National Collaborating Centre for Acute Care

Head Injury

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

METHODS, EVIDENCE & GUIDANCE

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Head Injury: triage, assessment, investigation and early management of head injury in infants, children and adults.

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Foreword

Updating a document can be more difficult than starting from scratch; certainly we have found incorporation of new evidence into the guideline first published by NICE four years ago to be more complex than initially envisaged. I thank the Guideline Development Group and the team at the National Acute Care Collaboration Centre for their enthusiastic and professional support and advice throughout this process. We have been helped in our task by contributions from patient groups and stakeholders. The final document is undoubtedly richer as a result of the extensive consultations which followed the publication of the first draft.

Perhaps the most important prompt for this update was the publication of validation studies related to the advice on CT imaging; one of the most significant components of the first guidance. New research evidence on the management of paediatric head injuries was also available and this has been particularly useful in clarifying the subtle differences in guidance for adults and children.

Emerging evidence on the value of CT in cervical spine imaging – and the increasing awareness that plain films may not reveal clinically important lesions – has led the Guideline Development Group to recommend greater use of CT in the assessment of the neck in those head injured patients who have impaired consciousness.

The transfer of critically ill or injured patients between hospitals is rarely out of the news and it has been an agenda item at our meetings throughout the update process. There are two issues. Should ambulances "by pass" local hospitals en route from the scene of an incident to reach a specialist centre? Secondly, if all patients continue, as at present, to be transported to the nearest hospital, what are the indications for "secondary transfer"? The evidence in both areas is weak – but there is more than there was four years ago. On balance the Guideline Development Group consider the case for transferring all seriously head injured patients to a specialist neuroscience centre to be sufficiently strong to recommend that "secondary transfer" should be the norm for this group of patients, irrespective of the need for a neurosurgical operation. In contrast, we do not consider the case has been made for "by pass". Both issues are critically

important; there is an urgent need for a stronger evidence base. We therefore recommend research in this area be given high priority.

The plight of those disabled after brain injury continues to cause concern. Our remit prevented a detailed examination of this important topic but we do comment on the indications for follow up and emphasise the need for further research.

Finally, we have taken the opportunity to review some sections of the previous guideline, addressing issues which have caused concern to users. I hope this update is even more helpful than its predecessor and that it will contribute to the improved care of head injured patients to which we all aspire.

Professor David Yates

Chair, Guideline Development Group

1st June 2007

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Guideline Development Group membership and acknowledgements

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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.

Acknowledgements (2003)

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

Acknowledgements (2007)

The development of this guideline was greatly assisted by the following people: Linda Brittain; Kelly Dickinson; Nishanthi Talawila; Caroline Lawson, Dr Barry Wall, Matt Stevenson.

Stakeholder involvement

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

Brain and Spine Foundation
British Association of Oral and Maxillofacial Surgeons
British Dietetic Association
British Medical Association
British Orthopaedic Association
British Paediatric Neurology Association
British Psychological Society, The
British Society of Rehabilitation Medicine
Department of Health and Welsh Assembly Government
Faculty of Public Health Medicine
Headway - The Brain Injury Association
Independent Healthcare Association
Leeds General Infirmary
Patient Involvement Unit
Royal College of Anaesthetists
Royal College of General Practitioners
Royal College of Nursing
Royal College of Ophthalmologists
Royal College of Paediatrics and Child Health
Royal College of Physicians
Royal College of Psychiatrists
Royal College of Speech and Language Therapists
Society of British Neurological Surgeons
Staffordshire Ambulance HQ
Victim Support
Walton Centre for Neurology and Neurosurgery NHS Trust
Welsh Ambulance Trust Headquarters
Wessex Neurological Centre

Stakeholder Involvement (2007)

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)
- British Association of Neuroscience Nurses
- British Dietetic Association
- British National Formulary (BNF)
- British Paediatric Mental Health Group of the Royal College of Paediatrics and Child Health
- British Paediatric Neurology Association
- British Paramedic Association
- British Psychological Society
- British Society of Interventional Radiology
- British Society of Neuroradiologists
- British Society of Rehabilitation Medicine
- Calderdale and Huddersfield Acute Trust
- 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
- Harrogate and District NHS Foundation Trust
- 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 Hosptials NHS Foundation Trust
- Society of British Neurological Surgeons
- South Manchester University Hospitals NHS Trust
- 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
- Welsh Scientific Advisory Committee (WSAC)
- Wessex Neurological Centre
- Wirral Hospital Acute Trust
- Withybush Hospital
- Women's & Children's Collaborating Centre

Guideline Review Panel (2007)

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:

Mr Peter Robb

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Abbreviations

ABC	Airways, breathing, circulation.
ALS	Advanced Life Support
APLS	Advanced Paediatric Life Support
ARR	Absolute risk reduction
ATLS	Advanced trauma life support
AVPU	AVPU score
BLS	Basic Life Support
CT	Computed tomography
CC	Cerebral Contusions
CCR	Canadian Cervical Spine Rule
ED	Emergency Department
EMD	Emergency Medical Dispatch
EPLS	European Paediatric Life Support
GCS	Glasgow Coma Scale or Score
GCS(Paed)	Paediatric version of the GCS
GDG	Guideline Development Group
GOS	Glasgow Outcome Scale
HTA	Health Technology Assessment
ICH	Intracranial Haematoma
JRCALC	Joint Royal Colleges Ambulance Liaison Committee
ITLS	International Trauma Life Support
LOC	Level of Consciousness
MRI	Magnetic Resonance Imaging
NEXUS	National Emergency X-Radiography Utilization Study
NHS	National Health Service
NICE	National Institute for Health and Clinical Excellence
NAI	Non-accidental injury
NRPB	National Radiological Protection Board
QALY	Quality Adjusted Life Year
PEPP	Paediatric Education for Pre-hospital Professionals
PHPLS	Pre-hospital Paediatric Life Support course
PHTLS	Pre-hospital Trauma Life Support course
PRCT	Prospective Randomised Controlled Trial
TBI	Traumatic Brain Injury
TICH	Traumatic Intracerebral Haemorrhage
SICH	Spontaneous Intracerebral Haemorrhage
STICH	Surgical Trial in Intracerebral Haemorrhage

Glossary

Absolute risk	Measures the probability of an event or outcome occurring (for example, an adverse reaction to the drug being tested) in the group of people under study. Studies that compare two or more groups of patients may report results in terms of the *Absolute Risk Reduction*.
Absolute Risk Reduction (ARR)	The ARR is the difference in the risk of an event occurring between two groups of patients in a study – for example if 6% of patients die after receiving a new experimental drug and 10% of patients die after having the old drug treatment then the ARR is 10% - 6% = 4%. Thus by using the new drug instead of the old drug 4% of patients can be prevented from dying. Here the ARR measures the risk reduction associated with a new treatment. See also *Absolute risk*.
Acute sector	Hospital-based health services which are provided on an in-patient, day case or out-patient basis.
Advanced Paediatric Life Support (APLS) course	A course for healthcare professionals run by the Advanced Life Support Group which teaches a practical systematic approach to the management of acutely ill or injured babies and children. (See http://**www.alsg.org**)
Advanced Trauma Life Support (ATLS) course	A course with the aim to teach a simple systematic approach to the management of trauma patients through interactive tutorials, skills teaching and simulated patient management scenarios. (see http://www.rcseng.ac.**uk**/education/courses/trauma_life_support_advanced.html)
Algorithm (in guidelines)	A flow chart of the clinical decision pathway described in the guideline, where decision points are represented with boxes, linked with arrows.
Allocation concealment	The process used to prevent advance knowledge of group assignment in a randomised controlled trial (RCT). The allocation process should be impervious to any influence by the individual making the allocation, by being administered by someone who is not responsible for recruiting participants.
Amnesia	Partial or total loss of memory, usually resulting from shock, psychological disturbance, brain injury, or illness.
Applicability	The extent to which the results of a study or review can be applied to the target population for a clinical guideline.
Appraisal of evidence	Formal assessment of the quality of research evidence and its relevance to the clinical question or guideline under consideration, according to predetermined criteria.
ARR	See *Absolute Risk Reduction*.
Basal skull fracture	A fracture involving the base of the cranium.
Battle's sign	Bruising which sometimes occurs behind the ear in cases of fracture of the base of the skull (basal skull fracture).
Best available evidence	The strongest research evidence available to support a particular guideline recommendation.
Bias	Influences on a study that can lead to invalid conclusions about a treatment or intervention. Bias in research can make a treatment look better or worse than it really is. Bias can even make it look as if the treatment works when it actually doesn't. Bias can occur by chance or as a result of *systematic* errors in the design and execution of a study. Bias can occur at different stages in the research process, for example, in the collection, analysis, interpretation, publication or review of research data. For examples see *Selection bias*, *Performance bias*, *Information bias*, *Confounding*, *Publication bias*.
Blinding or masking	The practice of keeping the investigators or subjects of a study ignorant of the group to which a subject has been assigned. For example, a clinical trial in which the participating patients or their doctors are unaware of whether they (the

