms not reported | Age 1-89 years | Single USA level 1 trauma centre and a rehabilitation centre | Cervical fracture on lateral, odontoid peg and antero-posterior views | Gold standard: All images reviewed by a radiologist blinded to the original diagnosis | N/A | N/A | N/A | 100% | Yes | No | No | No | No | None although all imaging and inpatients progress was collated | Small study only, no power study or confidence limits constructed to provide further evidence for not performing Antero-posterior radiography. |

362
<table>
<thead>
<tr>
<th>Barba et al (2001)</th>
<th>Retrospective observational cohort study</th>
<th>Level 3 evidence</th>
<th>Non universal gold standard</th>
<th>N=324</th>
<th>All levels of alertness</th>
<th>Symptomatic and asymptomatic</th>
<th>Gold standard: No uniform gold standard. Protocol was followed but negative results were not followed up</th>
<th>N/A</th>
<th>N/A</th>
<th>N/A</th>
<th>15 cervical spine injuries (4.6%)</th>
<th>Yes</th>
<th>Yes</th>
<th>Yes – the EAST guidelines were used except for CT after Head CT.</th>
<th>Yes</th>
<th>No</th>
<th>No</th>
<th>Not described</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alert patients with no neurology, alcohol or distracting injury may have their C-spine cleared clinically</td>
<td>Any patients not satisfying above criteria but not needing head CT should have 3 view plain imaging and CT of any unclear areas</td>
<td>Any persisting cervical pain should also have flexion-extension views</td>
<td>Any further persisting pain or neurology should have MRI scan</td>
<td>All of the above is in accordance with the EAST protocol In addition: All those undergoing a Head CT should also have a full helical CT scan of the C-spine, and lateral plain radiography</td>
<td>Their conclusion is that CT scanning using their protocol saves 17 minutes in the clearance of the C-spine</td>
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<td>Yes - the EAST guidelines were used except for CT after Head CT.</td>
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<td>6 patients had an injury detected only on CT scanning and not on plain radiography</td>
<td>Out of 316 patients 7% had C-spine cleared clinically, 45% cleared by 3-view radiography. (Although 30% of this group then needed CT to clarify poorly visualised areas) 47% had lateral radiography and CT</td>
<td>This paper’s main conclusions are that patients undergoing a Head CT should also have a C-spine CT and that this would save 17 minutes in assessment.</td>
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</table>

- N=740 patients with cervical injury
- All levels of alertness
- Symptomatic and asymptomatic
- Adults over 18 years old
- 1 level 1 and 5 level 2, USA trauma centres.
- Non-consecutive.
- Cervical injuries were found on a database of admitted patients.

<table>
<thead>
<tr>
<th>Missed cervical spine injury in admitted patients defined as diagnosis being made after cervical immobilisation had been removed (but prior to discharge)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gold standard: Discharge without missed fracture discovered in clinical records</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Not appropriate for this type of study</th>
<th>Not appropriate for this type of study</th>
<th>Not appropriate for this type of study</th>
<th>34 of 740 cervical injuries had a delayed diagnosis (4.6%)</th>
<th>Yes</th>
<th>No</th>
<th>No</th>
<th>No</th>
<th>No</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>This study describes the reasons for missed cervical spine fracture</td>
<td>No search for readmission seems to have been done. No search for those who may have been discharged with missed injury has been done</td>
<td>No rule described</td>
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</table>
Link et al (1994- in German) and (1995)176,177

Level 3
Non-consecutive study

Study to evaluate the usefulness of routine CT of the cranio-cervical junction in unconscious patients with severe head injury. 28 patients had a C-1 or C-2 fracture, and 11 of these were missed on plain radiographs. Recommend CT of cranio-cervical junction in all patients with severe head trauma.

N=202 patients with substantial cranial trauma GCS 3-6 Without obvious symptoms indicating cervical trauma Age 3-86 Single German hospital

N/A N/A 100% CT 18.3% atlas, axis or occipital condyle fractures. Yes Yes No No No None described Unclear as to what percentage of patients had plain radiography.


Level 3 evidence
Non-consecutive study

Retrospective cohort study MRI is the investigation of choice after primary imaging except if the patient is undergoing CT for other reasons

N=39 Case mix unknown Ages unknown Single German hospital Non-consecutive

Cervical injury on CT or MRI scan Gold standard Results from CT or MRI only, follow up unknown

N/A N/A N/A 100% Yes No NO No No Unknown CT found 100% of all osseous injuries but only 33% of longitudinal ligament injuries MRI identified all the soft tissue injuries but only 50% of C2 fractures, 89% of transverse process fractures, 92% of lamina fractures

This paper is in German.
<table>
<thead>
<tr>
<th>Author(s)</th>
<th>Evidence Level</th>
<th>Study Design</th>
<th>Setting</th>
<th>Population</th>
<th>Inclusion Criteria</th>
<th>Exclusion Criteria</th>
<th>Imaging</th>
<th>Findings</th>
<th>Conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Borock et al (1991)&lt;sup&gt;36&lt;/sup&gt;</td>
<td>Level 3 evidence</td>
<td>Prospective observational cohort study</td>
<td>N=179 alert symptomatic after negative plain radiography, or where radiographs are inconclusive, inadequate or suggestive of cervical injury, CT scanning is 100% sensitive at detecting cervical injury</td>
<td>N=179</td>
<td>Cervical spine injury Gold standard: Cervical injury on plain radiography or CT scan</td>
<td>Not applicable</td>
<td>Not applicable</td>
<td>100% CT for all inconclusive plain radiographs or continued symptoms</td>
<td>41 of 179 were symptomatic after negative plain radiography or where radiographs are inconclusive, inadequate or suggestive of cervical injury. CT scanning is 100% sensitive at detecting cervical injury. The conclusion that plain radiography does not find all cervical injuries is a legitimate conclusion, but the conclusion that CT scanning is 100% sensitive is unsound as CT scanning was the gold standard and no further follow up or imaging was universally applied or described.</td>
</tr>
<tr>
<td>Kreipke et al (1989)&lt;sup&gt;169&lt;/sup&gt;</td>
<td>Level 3 evidence</td>
<td>Prospective observational cohort study</td>
<td>Cervical spine radiography should be performed in patients with abnormal neurologic findings or symptoms referable to the neck. In alert asymptomatic patients, cervical spine radiography may be omitted.</td>
<td>N=860</td>
<td>Cervical spine fracture Gold standard: Findings on lateral, A-P, open mouth and Weir pillar views interpreted by one of the three radiologist authors of this paper.</td>
<td>39% (324/836)</td>
<td>100%</td>
<td>Their ordering rate would be 62% with this rule.</td>
<td>24 out of 860 had fracture or dislocation (2.8%)</td>
</tr>
</tbody>
</table>

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366
<table>
<thead>
<tr>
<th>Reference</th>
<th>Study Type</th>
<th>Study Design</th>
<th>Study Details</th>
<th>N (Patients)</th>
<th>Follow-up</th>
<th>Sensitivity</th>
<th>Specificity</th>
<th>Positive Predictive Value</th>
<th>Negative Predictive Value</th>
<th>Conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jen et al (2001)</td>
<td>Retrospective cohort</td>
<td>Plain radiography is less sensitive than helical CT scanning and should therefore be considered to be the standard modality in these cases</td>
<td>Fracture of 4 view plain radiography</td>
<td>N=604</td>
<td>Yes</td>
<td>33%</td>
<td>N/A</td>
<td>30/604 (5%)</td>
<td>30/604 (5%)</td>
<td>Not given</td>
</tr>
<tr>
<td>Schnarkowski et al (1991)</td>
<td>Retrospective cohort</td>
<td>To rule out cervical injuries in patients with incomplete visualisation of the cervical spine, cervical CT should be performed in addition to 3 view radiographs</td>
<td>Fracture on Plain radiography or CT</td>
<td>N=100</td>
<td>Yes</td>
<td>Unclear</td>
<td>Unclear</td>
<td>15/100 (15%)</td>
<td>85/90 (95%)</td>
<td>15/100 (15%)</td>
</tr>
<tr>
<td>Neifeld et al (1988)</td>
<td>Prospective observational cohort study</td>
<td>All patients with altered mental status, abnormal examination findings distracting injury, or pain or tenderness over the cervical spine need plain radiography. Asymptomatic patients or those with tenderness limited to the trapezius may be cleared clinically.</td>
<td>Cervical spine fracture or dislocation</td>
<td>N=886</td>
<td>Yes</td>
<td>95%</td>
<td>All patients were radiographed in this study. Rule would require 73% plain radiography</td>
<td>28 out of 886 (3%)</td>
<td>28 out of 886 (3%)</td>
<td>Yes</td>
</tr>
</tbody>
</table>