	patients) are taking the experimental drug or a placebo (dummy treatment). The purpose of 'blinding' or 'masking' is to protect against *bias*. See also *Double blind study*, *Single blind study*, *Triple blind study*.
C-spine	Cervical spine or bony part of the neck
Case-control study	A study that starts with the identification of a group of individuals sharing the same characteristics (for example, people with a particular disease) and a suitable comparison (control) group (for example, people without the disease). All subjects are then assessed with respect to things that happened to them in the past, for example, things that might be related to getting the disease under investigation. Such studies are also called *retrospective* as they look back in time from the outcome to the possible causes.
Case report (or case study)	Detailed report on one patient (or case), usually covering the course of that person's disease and their response to treatment.
Case series	Description of several cases of a given disease, usually covering the course of the disease and the response to treatment. There is no comparison (*control*) group of patients.
Causal relationship	Describes the relationship between two *variables* whenever it can be established that one causes the other. For example there is a causal relationship between a treatment and a disease if it can be shown that the treatment changes the course or outcome of the disease. Usually *randomised controlled trials* are needed to ascertain causality. Proving cause and effect is much more difficult than just showing an association between two variables. For example, if it happened that everyone who had eaten a particular food became sick, and everyone who avoided that food remained well, then the food would clearly be associated with the sickness. However, even if leftovers were found to be contaminated, it could not be proved that the food caused the sickness – unless all other possible causes (for example, environmental factors) had been ruled out.
Cerebrospinal fluid (CSF)	Clear fluid which is continuously being produced and absorbed by and in the brain, flowing in the ventricles (cavities) within the brain and around the surface of the brain and spinal cord
CSF otorrhea	Escape of CSF from the brain into the ear canal
Cervical spine	The cervical spine is the area of the vertebral column commonly refered to as the neck. The cervical spine is made up of seven vertebrae, refered to by 'C', appended with an identifying number. The number indicates the level of the spine in which the particular vertebra is located. The top vertebra is C1, the lowest C7
Cervico-dorsal junction	The junction between the bottom of the cervical spine and the top of the dorsal (or *thoracic*) spine.
Clinical audit	A *systematic* process for setting and monitoring standards of clinical care. Whereas 'guidelines' define what the best clinical practice should be, 'audit' investigates whether best practice is being carried out. Clinical audit can be described as a cycle or spiral. Within the cycle there are stages that follow a systematic process of establishing best practice, measuring care against specific criteria, taking action to improve care, and monitoring to sustain improvement. The spiral suggests that as the process continues, each cycle aspires to a higher level of quality.
Clinical decision rule	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[1].
Clinical effectiveness	The extent to which a specific treatment or intervention, when used under usual or everyday conditions, has a beneficial effect on the course or outcome of disease compared to no treatment or other routine care. (Clinical trials that assess effectiveness are sometimes called management trials.) Clinical 'effectiveness' is not the same as *efficacy*.
Clinical impact	The effect that a guideline recommendation is likely to have on the treatment, or treatment outcomes, of the target population.

Clinical question	This term is sometimes used in guideline development work to refer to the questions about treatment and care that are formulated in order to guide the search for research evidence. When a clinical question is formulated in a precise way, it is called a *focused question*.
Clinical trial	A research study conducted with patients which tests out a drug or other intervention to assess its effectiveness and safety. Each trial is designed to answer scientific questions and to find better ways to treat individuals with a specific disease. This general term encompasses *controlled clinical trials* and *randomised controlled trials*.
Clinician	A healthcare professional providing patient care, for example, doctor, nurse, physiotherapist.
Closed head injury	A blow to the head or a severe shaking causing tearing, shearing or stretching of the nerves at the base of the brain, blood clots in or around the brain or oedema (swelling) of the brain. There is no penetration of the skull or brain tissue by an object; the skull may be fractured but this does not result in a direct connection between the brain and the outside. (see Penetrating Brain Injury)
Cluster randomisation	A study in which groups of individuals (for example, patients in a General Practitioner surgery or on a hospital ward) are randomly allocated to treatment groups. Take, for example, a smoking cessation study of two different interventions – leaflets and teaching sessions. Each General Practitioner surgery within the study would be randomly allocated to administer one of the two interventions. See also *Cluster, Cluster design*.
Coagulopathy	A condition affecting the blood's ability to form a clot.
Cochrane Collaboration	An international organisation in which people find, appraise and review specific types of studies called *randomised controlled trials*. The Cochrane Database of Systematic Reviews contains regularly updated reviews on a variety of health issues and is available electronically as part of the *Cochrane Library*.
Cochrane Library	The Cochrane Library consists of a regularly updated collection of evidence-based medicine databases including the Cochrane Database of Systematic Reviews (reviews of *randomised controlled trials* prepared by the *Cochrane Collaboration*). The Cochrane Library is available on CD-ROM and the Internet.
Cohort	A group of people sharing some common characteristic (for example, patients with the same disease), followed up in a research study for a specified period of time.
Cohort study	An observational study that takes a group (cohort) of patients and follows their progress over time in order to measure outcomes such as disease or mortality rates and make comparisons according to the treatments or interventions that patients received. Thus within the study group, subgroups of patients are identified (from information collected about patients) and these groups are compared with respect to outcome, for example, comparing mortality between one group that received a specific treatment and one group which did not (or between two groups that received different levels of treatment). Cohorts can be assembled in the present and followed into the future (a 'concurrent' or 'prospective' cohort study) or identified from past records and followed forward from that time up to the present (a 'historical' or 'retrospective' cohort study). Because patients are not randomly allocated to subgroups, these subgroups may be quite different in their characteristics and some adjustment must be made when analysing the results to ensure that the comparison between groups is as fair as possible.
Coma	A sleep-like state in which a person is not conscious.
Co-morbidity	Co-existence of a disease or diseases in the people being studied in addition to the health problem that is the subject of the study.
Community health services	General Practice, ambulance crews, NHS walk-in centres and dental practitioners.
Concussion	The common result of a blow to the head or sudden deceleration usually causing an altered mental state, either temporary or prolonged. Physiological and/or anatomical disruption of connections between some nerve cells in the brain may occur. Often used by the public to refer to a brief loss of consciousness.
Confidence interval	A way of expressing certainty about the findings from a study or group of studies, using statistical techniques. A confidence interval describes a range of possible effects (of a treatment or intervention) that are consistent with the results of a study or group of studies. A wide confidence interval indicates a lack of certainty or precision about the true size of the clinical effect and is seen in studies with too few patients. Where confidence intervals are narrow they indicate more precise estimates of effects and a larger sample of patients studied. It is usual to interpret a '95%' confidence interval as the range of effects within which we are 95%