*Note: This table summarizes findings from various studies on the use of plain radiography versus helical CT scanning in the diagnosis of cervical spine injuries.*
<table>
<thead>
<tr>
<th>Reference</th>
<th>Study Type</th>
<th>Setting</th>
<th>Number (Type)</th>
<th>Findings</th>
<th>Rule</th>
<th>Gold Standard</th>
<th>Ordering Rate (%)</th>
<th>Fractures (Type)</th>
<th>Follow Up</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baker et al (1999)</td>
<td>Case series of cervical spine injury</td>
<td>N=72</td>
<td>Not possible in this study type</td>
<td>Radiographs fail to detect all injuries in conjunction with high risk mechanism</td>
<td>Gold standard: None</td>
<td>63% (178/281)</td>
<td>5 fractures (1.7%)</td>
<td>Yes</td>
<td>No</td>
<td>This paper is a case series of positive injuries only</td>
</tr>
<tr>
<td>McNamara et al (1990)</td>
<td>Retrospective observational cohort study</td>
<td>N=286</td>
<td>100%</td>
<td>Cervical spine fracture</td>
<td>Gold standard: The radiologists interpretation of all cervical radiography or other diagnostic imaging</td>
<td>Would require a 63% ordering rate</td>
<td>No follow up (see notes)</td>
<td>115 patients excluded due to poor documentation, inadequate follow up</td>
<td>45% of the asymptomatic patients had any imagines and 57% of these were just single lateral c-spine views. Gold standard not applied to large number of patients.</td>
<td></td>
</tr>
<tr>
<td>Study</td>
<td>Level of Evidence</td>
<td>Evidence Quality</td>
<td>Study Design</td>
<td>Inclusion Criteria</td>
<td>Cervical Injury Gold Standard</td>
<td>Sensitivity</td>
<td>Specificity</td>
<td>Positive Predictive Value</td>
<td>Follow-up</td>
<td>Follow-up Details</td>
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<tr>
<td>McNamara et al (1988)</td>
<td>4</td>
<td>4</td>
<td>Prospective observational cohort study</td>
<td>Adult only; all levels of alertness; symptomatic and asymptomatic</td>
<td>Plain radiography and post discharge follow up.</td>
<td>100%</td>
<td></td>
<td></td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Bachulis et al (1987)</td>
<td>4</td>
<td>4</td>
<td>Retrospective review of a trauma database of 4941 patients and description of those with fracture</td>
<td>Adult only; all levels of alertness; symptomatic and asymptomatic</td>
<td>Fracture on plain films or follow up</td>
<td>99%</td>
<td>40%</td>
<td>94/1823 (5%)</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Study</td>
<td>Design</td>
<td>Sample size</td>
<td>Levels of alertness</td>
<td>Symptomatic &amp; asymptomatic</td>
<td>Age stated</td>
<td>Study centre</td>
<td>Gold standard</td>
<td>N (%) with cervical spine injury</td>
<td>Predictive factors</td>
<td>Imaging performed</td>
</tr>
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<tr>
<td>Williams et al (1992)&lt;sup&gt;13&lt;/sup&gt; Level 4 evidence Inconsistent reference standards</td>
<td>Retrospective observational cohort study Trauma to the head, face or clavicles is not associated with higher rate of C-spine injury. GCS less than 14 is associated with an increased risk of injury No rule derived</td>
<td>N=5021 All levels of alertness Symptomatic and asymptomatic Age not stated Single USA level 1 trauma centre Consecutive</td>
<td>Cervical spine injury as coded by ICD-9 on database. Gold Standard: None</td>
<td>No rule</td>
<td>No rule</td>
<td>Not studied</td>
<td>227 had cervical spine injury (4.5%) GCS 14 and 15 – 3.9% GCS under 14 – 6.7% cervical spine injuries</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Jacobs et al (1986)&lt;sup&gt;14&lt;/sup&gt; Level 4 evidence Inconsistently applied gold standard</td>
<td>Prospective observational cohort study 9 factors predict C-spine injury: HISTORY: fall less than 10 feet is protective. EXAMINATION: Numbness, loss of sensation, Weakness. SIGNS: Neck spasm, Neck tenderness, loss of power, decreased sensation, loss of anal tone Any of these factors requires 3 view C-spine views.</td>
<td>N=233 All levels of alertness Symptomatic and asymptomatic Adults only Single USA trauma centre Consecutive</td>
<td>Cervical spine injury Gold standard Minimum of lateral view and AP view assessed independently by two radiologists. Physicians can predict C-spine injury with specificity of 94% All factor rule specificity is 88% Physicians can predict C-spine injury with sensitivity of 46% All factor rule sensitivity is 100%</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>A quarter of patients did not have the gold standard applied. Of note only 73% received imaging</td>
<td>Yes</td>
</tr>
</tbody>
</table>
### Head Injury Update Full Guideline: Draft for Consultation (Feb 2007)

<table>
<thead>
<tr>
<th>Reference</th>
<th>Study Design</th>
<th>Patient Population</th>
<th>Outcome Measures</th>
<th>Sensitivity</th>
<th>Specificity</th>
<th>Follow-up</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Klein et al (1998)</td>
<td>Retrospective case series</td>
<td>Patients with cervical fracture confirmed on CT scan</td>
<td>Posterior element cervical fracture</td>
<td>97%</td>
<td>11%</td>
<td>Yes</td>
<td>MRI is neither as sensitive nor as specific as CT scanning for bony abnormalities. Demonstrates that MRI misses 90% of posterior element fractures in the cervical spine.</td>
</tr>
<tr>
<td>Benzel et al (1996)</td>
<td>Prospective observational cohort study</td>
<td>Patients with equivocal cervical spine plain imaging or positive physical examination</td>
<td>Cervical soft tissue injuries on MRI</td>
<td>N/A</td>
<td>N/A</td>
<td>Yes</td>
<td>No gold standard</td>
</tr>
</tbody>
</table>

N=42 Patients with cervical fracture confirmed on CT scan. Adults over 15 years. Single USA level 1 trauma centre. Non-consecutive case series.

N=174 Patients with equivocal cervical spine plain imaging or positive physical examination. Adults only. Single USA university hospital. Non-consecutive and selected group.

N/A N/A N/A 36% had soft tissue abnormalitie s. 1 patient had surgical fusion, 35 had a cervical collar for 1 month, and 27 had a Minerva jacket for 2 months.
<table>
<thead>
<tr>
<th>Reference</th>
<th>Study Design</th>
<th>Patient Characteristics</th>
<th>Methods</th>
<th>Results</th>
<th>Summary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Freemyer et al (1989)</td>
<td>Prospective observational cohort study</td>
<td>N=53 adults over 14 years old</td>
<td>Level of alertness and symptoms not described</td>
<td>Gold standard: Results of 5-view image, assessed by 2 radiologists</td>
<td>Yes</td>
</tr>
<tr>
<td>Zabel et al (1997)</td>
<td>Retrospective cohort study</td>
<td>N=353 GCS &gt;13</td>
<td>Symptomatic and asymptomatic Adults over 15 years old</td>
<td>Gold standard: None</td>
<td>Yes</td>
</tr>
<tr>
<td>Ersoy et al 1995</td>
<td>Retrospective cohort study</td>
<td>N=303 GCS 15</td>
<td>Symptomatic and asymptomatic Adults and children over 5 years old</td>
<td>Gold standard: All plain X-rays were reviewed by a radiologist and a neurosurgeon, but types of plain X-rays not described and no follow up</td>
<td>Yes</td>
</tr>
<tr>
<td>Authors</td>
<td>Year</td>
<td>Level</td>
<td>Evidence</td>
<td>Study Type</td>
<td>Study Details</td>
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<tr>
<td>Saddison et al</td>
<td>1991</td>
<td>4</td>
<td>4</td>
<td>Small retrospective</td>
<td>All alert patients with cervical injury can be detected by imaging only those with cervical pain or tenderness.</td>
</tr>
<tr>
<td>Keenan et al</td>
<td>2001</td>
<td>3</td>
<td>3</td>
<td>Study not relevant to this review</td>
<td>This study looks at the reduction of plain radiographs to clear the C-spine are ordered when a full CT of the C-spine is done. NO assessment of the sensitivities or specificities of each modality</td>
</tr>
<tr>
<td>Harris</td>
<td>1994</td>
<td>3</td>
<td>3</td>
<td>This is a brief review</td>
<td>(With 3 references)</td>
</tr>
<tr>
<td>Rosenberg</td>
<td>1994</td>
<td>4</td>
<td>4</td>
<td>No original data in this article</td>
<td>– case studies.</td>
</tr>
<tr>
<td>Kriss et al</td>
<td>1996</td>
<td>3</td>
<td>3</td>
<td>This is a review</td>
<td></td>
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<tr>
<td>Reference</td>
<td>Evidence Level</td>
<td>Description</td>
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<tr>
<td>Maurice et al (1996)</td>
<td>Level 3</td>
<td>This paper investigates the effects of implementing C-spine guidelines in a UK Emergency department in terms of X-ray requests. Study not relevant to this review.</td>
<td></td>
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<tr>
<td>Hoffman et al (1991)</td>
<td>Level 5</td>
<td>This is a brief letter, with references to papers written by Hoffman, Mower, et al.</td>
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<tr>
<td>Emery et al (1989)</td>
<td>Level 3</td>
<td>Study of MRI scanning after cervical injury. MRI scans were performed 10 days after injury on average and so this paper does not address guidelines for the initial triage of injured patients.</td>
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<tr>
<td>Crim et al (2001)</td>
<td>Level 2</td>
<td>This is a review paper. However it is a comprehensive recent review with a treatment algorithm presented in the multi trauma patient.</td>
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<tr>
<td>Brillhart (2000)</td>
<td>Level 1</td>
<td>This is an abstract of the NEXUS study.</td>
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<tr>
<td>Ghen et al (1992)</td>
<td>Level 5</td>
<td>Paper not relevant to this review; opinion piece.</td>
<td></td>
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</table>

The Utility of Flexion/Extension views
<table>
<thead>
<tr>
<th>Names and evidence level</th>
<th>Rule description</th>
<th>Participants</th>
<th>Outcome measures</th>
<th>Specificity</th>
<th>Sensitivity</th>
<th>Investigatio n ordering rate</th>
<th>Prevalence</th>
<th>Derived using primary data</th>
<th>Derived using prospect. Data</th>
<th>Validated using primary data</th>
<th>Validated using prospect. Data</th>
<th>Multi-variate modelling</th>
<th>Follow-up</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ralston et al (2001)²⁴⁶</td>
<td>Retrospective cohort study In patients with normal plain radiography, flexion Extension views are of limited value. In a subset of patients with suspicious findings on standard cervical spine views, Flexion Extension views are useful in ruling out ligamentous instability.</td>
<td>N=129 patients who had undergone plain and F/E radiography No injury severity reported CHILDREN under 16 Single USA children’s trauma hospital Non-consecutive</td>
<td>Cervical injury on plain (AP and lateral only) and Flexion Extension views Gold standard: Final diagnosis given by radiologist blinded to patients results, with all images available to him</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>83 of 129 (64%)</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Not reported</td>
<td>F/E views had one false positive F/E views showed no abnormalities in 75 of 83 patients with suspicious plain radiography Note this study includes cervical strain, indeterminate plain radiography, cervical disc disease and SCIWORA in its group of positive final diagnoses. Only 3 fractures were found in this study.</td>
</tr>
<tr>
<td>Study</td>
<td>Design</td>
<td>Patients</td>
<td>Cervical Spine Injury on CT</td>
<td>Gold Standard</td>
<td>Follow Up</td>
<td>Article Comments</td>
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<tr>
<td>Tehranzadeh et al (1994)</td>
<td>Retrospective cohort</td>
<td>N=100</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>Yes, No, No, No, No, No</td>
<td>These 100 patients are 2.5% of patients who underwent plain radiography in this department in the study period. Follow up rate not reported. In a very small subset of patients the C7-T1 can be followed up safely.</td>
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<tr>
<td>Anglen et al (2001)</td>
<td>Retrospective cohort</td>
<td>N=837</td>
<td>Not applicable</td>
<td>Not applicable</td>
<td>Not applicable</td>
<td>Yes, No, No, No, No, No</td>
<td>1484 Flexion extension views were done at this institution. 407 were deemed inadequate 57 were missing 919 were negative. There were 39 positive reports but only 4 of these reports met the study inclusion criteria of coma, and negative other imaging. No confirmatory test was applied to those with negative F/E views and no follow up.</td>
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<tr>
<td>Lewis et al (1991)</td>
<td>Retrospective cohort study</td>
<td>N=141</td>
<td>All levels of alertness</td>
<td>Adults only</td>
<td>Single USA level 1 trauma centre</td>
<td>Non-consecutive – F/E views were ordered at physicians' discretion.</td>
<td>All Patients had F/E views performed after 3 view plain series</td>
<td>Gold standard: None. Other radiological tests were performed at the discretion of the physician. No follow up.</td>
<td>93%</td>
<td>99%</td>
<td>100%</td>
<td>11 out of 141 had cervical instability (8%)</td>
<td>4 of these not seen on plain views 1 false negative result</td>
<td>Yes</td>
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<tr>
<td>Brady et al (1999)</td>
<td>Retrospective cohort study</td>
<td>N=451</td>
<td>All levels of alertness</td>
<td>Symptoms not reported</td>
<td>Adults over 18 years old</td>
<td>Single USA trauma centre</td>
<td>Non consecutive</td>
<td>Cervical injury on lateral, AP, peg and flexion Extension views.</td>
<td>Gold standard: None applied</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>79 out of 451 (17.5%)</td>
<td>2 patients with SCIWORA</td>
</tr>
<tr>
<td>Study Authors</td>
<td>Study Type</td>
<td>Evidence Level</td>
<td>Study Details</td>
<td>Intervention</td>
<td>Control Group</td>
<td>Patient Recruitment</td>
<td>Radiographic Criteria</td>
<td>Interpreters</td>
<td>Fracture Detection</td>
<td>Complications</td>
<td>Conclusion</td>
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<tr>
<td>West et al (1997)</td>
<td>Retrospective case control study</td>
<td>Level 4</td>
<td>Three-view radiography allows most readers to detect a few more fractures than a single view radiograph.</td>
<td>Cervical injury diagnosed on 1 and then 3 view radiography interpreted by 20 radiographers of variety of grades</td>
<td>Gold standard for fracture was discharge diagnosis of cervical fracture</td>
<td>N=92</td>
<td>81.9% with 1 view, 79.7% with 3 views</td>
<td>100%</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Woods et al (1998)</td>
<td>Retrospective study of paediatric flexion extension views</td>
<td>Level 4</td>
<td>There were no complications from the use of flexion-extension views, and they were a useful addition to plain radiography.</td>
<td>Fracture on 3 view plain radiography or Flexion Extension views</td>
<td>Gold standard: negative radiology and discharged</td>
<td>N=133</td>
<td>N/A</td>
<td>100%</td>
<td>0% fractures, 5% abnormal F-E views but all discharged home. 2 cases of SCIWORA.</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Palmer et al (1995)</td>
<td>This study looks at the effect of ATLS training in the implementation of cervical spine protocols. Irrelevant to this review</td>
<td>Level 3</td>
<td>diplomacy in the implementation of cervical spine protocols. Irrelevant to this review</td>
<td>diplomacy in the implementation of cervical spine protocols. Irrelevant to this review</td>
<td>diplomacy in the implementation of cervical spine protocols. Irrelevant to this review</td>
<td>Compilation</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Mirvis et al (1995)</td>
<td>This is a review article</td>
<td>Level 3</td>
<td>This is a review article</td>
<td>This is a review article</td>
<td>This is a review article</td>
<td>Compilation</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
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</table>

This is a study that assesses 20 radiologists' ability to diagnose a known fracture on either 1 or 3 view radiographs.