	confident that the true effect lies.
Confounder or confounding factor	Something that influences a study and can contribute to misleading findings if it is not understood or appropriately dealt with. For example, if a group of people exercising regularly and a group of people who do not exercise have an important age difference then any difference found in outcomes about heart disease could well be due to one group being older than the other rather than due to the exercising. Age is the confounding factor here and the effect of exercising on heart disease cannot be assessed without adjusting for age differences in some way.
Consciousness	An alert cognitive state in which you are aware of yourself and your situation
Consensus development conference	A technique used for the purpose of reaching an agreement on a particular issue. It involves bringing together a group of about 10 people who are presented with evidence by various interest groups or experts who are not part of the decision making group. The group then retires to consider the questions in the light of the evidence presented and attempts to reach a consensus. See also *Consensus methods*.
Consensus methods	A variety of techniques that aim to reach an agreement on a particular issue. Formal consensus methods include *Delphi* and *nominal group* techniques, and *consensus development conferences*. In the development of clinical guidelines, consensus methods may be used where there is a lack of strong research evidence on a particular topic.
Consistency	The extent to which the conclusions of a collection of studies used to support a guideline recommendation are in agreement with each other. See also *Homogeneity*.
Control group	A group of patients recruited into a study that receives no treatment, a treatment of known effect, or a placebo (dummy treatment) - in order to provide a comparison for a group receiving an experimental treatment, such as a new drug.
Controlled clinical trial (CCT)	A study testing a specific drug or other treatment involving two (or more) groups of patients with the same disease. One (the experimental group) receives the treatment that is being tested, and the other (the comparison or control group) receives an alternative treatment, a placebo (dummy treatment) or no treatment. The two groups are followed up to compare differences in outcomes to see how effective the experimental treatment was. A CCT where patients are randomly allocated to treatment and comparison groups is called a *randomised controlled trial*.
Cost benefit analysis	A type of *economic evaluation* where both costs and benefits of healthcare treatment are measured in the same monetary units. If benefits exceed costs, the evaluation would recommend providing the treatment.
Cost 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.
Craniocervical juntion	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 B, A. A problem with this study design is that the effects of the first treatment may carry over into the period when the second is given. Therefore a crossover study should include an adequate 'wash-out' period, which means allowing sufficient time between stopping one treatment and starting another so that the first treatment has time to wash out of the patient's system.
Cross-sectional study	The observation of a defined set of people at a single point in time or time period – a snapshot. (This type of study contrasts with a *longitudinal study* which follows a set of people over a period of time.)
Data set	A list of required information relating to a specific disease.
Decision analysis	A systematic way of reaching decisions, based on evidence from research. This evidence is translated into probabilities, and then into diagrams or decision trees

	which direct the clinician through a succession of possible scenarios, actions and outcomes.
Diagnostic study	A study to assess the effectiveness of a test or measurement in terms of its ability to accurately detect or exclude a specific disease.
Double blind study	A study in which neither the subject (patient) nor the observer (investigator/clinician) is aware of which treatment or intervention the subject is receiving. The purpose of blinding is to protect against bias.
Drowsiness	A state of impaired awareness associated with a desire or inclination to sleep.
Dura Mater	The thick lining of the brain and spinal cord
Economic evaluation	Comparative analysis of alternative courses of action in terms of both their costs and consequences.
Effectiveness	See *Clinical effectiveness*.
Efficacy	The extent to which a specific treatment or intervention, under ideally controlled conditions (for example, in a laboratory), has a beneficial effect on the course or outcome of disease compared to no treatment or other routine care.
Elective	Name for clinical procedures that are regarded as advantageous to the patient but not urgent.
Emergency Department (ED or A&E)	A clinical department in a district general or teaching hospital which has trained staff and equipment able to receive, resuscitate, investigate and initially manage the full spectrum of emergencies. Most units accept patients of all ages, some are restricted to adults, others to children. All should be open at all times and all its facilities should be available at all times.
Emergency Department Clinician	A medically qualified member of an emergency department or an appropriately trained nurse working in an emergency department.
Empirical	Based directly on experience (observation or experiment) rather than on reasoning alone.
Epidemiology	Study of diseases within a population, covering the causes and means of prevention.
European Paediatric Life Support course (EPLS)	The EPLS provider course is intended to provide training for multi-disciplinary healthcare professionals in the early recognition of the child in respiratory or circulatory failure and the development of the knowledge and core skills required to intervene to prevent further deterioration towards respiratory or cardiorespiratory arrest. (see http://www.resus.org.uk)
Event rate	The proportion of patients in a group for whom a specified health event or outcome is observed. Thus, if out of 100 patients, the event is observed in 27, the event rate is 0.27 or 27%. Control Event Rate (CER) and Experimental Event Rate (EER) are the terms used in *control* and experimental groups of patients respectively.
Evidence based clinical practice	Evidence based clinical practice involves making decisions about the care of individual patients based on the best research evidence available rather than basing decisions on personal opinions or common practice (which may not always be evidence based). Evidence based clinical practice therefore involves integrating individual clinical expertise and patient preferences with the best available evidence from research
Evidence table	A table summarising the results of a collection of studies which, taken together, represent the evidence supporting a particular recommendation or series of recommendations in a guideline.
Exclusion criteria	See *Selection criteria*.
Experimental study	A research study designed to test if a treatment or intervention has an effect on the course or outcome of a condition or disease - where the conditions of testing are to some extent under the control of the investigator. C*ontrolled clinical trial* and *randomised controlled trial* are examples of experimental studies.
Experimental treatment	A treatment or intervention (for example, a new drug) being studied to see if it has an effect on the course or outcome of a condition or disease.
External validity	The degree to which the results of a study hold true in non-study situations, for example, in routine clinical practice. May also be referred to as the *generalisability* of study results to non-study patients or populations.
Extradural (or epidural)	A collection of blood between the skull inner surface and the dura mater caused by damage to the blood vessels running on the surface of the dura mater – often

haemorrage	associated with a fracture of the skull. The underlying brain injury may not be severe initially but the increasing pressure caused by the bleeding inflicts further damage.
Extradural space	The space on the outer side of the dura mater.
Extrapolation	The application of research evidence based on studies of a specific population to another population with similar characteristics.
Focal Neurological Deficit	A neurological deficit restricted to a particular part of the body or a particular activity
Forest plot	A graphical display of results from individual studies on a common scale, allowing visual comparison of results and examination of the degree of *heterogeneity* between studies.
Funnel plot	Funnel plots are simple scatter plots on a graph. They show the treatment effects estimated from separate studies on the horizontal axis against a measure of sample size on the vertical axis. *Publication bias* may lead to asymmetry in funnel plots.
Generalisability	The extent to which the results of a study hold true for a population of patients beyond those who participated in the research. See also *External validity*.
Glasgow Coma Scale	A standardised system used to assess the degree of brain impairment and to identify the seriousness of injury in relation to outcome. The system involves three determinants: eye opening, verbal responses and motor response all of which are evaluated independently according to a numerical value that indicates the level of consciousness and degree of dysfunction.
Gold standard	A method, procedure or measurement that is widely accepted as being the best available.
Haematoma	An accumulation of blood in or under the tissues.
Haemotympanum	A collection of blood in the middle ear space
Health economics	A field of conventional economics which examines the benefits of healthcare interventions (for example, medicines) compared with their financial costs.
Heterogeneity	Or lack of *homogeneity*. The term is used in *meta-analyses* and *systematic reviews* when the results or estimates of effects of treatment from separate studies seem to be very different – in terms of the size of treatment effects or even to the extent that some indicate beneficial and others suggest adverse treatment effects. Such results may occur as a result of differences between studies in terms of the patient populations, outcome measures, definition of *variables* or duration of follow-up.
Hierarchy of evidence	An established hierarchy of study types, based on the degree of certainty that can be attributed to the conclusions that can be drawn from a well conducted study. Well-conducted *randomised controlled trials* (RCTs) are at the top of this hierarchy. (Several large statistically significant RCTs which are in agreement represent stronger evidence than say one small RCT.) Well-conducted studies of patients' views and experiences would appear at a lower level in the hierarchy of evidence.
Homogeneity	This means that the results of studies included in a *systematic review* or *meta analysis* are similar and there is no evidence of *heterogeneity*. Results are usually regarded as homogeneous when differences between studies could reasonably be expected to occur by chance. See also C*onsistency*.
Hyperventilation	Abnormally rapid breathing. Hyperventilation results in excessive intake of oxygen and increased elimination of carbon dioxide, which may eventually lead to a disturbance in the blood chemistry.
Hypoglycaemia	Abnormally low levels of glucose in the blood, leading to muscular weakness, confusion, sweating and, in severe cases, coma. Hypoglycaemia is a complication of many anti-diabetic treatments.
Inclusion criteria	See *Selection criteria*.
Infant	Aged under 1 year.
Intention to treat analysis	An analysis of a clinical trial where patients are analysed according to the group to which they were initially randomly allocated, regardless of whether or not they had dropped out, fully complied with the treatment, or crossed over and received the