This study has selective cases and is underpowered.
<table>
<thead>
<tr>
<th>Names and evidence level</th>
<th>Rule description</th>
<th>Participants</th>
<th>Outcome measures</th>
<th>Specificity</th>
<th>Sensitivity</th>
<th>Investigatio n ordering rate</th>
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<th>Follow-up</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clancy (1999)&lt;sup&gt;+&lt;/sup&gt; Level 3 evidence</td>
<td>This is a UK review article but is pre NEXUS and Stiell’s work</td>
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<tr>
<td>Ajani et al (2002)&lt;sup&gt;+&lt;/sup&gt; Level 1 evidence</td>
<td>Prospective observational cohort study All patients suffering major trauma should have 3-view plain radiography, swimmers views if further evaluation of C7-T1 is needed and CT and/or MRI for abnormal areas. Flexion/Extension views to exclude cervical spine instability due to soft tissue trauma were performed if clinical examination was not possible.</td>
<td>N=100 Patients admitted to the ICU after major trauma. Symptomatic and asymptomatic Adults over 15 years old Single Australian Intensive care unit. Consecutive</td>
<td></td>
<td>Cervical spine injury Gold standard: Abnormality after conduction of protocol. Presumably follow up also performed</td>
<td>0%</td>
<td>100%</td>
<td>79 normal plain radiographs 48 had passive flexion/extension views 12 had active flexion/extension views 1 CT scan performed</td>
<td>6 out of 100 (6%) had unstable injuries</td>
<td>Unclear</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Follow up not described but presumably performed in this ICU unit</td>
<td>91 patients survived to complete evaluation. This protocol was assessed after it had been implemented for several years in this institution. Philadelphia collars remained in place for mean 65 hours (range 1.5 to 240 hours)</td>
</tr>
<tr>
<td>Study</td>
<td>Design</td>
<td>Sample Size</td>
<td>Inclusion Criteria</td>
<td>Sensitivity</td>
<td>Specificity</td>
<td>Outcome of Patients</td>
<td>Notes</td>
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<tr>
<td>Schenarts et al (2001)</td>
<td>Prospective</td>
<td>N=1356</td>
<td>Altered mental status requiring CT scan of 2 or more body systems Age over 14 years old Single USA trauma centre</td>
<td>Not assessed</td>
<td>100% sensitivity of EAST guidelines</td>
<td>70 out of 1356 (5.2%) were missed on plain radiography and CT scanning. Assessed by 2 radiologists.</td>
<td>Validates the EAST guidelines in patients with altered mental status (not investigated) The clinical history seems to have been gained from the hospital records and trauma registry not prospectively collected on admission.</td>
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<tr>
<td>Davis et al (2001)</td>
<td>Retrospective</td>
<td>N=301</td>
<td>GCS &lt;13 for more than 48 hours Assumed to be adults only as mean age 34. Single USA trauma centre. Consecutive Cervical injury as determined by fluoroscopy. Gold standard: All patients received 5 view plain radiographs, CT scanning and follow up.</td>
<td>Not assessed</td>
<td>100% sensitivity of EAST guidelines</td>
<td>2 of 301 patients had cervical injury diagnosed on fluoroscopy. 0.7% - both treated conservatively. Also 1 false positive and 1 false negative.</td>
<td>Neurological examination daily to discharge, post-mortem, and review of all notes 60 to 90 days after discharge. Fluoroscopy was performed a mean 6 days after admission (SD +/- 0.2 days) This study provides evidence for the validation of the 1998 EAST protocol in the subset of moderate and severe head injuries.</td>
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<tr>
<td>Study</td>
<td>Study type</td>
<td>Level of evidence</td>
<td>Setting</td>
<td>Patients</td>
<td>Methods</td>
<td>Cervical injury</td>
<td>Gold standard</td>
<td>Results</td>
<td>Follow-up</td>
<td>Comments</td>
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<tr>
<td>Brooks et al (2001)</td>
<td>Retrospective cohort validation study</td>
<td>Level 2</td>
<td>Single UK hospital</td>
<td>N=78 patients remaining unconscious or clinically inaccessible for &gt;24 hours</td>
<td>Dynamic screening, Unconscious or intubated trauma patients, Age range 11 to 90 years old, Single UK hospital</td>
<td>N/A</td>
<td>Not applicable</td>
<td>Not stated</td>
<td>Yes</td>
<td>Decubitus ulcers were common and occurred in 44% of patients, due to the collar remaining in place for long periods.</td>
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<tr>
<td>Davies et al (1995)</td>
<td>Prospective cohort study of dynamic fluoroscopy in patients that are not fully conscious</td>
<td>Level 2</td>
<td>Single USA trauma centre</td>
<td>N=116 Patients not fully conscious, GCS &lt;13</td>
<td>Dynamic fluoroscopy can safely clear the C-spine in not fully conscious patients</td>
<td>Fracture on fluoroscopy or 3 view radiography</td>
<td>Fracture on any imaging or on follow up</td>
<td>No missed clinically significant fractures</td>
<td>Yes</td>
<td>Decubitus ulcers were common and occurred in 44% of patients, due to the collar remaining in place for long periods.</td>
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<tr>
<td>Reference</td>
<td>Type of Study</td>
<td>Patients</td>
<td>Gold Standard</td>
<td>Sensitivity</td>
<td>Specificity</td>
<td>Radiographs Recommended?</td>
<td>Notes</td>
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<tr>
<td>Albrecht et al (2001)</td>
<td>Retrospective, well conducted cohort study</td>
<td>N=150, Not fully conscious patients only</td>
<td>Fracture on MRI scanning</td>
<td>100%</td>
<td>44/150 (27%)</td>
<td>Yes</td>
<td>Of the 108 patients with negative plain radiography who went on to have MRI, only 21 had a normal MRI allowing removal of the collar.</td>
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<tr>
<td>Berne et al (1999)</td>
<td>Prospective, observational cohort study</td>
<td>N=58, Patients admitted to ICU, C-spine unable to evaluate clinically</td>
<td>Fracture on CT</td>
<td>100%</td>
<td>20 of 58 (34%)</td>
<td>Yes</td>
<td>Small study</td>
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</table>

MRI provides a safe and risk free method for clearing the cervical spine in not fully conscious patients in ICU.

Helical CT scanning is superior to plain radiography in clearing the cervical spine.
### Holly et al (2002)\(^\text{137}\)

| Level 3 evidence | Non-consecutive study | Retrospective cohort study | Patients with moderate or severe head injury are at increased risk of cervical fracture and should have full plain radiography with CT and flexion/extension views and necessary. N=447 Patients with moderate or severe head injuries. GCS 3-12 or >12 with abnormal head CT Symptomatic patients 2 level 1 trauma centers. Non-consecutive | Cervical spine injury | Not done | Not done | Not done | 24 of 447 patients (5.4%) | Yes | No | No | No | No | Results of GOS reported for those with cervical fracture but follow up not described | Study is of limited relevance to us |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|

### D’Alise et al (1999)\(^\text{64}\)

<p>| Level 3 evidence | Non-consecutive study | Prospective observational cohort study | Using MR imaging in patients not fully conscious or intubated patients allows clearance of the cervical spine. N=121 Patients all intubated due to head or multi-system injury Adults and children Single USA trauma centre Non-consecutive | Cervical injury on MRI scanning | N/A | N/A | N/A | 31 of 121 (25%) had significant injuries not seen on plain radiography, 8 required surgery | Yes | Yes | No | No | No | None reported | No follow up was reported so that there was no attempt to verify that the MRI scan did not miss any injuries |</p>
<table>
<thead>
<tr>
<th>Study</th>
<th>Study Design</th>
<th>Participant Characteristics</th>
<th>Outcomes</th>
<th>Evidence Level</th>
<th>Study Conclusions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Katzberg et al (1999)</td>
<td>Prospective cohort study</td>
<td>MRI scans can more accurately detect a wide range of neck injuries compared to conventional CT</td>
<td>Cervical injury Gold standard: CT and MRI in all patients</td>
<td>N/A</td>
<td>No decision rule given. This is a study looking at the ability of MR scan to detect additional images to CT scanning</td>
</tr>
<tr>
<td>Cohn et al (1991)</td>
<td>Prospective cohort study</td>
<td>Lateral C-spine films are falsely reassuring and methods for intubation should treat the spine as unstable until 3 view clearance.</td>
<td>Fracture on radiography Gold standard: all patients had 3 view plain radiography and also other investigations at the clinician’s discretion</td>
<td>N/A</td>
<td>No</td>
</tr>
<tr>
<td>Jelly et al (2000)</td>
<td>Prospective observational cohort study</td>
<td>Routine CT of intubated and ventilated patients after blunt trauma can detect occult fractures of the cervico-thoracic junction, missed by plain radiography.</td>
<td>Cervical spine injury on 3 view radiography (lateral and 2 oblique views) And spiral CT scanning of C6 to T2</td>
<td>N/A</td>
<td>Only 73 of 204 trauma patients attending their unit were studied, as only 73 had both CT and plain radiography. Only 25 of 73 radiographs visualised C7-T1 space. Most of the fractures detected were not significant.</td>
</tr>
<tr>
<td>Study</td>
<td>Study Design</td>
<td>Setting</td>
<td>Participants</td>
<td>Gold Standard</td>
<td>Findings</td>
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<tr>
<td>Gerretts et al. (1991)</td>
<td>Retrospective observational cohort study</td>
<td>Single USA level 1 trauma centre</td>
<td>N=1331 Severe blunt injury patients all levels of alertness Symptomatic Adults over 17 years old Single USA level 1 trauma centre</td>
<td>Not reported</td>
<td>Cervical injury on 5 view radiography Delayed Diagnosis of cervical injury after negative complete C-spine series. Gold standard: All patients received 5 film plain views, and selective CT and MRI scans done. Final results diagnosed by the author – radiologist. Cervical spine injury was missed in 5 patients by plain radiography.</td>
</tr>
<tr>
<td>Nunez et al. (1996)</td>
<td>Retrospective case series</td>
<td>Non-consecutive - Selected at random</td>
<td>N=88 Patients who had a cervical fracture, plain radiography and helical CT GCS and symptoms not reported Age not reported Single USA trauma centre</td>
<td>N/A</td>
<td>Cervical injury on 3-view radiography and on helical CT Gold standard: Images all independently reviewed and 4 month follow up also available. Cervical spine injury was missed in 5 patients by plain radiography.</td>
</tr>
<tr>
<td>Study</td>
<td>Retrospective design</td>
<td>Number of patients</td>
<td>Eligibility criteria</td>
<td>Imaging protocol</td>
<td>Follow-up</td>
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<tr>
<td>Malomo et al (1995)</td>
<td>Cohort study</td>
<td>N=457</td>
<td>Patients following head injury associated with loss of consciousness who are above 10 years old.</td>
<td>Cervical spine injury on 5-view radiography.</td>
<td>Yes</td>
</tr>
<tr>
<td>Kirshenbaum et al (1990)</td>
<td>Case series</td>
<td>N=53</td>
<td>Patients after significant head injury</td>
<td>Cervical injury on 3-view plain radiography or CT.</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Cervical CT is the test diagnostic tool but also the gold standard, as no follow up was done to exclude missed injury by CT.
Sees et al\(^\text{275}\) (1998)

<table>
<thead>
<tr>
<th>Level 4 evidence</th>
<th>Small retrospective non consecutive study</th>
</tr>
</thead>
<tbody>
<tr>
<td>Retrospective case series</td>
<td>Fluoroscopy in patients not fully conscious is a safe procedure and easy to perform. In addition it may give reassurance that no cervical injury is present</td>
</tr>
<tr>
<td>N=20</td>
<td>Not fully conscious trauma patients admitted to an intensive care unit who had fluoroscopy</td>
</tr>
<tr>
<td>Age 40 +/- 3.6 years</td>
<td>Single USA army medical centre</td>
</tr>
<tr>
<td>Non consecutive</td>
<td>Cervical spine injury</td>
</tr>
<tr>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>1 patient had a cervical injury</td>
<td>Yes</td>
</tr>
<tr>
<td>No</td>
<td>No</td>
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<td>No</td>
<td>No</td>
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<td>No</td>
<td>No</td>
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<tr>
<td>No</td>
<td>No</td>
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<tr>
<td>Very small study</td>
<td></td>
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Hindman et al\(^\text{129}\) (1998)

<table>
<thead>
<tr>
<th>Level 3 evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>This paper is a review of Cervical Clearance in patients not fully conscious, advocating MRI followed by Dynamic Fluoroscopy</td>
</tr>
</tbody>
</table>

## The Paediatric patient

<table>
<thead>
<tr>
<th>Names and evidence level</th>
<th>Rule description</th>
<th>Participants</th>
<th>Outcome measures</th>
<th>Specificity</th>
<th>Sensitivity</th>
<th>Investigatio n ordering rate</th>
<th>Prevalence</th>
<th>Derived using primary data</th>
<th>Derived using prospect. Data</th>
<th>Validated using primary data</th>
<th>Validated using prospect. Data</th>
<th>Multi-variate modelling</th>
<th>Follow-up</th>
<th>Notes</th>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Classes</th>
<th>Evidence</th>
<th>Participants</th>
<th>Outcome measures</th>
<th>Specificity</th>
<th>Sensitivity</th>
<th>Investigatio n ordering rate</th>
<th>Prevalence</th>
<th>Derived using primary data</th>
<th>Derived using prospect. Data</th>
<th>Validated using primary data</th>
<th>Validated using prospect. Data</th>
<th>Multi-variate modelling</th>
<th>Follow-up</th>
<th>Notes</th>
</tr>
</thead>
</table>

387
Cervical spine X-rays are only indicated in high risk paediatric patients with a head injury who either complain of neck pain or cannot voice such complaints because of significant head injury or preverbal age.

N=268
Children with significant head injury defined as one with clinical and radiographic evidence on CT.
Symptomatic and asymptomatic
Children 0-19 years old
Single USA children’s hospital intensive care unit.
Consecutive patient that were admitted to the PICU.

Cervical injury on 3 view radiography
Gold standard: 3-view radiography only (only 80% of children received this)
No follow up

52% 100% 48% 10 out of 268 (3.7%)
Yes No No No No The entry criteria of significant head injury needing admission was made at the discretion of the PICU triage officer. GCS was not consistently recorded in these children
215 children had cervical radiographs (80%)
<table>
<thead>
<tr>
<th>Study</th>
<th>Evidence Level</th>
<th>Study Design</th>
<th>Population Description</th>
<th>Methods</th>
<th>Results</th>
<th>Relevance to this Review</th>
</tr>
</thead>
<tbody>
<tr>
<td>Schwartz et al (1997)</td>
<td>Level 4</td>
<td>Retrospective case series</td>
<td>Radiographic investigation is not necessary in asymptomatic children under 6 after a short fall.</td>
<td>N did not state how many patient’s charts were reviewed – total of 44 centre-years of notes were searched. All levels of alertness. Symptomatic and asymptomatic Children younger than 6 years old. 4 USA hospitals. Non-consecutive – all patients with injury were looked for but only positive cases were studied.</td>
<td>ICD-9 codes for cervical vertebral injury, cervical cord injuries and cervical vertebra and cord injury were considered as positive. Gold Standard: No gold standard applied to exclude injury. 8 children were found with cervical spine injury after a fall from a low height.</td>
<td>This is a large case series 33 children with cervical spine injury were excluded from the study as they did not meet the criteria for mechanism of injury. This study Is of little relevance to this review.</td>
</tr>
</tbody>
</table>
Dietrich et al (1991)\textsuperscript{79}

<table>
<thead>
<tr>
<th>Evidence Level</th>
<th>Study Type</th>
<th>Setting</th>
<th>Participants</th>
<th>Outcome Measures</th>
<th>Methodological Issues</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>Case series</td>
<td>Retrospective</td>
<td>All children with neck pain or tenderness need full radiographic evaluation of their cervical spine</td>
<td>Cervical spine injury as documented in hospital medical records</td>
<td>Not applicable, None</td>
</tr>
<tr>
<td>N=50 patients with cervical fracture</td>
<td>All levels of alertness</td>
<td>Symptomatic and asymptomatic</td>
<td>Children, aged 2 to 19 years old</td>
<td>Single USA children’s Hospital</td>
<td>Non-consecutive.</td>
</tr>
<tr>
<td>Not applicable</td>
<td>Not applicable</td>
<td>Not applicable</td>
<td>100%</td>
<td>Yes</td>
<td>No</td>
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<tr>
<td>No</td>
<td>No</td>
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</table>

<table>
<thead>
<tr>
<th>Level 4 evidence</th>
<th>No gold standard applied</th>
</tr>
</thead>
</table>

In children with a history of trauma and normal findings on cervical spine radiographs, additional flexion-extension radiographs are of questionable value.

N=247 patients who had plain radiography and flexion/extension views
All levels of alertness – 775 normal GCS
Symptomatic and asymptomatic CHILDREN ONLY, under 18 years old
Single USA trauma centre
Non-consecutive

Cervical injury on 3 view radiography (no peg view in under 4 year olds) Or on F/E views
Gold standard: Abnormal results of radiography or abnormality recorded in the notes while admitted

N/A N/A N/A 23 or 247 (9%)

Yes No No No No

The notes were reviewed of each admission to look of any missed injury. No outpatient follow up done

4 patients with questionable findings on plain radiography had their spine cleared on flexion/extension views. Other than this no useful information was gained from F/E views. There was no gold standard applied to the F/E views or to the plain views so the true number of false negatives is not known unless progress until discharge is an acceptable gold standard.
**Update 2007  Evidence Tables for clinical prediction rule for selecting patients that have sustained damage to the cervical spine for the imaging technique selected in question 4?**