	alternative treatment. Intention-to-treat analyses are favoured in assessments of clinical effectiveness as they mirror the non-compliance and treatment changes that are likely to occur when the treatment is used in practice.
Internal validity	Refers to the integrity of the study design.
Intervention	Healthcare action intended to benefit the patient, for example, drug treatment, surgical procedure, psychological therapy, etc.
Interventional procedure	A procedure used for diagnosis or treatment that involves making a cut or hole in the patient's body, entry into a body cavity or using electromagnetic radiation (including X-rays or lasers). The National Institute for Health and Clinical Excellence (NICE) has the task of producing guidance about whether specific interventional procedures are safe enough and work well enough for routine use.
Intracranial	Originating within the cranial (brain) cavity.
Intracranial haematoma	A collection of blood inside the cranium caused by damage to brain tissue or the rupture of a blood vessel. The resulting swelling can compress the brain.
Intracerebral haemorrhage	A bleed inside the brain tissue.
Intracranial lesion	A lesion of the brain.
Literature review	A process of collecting, reading and assessing the quality of published (and unpublished) articles on a given topic.
Longitudinal study	A study of the same group of people at more than one point in time. (This type of study contrasts with a *cross sectional study* which observes a defined set of people at a single point in time.)
Mandible	The lower jaw as a functional unit, regardless of which bones or cartilage make up the lower jaw in a particular organism.
Meningism	Stiffness of the neck associated with backwards extension of the cervical spine.
Meta analysis	Results from a collection of independent studies (investigating the same treatment) are pooled, using statistical techniques to synthesise their findings into a single estimate of a treatment effect. Where studies are not compatible for example, because of differences in the study populations or in the outcomes measured, it may be inappropriate or even misleading to statistically pool results in this way. See also *Systematic review & Heterogeneity*.
Methodology	The overall approach of a research project, for example, the study will be a *randomised controlled trial*, of 200 people, over one year.
Methodological quality	The extent to which a study has conformed to recognised good practice in the design and execution of its research methods.
Monte Carlo simulation	A modelling technique that uses random numbers to capture the effects of uncertainty. Multiple simulations are run (usually somewhere between 1,000 and 10,000). For each simulation, the value of each uncertain variable in the analysis is selected at random from a probability distribution for the value of that variable. The simulation results are compiled, providing a probability distribution for the overall result.
Motor response	Movement in response to an external stimulus
Multicentre study	A study where subjects were selected from different locations or populations, for example, a co-operative study between different hospitals; an international collaboration involving patients from more than one country.
Negative predictive value	The proportion of individuals with a negative test result who do NOT have the disease.
Neurorehabilitation services	A programme of clinical and vocational services with the goal of returning brain injured patients to a satisfying occupation,.
Neurosurgery	A surgical specialty for the treatment of diseases and disorders of the brain, spinal cord and nerves.
Non-experimental study	A study based on subjects selected on the basis of their availability, with no attempt having been made to avoid problems of bias.
Non-systematic review	See *Review*.
Objective measure	A measurement that follows a standardised procedure which is less open to subjective interpretation by potentially biased observers and study participants.
Observational study	In research about diseases or treatments, this refers to a study in which nature is allowed to take its course. Changes or differences in one characteristic (for example, whether or not people received a specific treatment or intervention) are studied in relation to changes or differences in other(s) (for example, whether or not they died), without the intervention of the investigator. There is a greater risk of

	selection bias than in *experimental studies*.
Occipital condyle	The articulation point between the skull and the first cervical vertebra.
Odds ratio	Odds are a way of representing probability, especially familiar for betting. In recent years odds ratios have become widely used in reports of clinical studies. They provide an estimate (usually with a *confidence interval*) for the effect of a treatment. Odds are used to convey the idea of 'risk' and an odds ratio of 1 between two treatment groups would imply that the risks of an adverse outcome were the same in each group. For rare events the odds ratio and the *relative risk* (which uses actual risks and not odds) will be very similar. See also *Relative risk, Risk ratio*.
Outcome	The end result of care and treatment and/ or rehabilitation. In other words, the change in health, functional ability, symptoms or situation of a person, which can be used to measure the effectiveness of care/ treatment/ rehabilitation. Researchers should decide what outcomes to measure before a study begins; outcomes are then assessed at the end of the study.
Paediatric	Pertaining to children and infants
Paraesthesia	Abnormal sensation such as burning or tingling due to a disorder of the sensory nervous system.
Penetrating head injury	Head injury where an object penetrates the scalp and skull and enters the brain or its lining.
Performance bias	Systematic differences in care provided apart from the intervention being evaluated. For example, if study participants know they are in the *control group* they may be more likely to use other forms of care; people who know they are in the experimental group may experience *placebo effects,* and care providers may treat patients differently according to what group they are in. Masking (*blinding*) of both the recipients and providers of care is used to protect against performance bias.
Periorbital haemotoma	Bleeding around or behind the eyes.
Pilot study	A small scale 'test' of the research instrument. For example, testing out (piloting) a new questionnaire with people who are similar to the population of the study, in order to highlight any problems or areas of concern, which can then be addressed before the full scale study begins.
Placebo	Placebos are fake or inactive treatments received by participants allocated to the *control group* in a clinical trial which are indistinguishable from the active treatments being given in the experimental group. They are used so that participants are ignorant of their treatment allocation in order to be able to quantify the effect of the experimental treatment over and above any *placebo effect* due to receiving care or attention.
Placebo effect	A beneficial (or adverse) effect produced by a *placebo* and not due to any property of the *placebo* itself.
Positive predictive value	The proportion of individuals with a positive test result who actually have the disease.
Power	See *Statistical power*.
Primary care	Healthcare delivered to patients outside hospitals. Primary care covers a range of services provided by General Practitioners, nurses and other healthcare professionals, dentists, pharmacists and opticians.
Probability	How likely an event is to occur, for example, how likely a treatment or intervention will alleviate a symptom.
Prognostic factor	Patient or disease characteristics, for example, age or *co-morbidity*, which influence the course of the disease under study. In a randomised trial to compare two treatments, chance imbalances in *variables* (prognostic factors) that influence patient outcome are possible, especially if the size of the study is fairly small. In terms of analysis these prognostic factors become *confounding factors*. See also *Prognostic marker*.
Prognostic marker	A *prognostic factor* used to assign patients to categories for a specified purpose – for example, for treatment, or as part of a clinical trial, according to the likely progression of the disease. For example, the purpose of randomisation in a clinical trial is to produce similar treatment groups with respect to important *prognostic factors*. This can often be achieved more efficiently if randomisation takes place within subgroups defined by the most important prognostic factors. Thus if age was very much related to patient outcome then separate randomisation schemes would

	be used for different age groups. This process is known as stratified random allocation.
Prospective study	A study in which people are entered into the research and then followed up over a period of time with future events recorded as they happen. This contrasts with studies that are *retrospective*.
Publication bias	Studies with statistically significant results are more likely to get published than those with non-significant results. *Meta-analyses* that are exclusively based on published literature may therefore produce biased results. This type of bias can be assessed by a *funnel plot*.
***P* value**	If a study is done to compare two treatments then the *P* value is the probability of obtaining the results of that study, or something more extreme, if there really was no difference between treatments. (The assumption that there really is no difference between treatments is called the 'null hypothesis'.) Suppose the *P*-value was *P*=0.03. What this means is that if there really was no difference between treatments then there would only be a 3% chance of getting the kind of results obtained. Since this chance seems quite low we should question the validity of the assumption that there really is no difference between treatments. We would conclude that there probably is a difference between treatments. By convention, where the value of *P* is below 0.05 (that is, less than 5%) the result is seen as statistically significant. Where the value of *P* is 0.001 or less, the result is seen as highly significant. *P* values just tell us whether an effect can be regarded as statistically significant or not. In no way do they relate to how big the effect might be, for which we need the *confidence interval*.
Qualitative research	Qualitative research is used to explore and understand people's beliefs, experiences, attitudes, behaviour and interactions. It generates non-numerical data, for example, a patient's description of their pain rather than a measure of pain. In healthcare, qualitative techniques have been commonly used in research documenting the experience of chronic illness and in studies about the functioning of organisations. Qualitative research techniques such as *focus groups* and *in depth interviews* have been used in one-off projects commissioned by guideline development groups to find out more about the views and experiences of patients and carers.
Quality adjusted life years (QALYS)	A measure of health outcome. QALYS are calculated by estimating the total life-years gained from a treatment and weighting each year with a quality of life score.
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.)
Rehabilitation	A programme of clinical and vocational services with the goal of returning patients