<table>
<thead>
<tr>
<th>Study details</th>
<th>Patients</th>
<th>Diagnostic Tool</th>
<th>Outcome measures</th>
<th>Effect size</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Bandiera2003</strong></td>
<td><strong>Patients</strong></td>
<td><strong>Assessment tool under investigation:</strong> Physicians were asked to prospectively estimate the probability that the patient would have a clinically important c-spine injury by opting for one of the following: 0%, 1%, 2%, 3%, 4%, 5%, 10%, 20%, 30%, 40%, 50%, 75%, 100%. Physicians were asked to base this estimate on their judgement after considering facts obtained in patients history and physical examination alone, without assistance of decision rule and before radiographs were reviewed.</td>
<td><strong>CLINICALLY IMPORTANT C-SPINE INJURY</strong> Physicians judgement (n=6265) (To predict at least 0% probability of clinically important c-spine injury).</td>
<td><strong>Sensitivity</strong> 92.2% (95% CI 82% to 96%)</td>
<td><strong>Funding:</strong> Supported by peer-reviewed grants from the MRC of Canada and Ontario Ministry of Health Emergency Health Services Committee.</td>
</tr>
<tr>
<td><strong>Study design:</strong> Prospective cohort study</td>
<td><strong>Outcome measures</strong></td>
<td><strong>Specificity</strong> 53.9% (95% CI 82% to 96%)</td>
<td><strong>Prevalence</strong> 64 (1.0%)</td>
<td><strong>Limitations:</strong> Not all patients received imaging and were instead followed up by 14 day telephone interview.</td>
<td></td>
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<tr>
<td><strong>Evidence level:</strong> 2+</td>
<td><strong>Diagnosis</strong></td>
<td><strong>Baseline</strong></td>
<td><strong>Additional outcomes:</strong> The areas under the ROC curve for predicting cervical spine injury were physician judgement 0.85 (95% CI 0.80 to 0.89) and Canadian C-spine rule 0.91 (95% CI 0.89 to 0.92; p&lt;0.05).</td>
<td></td>
<td><strong>Notes:</strong> This study was undertaken as part of phase I of the Canadian C-Spine Study.</td>
</tr>
<tr>
<td><strong>Duration of follow-up:</strong> 14 days follow-up by structured telephone interview (patients that did not receive imaging)</td>
<td><strong>Assessment tool under investigation:</strong> Physicians were asked to prospectively estimate the probability that the patient would have a clinically important c-spine injury by opting for one of the following: 0%, 1%, 2%, 3%, 4%, 5%, 10%, 20%, 30%, 40%, 50%, 75%, 100%. Physicians were asked to base this estimate on their judgement after considering facts obtained in patients history and physical examination alone, without assistance of decision rule and before radiographs were reviewed.</td>
<td><strong>CLINICALLY IMPORTANT C-SPINE INJURY</strong> Comparison to Canadian C-spine rule (n=6265)</td>
<td><strong>Sensitivity</strong> 100% (95% CI 94% to 100%)</td>
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<tr>
<td><strong>All patients</strong></td>
<td><strong>Imaging</strong></td>
<td><strong>Specificity</strong> 44.0% (95% CI 43% to 45%)</td>
<td><strong>Prevalence</strong> 64 (1.0%)</td>
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<tr>
<td><strong>N:</strong> 6265</td>
<td><strong>Physicians judgement</strong></td>
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<tr>
<td><strong>Age (mean):</strong> 36.6 (SD 16)</td>
<td><strong>Comparison to Canadian C-spine rule</strong></td>
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<td><strong>M/F:</strong> 3177/3088</td>
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<tr>
<td>Clinically important C-spine injury = 64/6265 (1%)</td>
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<tr>
<td>Clinically unimportant C-spine injury = 16 (0.3%)</td>
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</table>

**Funding:**
Supported by peer-reviewed grants from the MRC of Canada and Ontario Ministry of Health Emergency Health Services Committee.

**Limitations:**
Not all patients received imaging and were instead followed up by 14 day telephone interview.

**Additional outcomes:**
The areas under the ROC curve for predicting cervical spine injury were physician judgement 0.85 (95% CI 0.80 to 0.89) and Canadian C-spine rule 0.91 (95% CI 0.89 to 0.92; p<0.05).

In 89 cases the interobserver k for predicting a 0% probability of important c-spine injury according to physicians judgment was 0.46 (95% CI 0.28 – 0.65).

**Notes:** This study was undertaken as part of phase I of the Canadian C-Spine Study.
<table>
<thead>
<tr>
<th>Study details</th>
<th>Patients</th>
<th>Diagnostic Tool</th>
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</tr>
</thead>
<tbody>
<tr>
<td><strong>Stiell2003</strong>&lt;sup&gt;301&lt;/sup&gt;</td>
<td><strong>Patient group:</strong> consecutive adult patients with acute trauma to the head or neck who were both in stable condition and alert and who had either neck pain or no neck pain but met all of the following criteria: they had visible injury above the clavicles, were non ambulatory, and who had a dangerous mechanism of injury. Additional eligibility criteria were a GCS of 15, normal vital signs and injury within the previous 48 hours. &lt;br&gt;<strong>Location:</strong> Emergency departments of nine Canadian tertiary care hospitals.</td>
<td><strong>Assessment tool under investigation:</strong> Canadian C-Spine Rule (CCR) compared to NEXUS Low Risk Criteria (NLC)</td>
<td><strong>Clinically important C-spine injury:</strong> &lt;br&gt;NEXUS (not including 845 indeterminate patients)</td>
<td>(n=7438)</td>
<td><strong>Funding:</strong> Support by peer-reviewed grants from Canadian Institutes of Health research and Ontario Ministry of Health Emergency Health Services Committee.</td>
</tr>
<tr>
<td><strong>Study design:</strong> Prospective Cohort Study</td>
<td><strong>Evidence level:</strong> 2+ &lt;br&gt;<strong>Duration of follow-up:</strong> 14 day follow-up of patients who did not have radiography.</td>
<td><strong>845 patients were classified as indeterminate</strong> and omitted from primary analysis. These patients were not tested on range of motion which is required for prediction by Canadian C-Spine rule.</td>
<td><strong>Outcome:</strong> CCR (not including 845 indeterminate patients)</td>
<td>(n=7438)</td>
<td><strong>Limitations:</strong> Classification of unimportant clinical injuries.</td>
</tr>
<tr>
<td><strong>All patients</strong></td>
<td><strong>N:</strong> 8283 &lt;br&gt;N C-Spine Injury: 169 (2%)</td>
<td><strong>Reference standard:</strong> Plain radiography as requested by judgement of the</td>
<td><strong>Outcome:</strong> NEXUS (secondary analysis including indeterminate patients):</td>
<td>(n=8283)</td>
<td><strong>Additional outcomes:</strong> 45 cases of clinically unimportant injuries, the sensitivity of the CCR was 97.8% compared to 80.% for the NLC.</td>
</tr>
<tr>
<td><strong>Age (mean): 37.6±16</strong>&lt;br&gt;<strong>M/F:</strong> 4328/3955</td>
<td></td>
<td><strong>Canadian C-Spine Rule (CCR) compared to NEXUS Low Risk Criteria (NLC)</strong></td>
<td><strong>Sensitivity</strong></td>
<td>99.4% (95% CI, 96-100)</td>
<td>The kappa value for interobserver agreement in the interpretation of the overall rules in 142 cases was 0.63 (95% CI, 0.49-0.77) for the CCR and 0.47 (95% CI, 0.28-0.65) for NEXUS.</td>
</tr>
<tr>
<td></td>
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<td></td>
<td><strong>Specificity</strong></td>
<td>45.1% (95% CI, 44-46)</td>
<td>Potential effect on radiography was evaluated by estimating the proportion of patients who would require radiography according to the rules. (CCR: 55.9% and</td>
</tr>
<tr>
<td></td>
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<td></td>
<td><strong>Positive predictive value</strong></td>
<td>&lt;0.001</td>
<td></td>
</tr>
<tr>
<td>Study details</td>
<td>Patients</td>
<td>Diagnostic Tool</td>
<td>Outcome measures</td>
<td>Effect size</td>
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</tr>
<tr>
<td>3603 eligible patients were not enrolled by physicians and 635 had data forms but no outcome assessments (these subjects did not undergo radiography).</td>
<td>treating physician.</td>
<td>Outcome: CCR (secondary analysis including indeterminate patients): when the CCR was assumed to be negative for all indeterminate cases:</td>
<td>(n=8283)</td>
<td>NEXUS: 66.6% (excluding indeterminates)</td>
<td>Length of stay and clinical acceptability rated.</td>
</tr>
</tbody>
</table>
Data extraction for papers describing rules for diagnosis of long term disability