services	to a satisfying occupation.
Relative risk	A summary measure which represents the ratio of the risk of a given event or outcome (for example, an adverse reaction to the drug being tested) in one group of subjects compared to another group. When the 'risk' of the event is the same in the two groups the relative risk is 1. In a study comparing two treatments, a relative risk of 2 would indicate that patients receiving one of the treatments had twice the risk of an undesirable outcome than those receiving the other treatment. Relative risk is sometimes used as a synonym for *risk ratio* .
Reliability	Reliability refers to a method of measurement that consistently gives the same results. For example someone who has a high score on one occasion tends to have a high score if measured on another occasion very soon afterwards. With physical assessments it is possible for different clinicians to make independent assessments in quick succession – and if their assessments tend to agree then the method of assessment is said to be reliable.
Retrospective study	A retrospective study deals with the present/ past and does not involve studying future events. This contrasts with studies that are *prospective*.
Review	Summary of the main points and trends in the research literature on a specified topic. A review is considered non-systematic unless an extensive literature search has been carried out to ensure that all aspects of the topic are covered and an objective appraisal made of the quality of the studies.
Risk ratio	Ratio of the risk of an undesirable event or outcome occurring in a group of patients receiving experimental treatment compared with a comparison (control) group. The term *relative risk* is sometimes used as a synonym of risk ratio.
Sample	A part of the study's target population from which the subjects of the study will be recruited. If subjects are drawn in an unbiased way from a particular population, the results can be generalised from the sample to the population as a whole.
Sampling	Refers to the way participants are selected for inclusion in a study.
Sampling frame	A list or register of names which is used to recruit participants to a study.
Secondary care	Care provided in hospitals.
Seizure	An uncontrolled discharge of nerve impulses which may spread throughout the brain. It usually lasts only a few minutes. It may be associated with loss of consciousness or loss of bowel and bladder control.
Selection bias	Selection bias has occurred if: the characteristics of the *sample* differ from those of the wider population from which the sample has been drawn OR there are systematic differences between comparison groups of patients in a study in terms of prognosis or responsiveness to treatment.
Selection criteria	Explicit standards used by guideline development groups to decide which studies should be included and excluded from consideration as potential sources of evidence.
Semi-structured interview	Structured interviews involve asking people pre-set questions. A semi-structured interview allows more flexibility than a structured interview. The interviewer asks a number of open-ended questions, following up areas of interest in response to the information given by the respondent.
Sensitivity	In diagnostic testing, it refers to the chance of having a positive test result given that you have the disease. 100% sensitivity means that all those with the disease will test positive, but this is not the same the other way around. A patient could have a positive test result but not have the disease – this is called a 'false positive'. The sensitivity of a test is also related to its 'negative predictive value' (true negatives) – a test with a sensitivity of 100% means that all those who get a negative test result do not have the disease. To fully judge the accuracy of a test, its *Specificity* must also be considered.
Sequelae	Plural of sequela, which is any abnormal condition that occurs subsequent to and/or is caused by disease, injury, or treatment.
Single blind study	A study in which either the subject (patient/participant) or the observer (clinician/investigator) is not aware of which treatment or intervention the subject is receiving.
Specific indication	When a drug or a device has a specific remit to treat a specific condition and is not licensed for use in treating other conditions or diseases.
Specificity	In diagnostic testing, it refers to the chance of having a negative test result given that you do not have the disease. 100% specificity means that all those without the disease will test negative, but this is not the same the other way around. A patient

	could have a negative test result yet still have the disease – this is called a 'false negative'. The specificity of a test is also related to its 'positive predictive value' (true positives) – a test with a specificity of 100% means that all those who get a positive test result definitely have the disease. To fully judge the accuracy of a test, its *Sensitivity* must also be considered.
Standard deviation	A measure of the spread, scatter or variability of a set of measurements. Usually used with the mean (average) to describe numerical data.
Stand by call	Contact between a paramedic or other healthcare worker and an emergency department, by telephone or radio, to alert the department to the impending arrival of a seriously ill or injured patient who will require immediate resuscitation.
Statistical power	The ability of a study to demonstrate an association or causal relationship between two *variables*, given that an association exists. For example, 80% power in a clinical trial means that the study has a 80% chance of ending up with a *P* value of less than 5% in a statistical test (that is, a statistically significant treatment effect) if there really was an important difference (for example, 10% versus 5% mortality) between treatments. If the statistical power of a study is low, the study results will be questionable (the study might have been too small to detect any differences). By convention, 80% is an acceptable level of power. See also *P value*.
Structured interview	A research technique where the interviewer controls the interview by adhering strictly to a questionnaire or interview schedule with pre-set questions.
Study checklist	A list of questions addressing the key aspects of the research methodology that must be in place if a study is to be accepted as valid. A different checklist is required for each study type. These checklists are used to ensure a degree of consistency in the way that studies are evaluated.
Study population	People who have been identified as the subjects of a study.
Study quality	See *Methodological quality*.
Study type	The kind of design used for a study. *Randomised controlled trial*, *case-control study*, *cohort study* are all examples of study types.
Sub-group analysis	An analysis in which the intervention effect is evaluated in a defined subset of the participants in the trial, or in complementary subsets, such as by sex or in age categories.
Subdural space	The space beneath the dura mater, between it and the much thinner *arachnoid mater*. This is often the area of rupture of delicate thin-walled veins following head injuries.
Subdural haematoma (or haemorrhage)	A collection of blood between the dura mater and the arachnoid mater caused by traumatic damage to the associated brain and blood vessels. The rise in pressure caused by such bleeding can cause further significant damage
Subject	A person who takes part in an experiment or research study.
Subluxation	A partial dislocation of a joint in which the joint surfaces remain in contact, albeit out of alignment.
Survey	A study in which information is systematically collected from people (usually from a sample within a defined population).
Systematic	Methodical, according to plan; not random.
Systematic error	Refers to the various errors or biases inherent in a study. See also *Bias*.
Systematic review	A review in which evidence from scientific studies has been identified, appraised and synthesised in a methodical way according to predetermined criteria. May or may not include a *meta-analysis*.
Systemic	Involving the whole body.
Target population	The people to whom guideline recommendations are intended to apply. Recommendations may be less valid if applied to a population with different characteristics from the participants in the research study – for example, in terms of age, disease state, social background.
Tertiary centre	A specialist medical centre providing complex treatments which receives referrals from both primary and secondary care. Sometimes called a tertiary referral centre. See also *Primary care* and *Secondary care*.
Torticollis	Involuntary spasms of the musculature in the neck.
Triangulation	Use of three or more different research methods in combination; principally used as a check of validity. The more the different methods produce similar results, the more valid the findings.

Triple blind study	A study in which the statistical analysis is carried out without knowing which treatment patients received, in addition to the patients and investigators/clinicians being unaware which treatment patients were getting.
Unconsciousness	A temporary or prolonged loss of awareness of self and of surroundings
Validity	Assessment of how well a tool or instrument measures what it is intended to measure. See also *External validity*, *Internal validity*.
Variable	A measurement that can vary within a study, for example, the age of participants. Variability is present when differences can be seen between different people or within the same person over time, with respect to any characteristic or feature which can be assessed or measured.

1 Background and scope

1.1 Introduction

This guideline was first published in June 2003. The present guideline is a partial update of only some areas where new evidence has been published since the publication of the original guideline (see CG4 website http://guidance.nice.org.uk/cg41/niceguidance/word/English). This guideline incorporates both the original and the updated sections. All updated sections of the guideline are not shaded in grey to allow easy identification by the reader. All shaded sections have not been updated and is the original guideline. In this update, there are new recommendations in the sections on pre-hospital management, emergency department assessment, investigations for clinically important brain injuries, investigation for non-accidental injury in children, and transfer from secondary settings. These are highlighted in the document as 'New'. A number of amendments have been made to other recommendations from the initial guideline, and these are highlighted in the document as 'Amended'. 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.[2,3] Extrapolating on the basis of relative population size gives an estimate of a further 6,700 head injury admissions in Wales. There are no reliable up to date figures for the total denominator of attenders with a head injury at emergency departments. A figure of one million emergency department attenders for the United Kingdom as a whole is often quoted but this is based on figures from the late 1970s.[4] It is estimated that head injury admissions represent around 20% of all head injury attenders,[5] which would imply around 600,000 patients per annum attending emergency departments in England and Wales with a head injury. The true emergency department attendance rate may be closer to 700,000 patients however, as it is likely that the proportion of patients with head injury admitted to hospital has fallen below 20% in recent years. The poor quality of information regarding head injury attenders should improve as the use of a common emergency department dataset increases.

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[6] 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)[7].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).[5] As few as 0.2% of all patients attending emergency departments with a head injury will die as a result of this injury.[7,8]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.[9] Therefore emergency departments are required to see a large number of patients with a minor/mild head injury, and identify the very small number of these that will go on to have serious acute intracranial complications.

1.2 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.[10] They were used in the UK for over 15 years and relied on various clinical factors, particularly the level of consciousness, to place patients with a head injury into different risk categories. The main investigation incorporated into these guidelines was skull radiography, reflecting the importance of skull fracture as a risk factor for intracranial complications. Modifications to this guideline have since been published by the Society of British Neurological Surgeons in 1998, the Royal College of Surgeons of England in 1999 and by the Scottish Intercollegiate Guidelines Network in 2000.[11-13]The assessment and imaging of patients who have sustained a head injury is also addressed by guidelines from the Royal College of Radiologists.[14]

The recent recommendations of the Scottish Intercollegiate Guidelines Network centre around the identification of patients with a high (for example, over 10%) risk of intracranial complications using the GCS, the presence of a skull fracture and various other clinical variables. These high-risk patients are recommended for computed tomography (CT) scanning. Admission for observation was considered a tool for patients with a 'medium-risk' of intracranial complications[13] 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

An enhanced role for CT imaging after head injury was advocated by Neurosurgeons in 1990[15] and 1998[11], the 1999 guidelines from the Royal College of Surgeons of England and the 2000 guidelines from the Scottish Intercollegiate Guidelines Network. These statements recommended a more liberal CT scanning policy, while still adhering to the skull X-ray as the first line investigation in the majority of minor/mild head injuries.

This change in emphasis is reflected in an observed increase in CT scanning in the UK. Between 2002 and 2004 the number of CT brain scans requested in UK hospitals has more than doubled[16]. This move to CT reflects a general consensus that earlier definitive imaging is associated with improved outcomes.[15,17]

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 assessment tools, coupled with *observation* for patients with 'medium-risk' and *CT* for the highest risk groups. This translates to a CT scan rate of about 32% of all patients attending the emergency department with a head injury[18-21]. In contrast, rates of CT scanning in the USA at this time were between 75% to 100% of all patients with normal GCS and some previous loss of consciousness following a head injury.[22]

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.[23-25]

1.5 The skull radiograph

Historically, in the absence of readily available CT scanning resources, skull X-ray was used to categorise patients with minor/mild head injuries into high and low risk groups. Previously in the UK up to 74% of all patients attending emergency departments with a head injury received a skull X-ray,although only about 2% of these X-rays will show a fracture[26,27].

An elevation of risk following positive skull X-ray is widely acknowledged and supported by UK evidence.[17] 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.[23] The equivalent predictive values were 0.41 (positive predictive value) and 0.94 (negative predictive value). These figures imply that if there is a skull fracture diagnosed on radiography, the risk of an intracranial haemorrhage is elevated (about 4.9

times higher than before testing) but one cannot rule out an intracranial haemorrhage in patients for whom a skull X-ray does not show a skull fracture.

One reason for the low sensitivity of skull X-ray in predicting an intracranial haemorrhage is the reliability of radiographic interpretation. It has been consistently shown that clinically competent emergency department clinicians will miss between 13% and 23% of all skull fractures that are detected when radiographs are subsequently reviewed by a radiologist.[20,27,28]

As CT scanning has both sensitivities and specificities approaching 100% for detecting and locating a surgically significant focal intracranial lesion, it has been established as the definitive diagnostic investigation in patients who have sustained a head injury. The relatively low ordering rate for CT in the UK has historically been a function of availability. However, there has been a substantial investment in CT scanners in England and Wales over the last decade, increasing the capacity of modern scanners within the NHS considerably. In addition, CT technology has advanced considerably in recent years (for example, multisection helical CT), reducing the duration of an examination, improving the imaging output and reducing radiation exposure. The new scanners have greatly reduced the need for general anaesthesia and reduced the sedation rate in infants and patients rendered combative by their injuries.[29,30]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. [2,3]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.[7,8,20]

Also of concern is the quality of the observation that patients receive while in hospital. In a recent retrospective survey of 200,000 children in the North-East of England, only 14 children who presented with a minor head injury required neurosurgery. However, the recognition of secondary deterioration was delayed in all 14 patients, with documented routine neurological observations in only one child. Diagnosis of an intracranial haematoma was made between 6 hours and 14 days after the head injury, with a median delay of 18 hours.[31]

This is not a problem unique to the UK. In the USA it has been found that only 50% of patients admitted with a minor head injury had documentation of neurological observations and for the majority of these, the frequency of observations was not sufficient to detect early neurological deterioration.[32] 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,[12] but it is unclear whether this has resulted in an increased proportion of patients with head injury being observed in appropriately staffed wards.

1.7 Morbidity

The incidence of morbidity after head injury is higher than had been previously appreciated[33] and far exceeds the capacity of UK neurorehabilitation services. In a study of head injury admissions in 1995/96 in Glasgow, 47% of patients followed up for one year after discharge had survived with some form of restriction to lifestyle. Surprisingly, the proportion of patients experiencing the most serious sequelae (that is, moderate or severe), did not vary according to the severity of the initial injury. The study found that 47% of patients admitted with apparently minor/mild head injuries experienced significant sequelae on follow-up, compared to 45% of patients admitted for moderate head injury, and 48% of patients admitted for severe head injury. Only 47% of survivors with sequelae were seen in hospital after discharge and only 28% received some input from rehabilitation services. A second large UK study examined the outcome of patients attending a minor head injury clinic[34]. They saw 639 patients who had originally presented with a minor head injury. Fifty-six per cent were not back to work at 2 weeks, and 12% had not returned to work at 6 weeks. In addition at 6 weeks many had persisting symptoms including headache (13%), memory loss (15%) and concentration problems (14%). These data have been reproduced in other countries.[35,36]

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.[2-5,7]

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 account for 8 per 100,000 of these deaths.[19,22,37-40]

Comparisons with a Canadian population are important at this stage because of the importance of Canadian evidence to these guidelines. A large Canadian study on people with GCS greater than 12 following a head injury found that 31% of these people had sustained falls (comparable with UK estimates) and 43% had been in some form of road traffic accident (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%).[25] The Guideline Development Group is of the opinion that a head injury episode is more likely to have alcohol involvement in the UK than in Canada.

1.9 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. However, there are still differences between the protocols being used in North America and the UK.

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

There is evidence that outcomes for severely injured patients in England and Wales, as measured by severity adjusted odds of death, improved steadily up to the mid-1990s, but have not improved since. There is also indirect evidence that trauma care for patients with severe head injury in England and Wales is delivering a lower proportion of expected survivors when compared to trauma care in the United States, although these data are confounded by

case mix issues, especially the older age profile of patients with head injury in England and Wales.[41] 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.[42] This shortfall can lead to delays in patient transfer, and is symptomatic of larger resource and workload issues for neurosurgery in the UK.[43] 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 published in June 2003. The guideline provided advice on effective care using the best possible research evidence. The guideline was 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, notably 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 of observation or discharged home;
- criteria for surgical intervention;
- information for patients and their carer/s prior to and during hospital admission;
- management at home of patients who are discharged within 48 hours of admission including advice to primary

care and emergency department staff on the management of patients who re-present with suspicious symptoms;.