<table>
<thead>
<tr>
<th>Names and evidence level</th>
<th>Rule description</th>
<th>Participants</th>
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</thead>
</table>
| Bazarian et al 2001      | Prospective observational study 69 patients with GCS >15, with LOC < 10 mins, normal CT, no skull fracture, no focal neurology, no alcohol intoxication LOW RISK GROUP PCS occurs in 9% of patients scoring >24 on Hopkins Verbal Learning A test and of those injured by sports >22 on HVLA HIGH RISK PCS occurred in 89% of women scoring <9 on the Digit span test and of those injured in falls or MVAs <11.5 on HVLB2 test | N=69 GCS 15 Adults <16 years old Single USA emergency department Consecutive | Telephone questionnaire: The Rivermead Post concussion symptoms questionnaire (Patients received a battery of neurobehavioural tests on presentation to the Emergency dept. also) | For presence of high risk factor as rule: Specificity is 93% | For presence of high risk factor as rule: Sensitivity is 56% | N/A | 58% of patients had Post concussional syndrome 1 month after injury | Yes Yes No No | Yes and recursive partitioning | 1 month follow up | Unfortunately this study is underpowered for recursive partitioning: recommended powering is 10 positive outcomes per test variable used. This would have required them to have at least 200 patients in this study just for the derivation set.
Therefore their Low risk group contains just 11 patients and the high-risk group has only 24 patients. In addition 50% of the patients in the study fall into a “medium risk” category |
<table>
<thead>
<tr>
<th>Study Authors</th>
<th>Year</th>
<th>Evidence Level</th>
<th>Study Design</th>
<th>Sample Information</th>
<th>Test Information</th>
<th>Results</th>
<th>Follow-Up</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Powell et al</td>
<td>1996</td>
<td>2</td>
<td>Prospective cohort study of minor head injured patients who were seen by a psychologist prior to discharge and again at 3 months.</td>
<td>N=62 GCS 13-15 Adults over 16 Single UK hospital Consecutive</td>
<td>Galveston Orientation and amnesia Test: GOAT SOMC Digit span Trail making test AMIPB HADS</td>
<td>Between 51% and 86% of all patients had troublesome post concussional symptoms, with headaches and tiredness being the most common symptom.</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Mittenberg et al</td>
<td>1997</td>
<td>2</td>
<td>Prospective case-control study</td>
<td>N=65 All GCS Children Single USA hospital Consecutive</td>
<td>Structured telephone interview 6 weeks post injury assessing post concussion syndrome according to ICD-10 and DSM-IV criteria</td>
<td>11% of Mod-severe group asymptomatic 16% of mild head injury group asymptomatic 40% of orthopaedic controls asymptomatic This study was compared to the adult version and it was found that children have the same frequency of symptoms as adults.</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Rimel et al</td>
<td>1981</td>
<td>2</td>
<td>Prospective observational cohort study</td>
<td>N=424 GCS 13-15 Adults and children Admissions to a USA Hospital Consecutive</td>
<td>At 3 months: Neurological assessment, employment status 133 patients had neuropsychological assessment,</td>
<td>70% had persistent headaches 59% had memory problems 34% of previously employed people were now unemployed</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>
Barth et al. 1983

This paper is a subset of the Rimel cohort described earlier. Prospective cohort study
Age, education, rapid visuomotor problem solving and memory were predictive of cognitive function after minor head injury
Post-traumatic amnesia and period of loss of consciousness was not predictive

<table>
<thead>
<tr>
<th>Study</th>
<th>Design</th>
<th>Methodology</th>
<th>Sample Characteristics</th>
<th>Follow-up</th>
<th>outcome</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barth et al. 1983</td>
<td>Prospective cohort study</td>
<td>Age, education, rapid visuomotor problem solving and memory were predictive of cognitive function after minor head injury</td>
<td>N=73, GCS 13-15, LOC&lt;20 mins &lt;48hrs admission</td>
<td>Multiple Neuropsychological evaluation tests, 3 months after injury</td>
<td>N/A</td>
<td>N/A N/A</td>
</tr>
</tbody>
</table>

Thornhill et al. 2000

Prospective cohort study to determine the frequency of disability in adults admitted to hospital
No rule derived
Only age over 40, pre-existing physical limitations and history of brain illness were found to be univariate predictors for disability

<table>
<thead>
<tr>
<th>Study</th>
<th>Design</th>
<th>Methodology</th>
<th>Sample Characteristics</th>
<th>Follow-up</th>
<th>outcome</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thornhill et al. 2000</td>
<td>Prospective cohort study to determine the frequency of disability in adults admitted to hospital</td>
<td>All GCS results stratified</td>
<td>N=549, All GCS results stratified</td>
<td>Glasgow Outcome score, Problem orientated questionnaire. At 1 year post injury</td>
<td>N/A</td>
<td>N/A N/A</td>
</tr>
</tbody>
</table>
### Ogasawara et al. (2000)

**Study Design:** Prospective cohort study of GCS 13-15 patients

**Participants:** N=76 GCS 13-15 Adults

**Outcome Measures:** Multiple neuropsychiatric scores including: GOAT, GOS, Rivermead, MMSE, GHQ, NBRS

**Results:** Testing at a mean period of 44 days post injury found 77% headaches in GCS 15 patients, 70% dizziness, 82% Fatigue.

**Comments:** Unlike GCS where neurosurgery and abnormal CT are more common with lower GCS, neuropsychiatric measures are similar across the spectrum of GCS 13, 14 and 15.

---

### Millis (1994)

**Study Design:** Prospective case control study

**Participants:** N=63 GCS 3-15 but stratified to 3-12 and 13-15 Adults

**Outcome Measure:** Warington Recognition Memory test as outcome measure

**Results:** Patients who had a minor head injury but were seeking financial compensation had significantly lower scores on all tests than either similar patients not seeking compensation or patients who had a moderate or severe head injury are significantly lower.

**Comments:** This paper provides interesting evidence that unlike intracranial injury, post-concussive symptoms do not increase with reducing GCS.

---

### Bazarian et al. (2000)

**Study Design:** Prospective observational study with orthopaedic control group

**Participants:** N=71 cases and 41 controls

**Outcome Measure:** Whether patient attended follow up.

**Results:** 44% of patients attended for follow up 1-month post injury. 75% of non follow up group had no symptoms as the reason for not attending but only 38% of the follow up group stated that the reason they attended for follow up was that they had symptoms.

**Comments:** Provides some factors that predict lack of follow up. But presence of follow up is not a good predictor of disability – as found in this study.
<table>
<thead>
<tr>
<th>Study</th>
<th>Evidence Level</th>
<th>Study Design</th>
<th>Population</th>
<th>Methods</th>
<th>Disability Measures</th>
<th>Follow-up</th>
<th>Disability at 5 years</th>
<th>Face to face interview 5 years after initial trauma</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Masson et al. (1997)</td>
<td>Level 3</td>
<td>Population based cohort study</td>
<td>N=407 HI pts</td>
<td>All GCS scores Adults and children Study of all injuries serious enough to cause death or hospitalisation in Aquitaine region in France in 1986</td>
<td>200 item disability questionnaire GOS</td>
<td>N/A N/A N/A</td>
<td>Disability in a population after head injury is 9 per 100,000. Headache, dizziness and anxiety were common whatever the initial head injury severity score. 15% of all head injured patients were still not working due to their head injury at 5 years In the AIS 1-2 group 5% had some disability 5 years after injury</td>
<td>Yes Yes No No No</td>
<td>Face to face interview 5 years after initial trauma. AIS scores rather than GCS scores were used to assess head injury severity No control group studied</td>
</tr>
<tr>
<td>Haboubi et al. (2001)</td>
<td>Level 3</td>
<td>Prospective experience of a minor head injury clinic, seeing all head injured patients 2 weeks after injury</td>
<td>N=639 GCS13-15 Admitted for &lt;48hrs Adults over 16 Single UK minor head injuries clinic</td>
<td>Time to return to work Common symptoms</td>
<td>N/A N/A N/A</td>
<td>56% were unable to return to work 2 weeks after discharge. And 49 patients were not well enough to work 6 weeks post injury. 20% of those followed up had a headache at 6 weeks</td>
<td>Yes Yes No No No Yes</td>
<td>307 of the 407 were successfully followed up.</td>
<td></td>
</tr>
<tr>
<td>Bazarian et al. 1999</td>
<td>Prospective case control study of 71 minor head injured patients (LOC&lt;10 mins, GCS 15) with 60 orthopaedic patients as controls. Predictors were: Female gender, presence of both antero- and retrograde amnesia, digit span forward scores, Hopkins verbal learning A scores – at 1 month. No variables predicted concussion at 6 months.</td>
<td>N= 131 Adults over 16 GCS 15 only Single USA hospital Convenience sample</td>
<td>N/A N/A N/A Incidence of post concussive syndrome at 1 month was 58%, 3 months 43% and at 6 months 25%.</td>
<td>Yes</td>
<td>Yes</td>
<td>NO</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Deb et al. 1998</td>
<td>Prospective cross-sectional survey 1 year after head injury. Variables that correlated with Edinburgh Rehabilitation status scale: Age, Sex, alcohol, initial GCS, history of previous head injury, MMSE, and NART score.</td>
<td>N=148 GCS 13-15, but presence of LOC, skull fracture or CT abnormality. Adults &gt;17 years old Scottish Health Authority Database. Non consecutive.</td>
<td>GOS Edinburgh Rehabilitation status scale Barthel index MMSE Post concussional questionnaire</td>
<td>N/A N/A N/A Incidence of post concussive syndrome at 1 month was 3% severe disability 25% moderate disability 70% no disability according to GOS. 55% had post-concussional symptoms 30% irritable 29% sleep problems 27% impatience</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
</tbody>
</table>
Koeflen et al\textsuperscript{168} 1997 Level 3 evidence

| Prospective case-control study | Case group: Children 6-15 years old who had a CT after HI at least 1 yr previously and had current normal GOS and no neurological signs | Control group: 59 uninjured children from a paediatric hospital |
|--------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| N=59                           | MRI scan: All GCS scores Children 6-15 years old Single German Hospital | Neuropsychological assessment |
| MRI scan findings & N/A        | 66% of children defined as normal Glasgow Outcome Score had abnormalities on MRI scanning | All children with normal MRI findings had neuropsychometric testing that matched the control group |
| Neuropsychometric testing & N/A| Children with abnormal MRI had significantly reduced neuropsychometric scores compared to controls or normal MRI group | No relevant outcome measure |