- guidance on appropriate handover arrangements;
- information for patients and carers.

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 did not provide advice on the management of patients with other traumatic injury to the head (for example, to the eye or face). It does not address the rehabilitation or long term care of patients with a head injury but the guideline does explore possible criteria for the early identification of patients who require rehabilitation.

1.12 Healthcare setting

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

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

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

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. Since the Head Injury guideline was published there have been new studies with some changes in criteria with respect to CT scanning. This was identified as an area of concern at the time of the initial publication. In addition, a variety of comments have been received post publication on the following areas: guidance for CT scanning, issues relating

to the Glasgow Coma Scale (GCS), competencies and settings with particular respect to Emergency Department, Minor Injuries Unit and the community. There was sufficient new evidence to prompt an update. This update affects a few recommendations within the original guideline.

New evidence has been incorporated using the latest version of the NICE technical manual (April 2007). The original guideline was produced using standard methodology 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 guideline review is carried out at 2 years and a proposal will be put forward to the Guidelines Executive at NICE based on this review.

1.14 What are clinical practice guidelines?

NICE 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 healthcare. We use predetermined and systematic methods to identify and evaluate the evidence relating to specific clinical questions.

Clinical guidelines:

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

While guidelines assist the practice of healthcare professionals, they do not replace their knowledge and skills. NICE produce guidelines using the following steps[44]:

- Guideline topic is referred to NICE from the Department of Health (except guideline updates)
- 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 update scope is based on the previous guideline.
- 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:

- 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 (Understanding NICE Guidance) 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 (NCC-AC). 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 and scope have not been altered for this update.

1.17 What the update guideline covers

The guideline covers best practice advice on the care of adults, children (aged 1-15 years) and infants (under one year) who present with a suspected or confirmed traumatic head injury with or without other major trauma. In certain circumstances, the age group 'infants and young children' (that is, those aged under 5 years) is used. Cut-off points of 10 years and 12 years are also used. 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. The primary patient outcome of concern throughout the guideline is 'clinically important brain or cervical spine injury'. For the purposes

of this guideline, clinically important brain or cervical spine injury is defined as any acute condition that has been identified by imaging or by assessment of risk factors.

This update covers the following;

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

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

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

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

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 (NICE) funds the National Collaborating Centre for Acute Care 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 NICE. A

few new members were involved in this update where the Chair and NCC felt those clinical specialties would be useful.

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

2.2 Working principles

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

For the purposes of the guidelines it was agreed that 'infants' are aged under 1 year, 'children' are 1-15 year olds and 'adults' are aged 16 years or more. In certain circumstances, the age group 'infants and young children' (that is, aged under 5 years) is used. Cut-off points of 10 years and 12 years are also used where appropriate. '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 operation is not appropriate for some patients and 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 head trauma.

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)
- Health Management Information Consortium (HMIC)

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

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

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

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 GDG members to the final guidelines. An initial set of recommendations was circulated in questionnaire format, and GDG members rated their agreement with each recommendation on a nine point scale (strongly disagree to strongly agree). Separate ratings were made where relevant for infants, children and adults. A meeting was then held on July 25th 2002 to discuss the recommendations in the light of GDG responses to the questionnaire. A revised set of recommendations was drawn up following the meeting and again circulated to GDG members for their appraisal. At this stage there was near complete agreement with all

recommendations, and only minor revisions in wording were required. The recommendations presented in this guideline are the result of the consensus exercise.

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

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 (for example, eligibility for early discharge).

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

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 update methodology*

The guideline update was commissioned by NICE and developed in accordance with the guideline development process outlined in 'The guidelines manual' updated in April 2006[45] and 2007[44].

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 GDG. The clinical questions were initially drafted by the review team and were refined and validated by the GDG. The questions were based on the scope (Appendix 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 D. The following databases were included in the literature search to identify relevant journal articles:

- Medline (Dialog Datastar) 1951-2006
- Embase (Dialog Datastar) 1974-2006

- PsycINFO 1806-2006
- Health Economic and Evaluations Database (HEED)
- NHS Economic Evaluation Database (NHSEED)

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

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

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. The system used for the update was the one 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

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

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

Table 2: Levels of evidence for studies of the accuracy of diagnostic tests. Adapted from 'The Oxford Centre for Evidence-based Medicine Levels of Evidence' (2001) and the Centre for Reviews and Dissemination 'Report Number 4' (2001).

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

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

[b] Level-1 studies are studies:
• that use a blind comparison of the test with a validated reference standard (gold standard)

• in a sample of patients that reflects the population to whom the test would apply.

[c] Level-2 studies are studies that have only one of the following:
• narrow population (the sample does not reflect the population to whom the test would apply)
• a poor reference standard (defined as that where the 'test' is included in the 'reference', or where the 'testing' affects the 'reference')
• a comparison between the test and reference standard that is not blind
• case–control design.

[d] Level-3 studies are studies that have at least two or three of the features listed for level-2 studies.

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 GDG also suggested further references and these were assessed in the same way.

Selected studies were ordered and assessed in full by the NCC-AC team using agreed inclusion/ exclusion criteria specific to the guideline topic, and using NICE methodology quality assessment checklists appropriate to the study design[45].

2.15 *Health economics methods*

See chapter 11.

2.16 *Grading of recommendations*

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

2.17 *Research recommendations*

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

2.18 *Prioritisation of recommendations for implementation*

To assist users of the guideline in deciding the order in which to implement the recommendations, the GDG identified up to ten 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.

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 Initial assessment in the emergency department

All patients presenting to an emergency department with a head injury should be assessed 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 cervical spine).

3.1.2 Urgency of imaging

[Amended] Computed tomography (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 risk factors:

- **GCS less than 13 on initial assessment in the emergency department.**
- **GCS less than 15 at 2 hours after the injury.**

- **Suspected open or depressed skull fracture.**

- **Any sign of basal skull fracture (haemotympanum, 'panda' eyes, cerebrospinal fluid leakage from the ear or nose, Battle's sign).**

- **More than one episode of vomiting in adults; three or more episodes of vomiting in children.**

- **Post-traumatic seizure.**

- **Coagulopathy (history of bleeding, clotting disorder, current treatment with warfarin) providing that some loss of consciousness or amnesia has been experienced; patients receiving antiplatelet therapy may be at increased risk of intracranial bleeding, though this is currently unquantified –**

clinical judgement should be used to assess the need for an urgent scan in these patients.

- Focal neurological deficit.

[Amended] Patients who have any of the following risk factors:

- Amnesia for events more than 30 minutes before impact (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).

- Age 65 years or older, providing that some loss of consciousness or amnesia has been experienced.

- 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.

and none of the following risk factors:

- GCS less than 13 on initial assessment in the emergency department.

- GCS less than 15 at 2 hours after the injury.

- Suspected open or depressed skull fracture.

- Any sign of basal skull fracture (haemotympanum, 'panda' eyes, cerebrospinal fluid leakage from the ear or nose, Battle's sign).

- More than one episode of vomiting in adults; three or more episodes of vomiting in children.

- Post-traumatic seizure.

- Coagulopathy (history of bleeding, clotting disorder, current treatment with warfarin) providing that some loss of consciousness or amnesia has been experienced; patients receiving antiplatelet therapy may be at increased risk of intracranial bleeding, though this is currently unquantified – clinical judgement should be used to assess the need for an urgent scan in these patients.

- Focal neurological deficit.

should have CT imaging of the head 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).

[New] Children under 10 years of age with a Glasgow Coma Score (GCS) of 8 or less should have CT imaging of the cervical spine within 1 hour of presentation or when they are sufficiently stable.

[Amended] Imaging of the cervical spine should be performed within 1 hour of a request having been received by the radiology department or when the patient is sufficiently stable. Where a request for urgent CT imaging of the head (that is, within 1 hour) has also been received, the cervical spine imaging should be carried out simultaneously.