Cattelani et al\textsuperscript{48} 1996 Level 4 evidence

<p>| Prospective cohort study. Split into 2 groups, as per outcome measure | Case group: Presence or absence of minimal abnormalities on neurological examination or CT scanning or EEG. Consecutive | No relevant outcome measure |
|-----------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| N=53 | MRI scan: GCS13-15, LOC &lt;20 mins Single Italian neurological unit | No relevant outcome measure |
| MRI scan findings &amp; N/A | 96% of sample were eligible for some form of compensation at the time of interview | The outcome measure is presence of contusion of frontal lobes or positive EEG, but it is far from clear as to whether their case group includes all those who will go on to develop Concussion |</p>
<table>
<thead>
<tr>
<th>Author(s)</th>
<th>Study Design</th>
<th>Sample Size</th>
<th>Criteria</th>
<th>Outcome Measures</th>
<th>Sensitivity</th>
<th>Specificity</th>
<th>Results</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>McDonald et al.</td>
<td>Prospective validation of the WAIT test (Wolinsky Amnesia Information test)</td>
<td>N=75</td>
<td>All GCS scores, Adults</td>
<td>The “GOAT” questionnaire, GCS, Positive CT scan</td>
<td>N/A</td>
<td>N/A</td>
<td>No convincing disability assessment</td>
<td>This paper uses other questionnaires, the GCS at time of injury and the CT scan at time of injury as the outcome measure – none are relevant to long term disability</td>
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<tr>
<td></td>
<td>The WAIT test has good interobserver agreement for use in Closed head injuries</td>
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<tr>
<td>Asikainen et al.</td>
<td>Prospective cohort study</td>
<td>N=508</td>
<td>All GCS scores, Adults and children (46% under 16 years)</td>
<td>GOS Post injury occupational outcome</td>
<td>N/A</td>
<td>N/A</td>
<td>Only 50% of patients with an initial GCS 13-15 had a good recovery and up to 20% were still unable to work</td>
<td>1500 patients were seen in this period. Only the 508 that were followed up for 5 years were included in the study. This study is therefore actually quite a highly selected group of head injured patients</td>
</tr>
<tr>
<td></td>
<td>GCS correlated with all outcomes</td>
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<td>Length of coma, and duration of post-traumatic amnesia correlated with GOS</td>
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<td></td>
<td>Patients attending Finnish rehabilitation clinic</td>
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<td></td>
<td>Consecutive</td>
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<tr>
<td>Blostein et al.</td>
<td>Prospective validation study of Neurobehavioural Cognitive Status Examination test</td>
<td>N=107</td>
<td>GCS 13-15, LOC&lt;30min, Adults over 16 years old, Single USA level 1 trauma centre</td>
<td>Neurobehavioural Cognitive Status Examination Initial GCS 97% specificity of this score excluding g initial GCS 13-14</td>
<td>N/A</td>
<td>N/A</td>
<td>Positive screen was found in 44 patients. This positive screen was correlated only with initial GCS, but not CT results,</td>
<td>107 out of 587 admitted patients with traumatic Brain injury met the criteria for the study The initial GCS score is not a reliable predictor or long term disability and therefore this is not a valid outcome measure</td>
</tr>
<tr>
<td></td>
<td>A positive test correlated with abnormal initial GCS score</td>
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<td></td>
<td>Consecutive patients fitting criteria for entry</td>
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<tr>
<td>Study</td>
<td>Year</td>
<td>Level of Evidence</td>
<td>Study Design</td>
<td>Sample Details</td>
<td>Outcome Measures</td>
<td>Findings</td>
<td>Study Methodology</td>
<td>Study Limitations</td>
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<tr>
<td>Paret et al</td>
<td>1993</td>
<td>Level 4</td>
<td>Cross-sectional survey of head injured patients</td>
<td>N=86, 23 pts GCS 3-12, 63 pts GCS 13-15, Ages 6-15</td>
<td>N/A, N/A, N/A</td>
<td>There was some relationship between adaptive behaviour and severity of injury but this study found many confounding variables</td>
<td>Yes, Yes, No, No, Yes, N/A</td>
<td>62% participation rate</td>
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<td></td>
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<td>From a register of a Children’s USA hospital</td>
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<td>Results description is problematic No control group Their outcome measure is of questionable validity as a marker of long term disability</td>
</tr>
<tr>
<td>Blakely et al</td>
<td>1993</td>
<td>Level 3</td>
<td>This is a review article of the diagnosis of long-term sequelae following minor head injury in the context of providing evidence for the judicial service.</td>
<td>No original data</td>
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<tr>
<td>Ruff et al</td>
<td>1994</td>
<td>Level 4</td>
<td>Case series of 9 patients with minor head injuries, negative CT and MRI but positive neuropsychological tests and Positive PET scanning.</td>
<td></td>
<td></td>
<td></td>
<td>Not relevant to our search for discriminant variables that predict disability</td>
<td></td>
</tr>
<tr>
<td>Rao et al</td>
<td>1990</td>
<td>Level 2</td>
<td>This is a study looking at 79 head injured patients who had undergone inpatient rehabilitation after discharge from an acute ward within 3 months of admission. All patients had been in a coma for at least 6 hours post injury.</td>
<td></td>
<td></td>
<td></td>
<td>This study is not relevant to our question</td>
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<tr>
<td>McGregor et al.(^{196})</td>
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<td>1997</td>
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<tr>
<td>Level 3 evidence</td>
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</table>

This is an interesting review article of published literature looking at the economic aspects of rehabilitation programmes.

No UK studies were found. Of the 13 American papers reviewed, no convincing evidence for the effectiveness of rehabilitation was found. Also the validity of the costs presented was questioned. The largest study contained 202 patients.
Appendix J.  Adult observation proforma

In separate file
### Appendix K. Paediatric observation proforma

In separate file
Appendix L. Letter of referral to neurosurgical department

In separate file
Appendix M. The Glasgow Coma Scale for adults

The Glasgow Coma Scale is scored between 3 and 15, 3 being the worst, and 15 the best. It is composed of three parameters: Best Eye Response, Best Verbal Response, Best Motor Response. The definition of these parameters is given below.

**Best Eye Response. (4)**

2. No eye opening.
3. Eye opening to pain.
4. Eye opening to verbal command.
5. Eyes open spontaneously.

**Best Verbal Response. (5)**

1. No verbal response
2. Incomprehensible sounds.
3. Inappropriate words.
4. Confused
5. Orientated

**Best Motor Response. (6)**

1. No motor response.
2. Extension to pain.
3. Flexion to pain.
5. Localising pain.
6. Obeys Commands.
Appendix N. Paediatric version of the Glasgow Coma Scale

The Paediatric version of the Glasgow Coma Scale is scored between 3 and 15, 3 being the worst, and 15 the best. It is composed of three parameters: Best Eye Response, Best Verbal Response, Best Motor Response. The definition of these parameters is given below.

Best Eye Response. (4)
1. No eye opening.
2. Eye opening to pain.
3. Eye opening to verbal command.
4. Eyes open spontaneously.

Best Verbal Response. (5)
1. No vocal response.
2. Occasionally whimpers and/or moans.
3. Cries inappropriately.
4. Less than usual ability and/or spontaneous irritable cry.
5. Alert, babbles, coos, words or sentences to usual ability.

Communication with the infant or child's caregivers is required to establish the best usual verbal response. A 'grimace' alternative to verbal responses should be used in pre-verbal or intubated patients.

Best Grimace Response (5)
1. No response to pain.
2. Mild grimace to pain.
3. Vigorous grimace to pain.
4. Less than usual spontaneous ability or only response to touch stimuli.
5. Spontaneous normal facial/oro-motor activity.

Best Motor Response. (6)
1. No motor response to pain.
2. Abnormal extension to pain (decerebrate).
3. Abnormal flexion to pain (decorticate).
4. Withdrawal to painful stimuli.
5. Localises to painful stimuli or withdraws to touch.
6. Obeys commands or performs normal spontaneous movements.
Appendix O. Algorithms 1, 2 3a, 3b and 4

In separate file
Bibliography


40. Brenner DJ, Elliston CD, Hall EJ, Berdon WE. Estimates of the cancer risks from pediatric CT radiation are not merely theoretical: comment on "point/counterpoint: in x-ray computed tomography, technique factors should be selected appropriate to patient size. against the proposition". Medical Physics 2001, 28(11):2387-8.


HEAD INJURY UPDATE FULL GUIDELINE: DRAFT FOR CONSULTATION
(FEB 2007)


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