3.1.3 Admission

[Amended] In circumstances where a patient with a head injury requires hospital admission, it is recommended that the patient be admitted only under the care of a team led by a consultant who has been trained in the management of this condition during his/her higher specialist training. The consultant and his/her team should have competence (defined by local agreement with the neuroscience unit) in assessment, observation and indications for imaging (see recommendations in 3.7); inpatient management; indications for transfer to a neuroscience unit (see recommendations in 3.6); and hospital discharge and follow-up (see recommendations in 3.8).

3.1.4 Organisation of transfer of patients between referring hospital and neuroscience unit

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

- transfer would benefit all patients with serious head injuries (GCS ≤ 8), irrespective of the need for neurosurgery

- if transfer of those who do not require neurosurgery is not possible, ongoing liaison with the neuroscience unit over clinical management is essential.

3.1.5 Advice about long-term problems and support services

[Amended] 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.

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 (GCS). 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.

3.2.1.1 **Monitoring and exchange of information about individual patients should be based on the three separate responses on the Glasgow Coma Score (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 Glasgow Coma Score 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 **[Amended] It is recommended that General Practitioners, nurses, dentists and ambulance crews should receive training, as necessary, to ensure that they are capable of assessing the presence or absence of the risk factors listed in recommendations 3.3.2. (D)**

3.2.4 **Support for familes 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 emergency 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 **[Amended] Healthcare 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 long peiods at the bedside. If they wish to stay with the patient, they should be encouraged to take regular breaks. (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 lines**

3.3.1.1 **[Amended] Telephone advice services (for example, NHS Direct, emergency department helplines) should refer people who have sustained a head injury to the emergency ambulance services (that is, 999) for emergency transport to the emergency department if they have experienced any of the following (alternative terms to facilitate communication are in parenthesis):**

- 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 motorized recreational vehicles, bicycle collision, or any other potentially high-energy mechanism).

- The injured person or their carer is incapable of transporting the injured person safely to the hospital emergency department without the use

of ambulance services (providing any other risk factor indicating emergency department referral is present). (D)

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

- **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 under 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 65 years or older.**

- **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 under 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 3.3.1.1 and 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 [Amended] Community health services (general practice, ambulance crews, NHS walk-in centres, dental practitioners) and NHS minor injury clinics should refer patients who have sustained a head injury to a hospital emergency department, using the ambulance service if deemed necessary (see section 3.4.1.1); if any of the following are 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.**

- **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, 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 motorized recreational vehicles, bicycle collision, or any other potentially high-energy mechanism).**

- **History of bleeding or clotting disorder.**

- **Current anticoagulant therapy such as warfarin.**

- **Current drug or alcohol intoxication.**

- **Age 65 years or older.**

- **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 an emergency department 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 the emergency department

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 the emergency department. (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 [Amended] Adults who have sustained a head injury should initially be assessed and their care managed according to clear principles and standard practice, as embodied in: the Advanced Trauma Life Support (ATLS) course/European Trauma course; the International Trauma Life Support (ITLS) course; the Pre-hospital Trauma Life Support (PHTLS) course; the Advanced Trauma Nurse Course (ATNC); the Trauma Nursing Core Course (TNCC); and the Joint Royal Colleges Ambulance Service Liaison Committee (JRCALC) Clinical Practice Guidelines for Head Trauma. For children, clear principles are outlined in the Advanced Paediatric Life Support (APLS)/European Paediatric Life Support (EPLS) course, the Pre-hospital Paediatric Life Support (PHPLS) course and the Paediatric Education for Pre-hospital Professionals (PEPP) course. (D)

3.4.2.2 Ambulance crews should be fully trained in the use of the adult and paediatric versions of the Glasgow Coma Scale. (D)

3.4.2.3 Ambulance crews should be trained in the detection of non-accidental injury and should pass information to emergency department personnel when the relevant signs and symptoms arise. (D)

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

3.4.2.5 [Amended] Patients who have sustained a head injury should be transported directly to a facility that has been identified as having the resources necessary to resuscitate, investigate and initially manage any patient with multiple injuries. It is expected that all acute hospitals and all neuroscience units accepting patients directly from an incident will have these resources, and that these

resources will be appropriate for a patient's age. (D)

3.4.2.6 **[Amended] 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 by the healthcare professional**
- **neck pain or tenderness**
- **focal neurological deficit**
- **paraesthesia in the extremities**
- **any other clinical suspicion of cervical spine injury. (D)**

3.4.2.7 **[Amended] 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 emergency 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 **[New] Pain should be managed effectively because it can lead to a rise in intracranial pressure. Reassurance and splintage of limb fractures are helpful; catheterisation of a full bladder will reduce irritability. Analgesia as described in 3.5.1.9 should be given only under the direction of a doctor.**

3.5 ***Assessment and investigation in the emergency department***

3.5.1 **Good practice in emergency department assessment**

The main focus of emergency department assessment for patients who have sustained a head injury should be the risk of clinically important brain injuries and injuries to the cervical spine and the consequent need for imaging. Due attention should also be paid to co-existing injuries and to other concerns the clinician may have (for example, 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.

3.5.1.1 **The priority for all emergency department 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 emergency department clinicians involved in the assessment of patients**

with a head injury should be capable of assessing the presence or absence of the risk factors in the guidance on patient selection and urgency for imaging (head and 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 the emergency department with impaired consciousness (GCS less than 15) should be assessed immediately by a trained member of staff. (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 recommendations 3.6.1.7 and 3.6.1.8 to assist with resuscitation. (D)**

3.5.1.6 **All patients presenting to an emergency department with a head injury should be assessed 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 cervical spine – see later recommendations). (D)**

3.5.1.7 **[Amended] In patients considered to be at high risk for clinically important brain injury and/or cervical spine injury, assessment should be extended to full clinical examination to 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. See recommendations 3.5.3.1 to 3.5.4.2 (imaging of the head) and 3.5.5.1 to 3.5.7.2 (imaging of the cervical spine). (D)**

3.5.1.8 **[Amended] Patients who, on initial assessment, are considered to be at low risk for clinically important brain injury and/or cervical spine injury should be re-examined within a further hour by an emergency department clinician. Part of this assessment should fully establish the need to request CT imaging of the head and/or imaging of the cervical spine. 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 3.5.5.1 to 3.5.7.2 (imaging of the cervical spine). (D)**

3.5.1.9 **[NEW] Pain should be managed effectively because it can lead to a rise in intracranial pressure. Reassurance and splintage of limb fractures are helpful; catheterisation of a full bladder will reduce irritability. Significant pain should be treated with small doses of intravenous opioids titrated against clinical response and**

baseline cardiorespiratory measurements.

3.5.1.10 **[Amended] Throughout the hospital episode, all healthcare professionals should use a standard head injury proforma in their documentation when assessing and observing patients with head injury. This form should be of a consistent format across all clinical departments and hospitals in which a patient might be treated. 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 proformas that should be used in patients with head injury are provided in Appendices J, K1 and K2). (D)**

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

3.5.1.12 **Patients who returned to an emergency department within 48 hours of discharge 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, magnetic resonance imaging (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 **[NEW] Plain X-rays of the skull should not be used to diagnose significant brain injury without prior discussion with a neuroscience unit. However, they are useful as part of the skeletal survey in children presenting with suspected non-accidental injury.**

3.5.2.6 **[NEW] Unless the CT result is required within 1 hour, it is acceptable to admit a patient for effective overnight observation and delay the CT scan until the next morning if the patient presents out of hours and any of the following risk factors are present in**

addition to a period of loss of consciousness or amnesia:

- age 65 years or older

- amnesia for events more than 30 minutes before impact

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

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

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

<u>For adults</u>

3.5.3.1 **[Amended] 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 requested immediately:**

- GCS less than 13 on initial assessment in the emergency department.

- GCS less than 15 at 2 hours after the injury on assessment in the emergency department.

- Suspected open or depressed skull fracture.

- Any sign of basal skull fracture (haemotympanum, 'panda' eyes, cerebrospinal fluid leakage from the ear or nose, Battle's sign).

- Post-traumatic seizure.

- Focal neurological deficit.

- More than one episode of vomiting.

- Amnesia for events more than 30 minutes before impact. (B)

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

- Age 65 years or older.

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

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

<u>For children</u>

3.5.3.3 **[NEW] Children (under 16 years) who have sustained a head injury and present with any one of the following risk factors should have CT scanning of the head requested immediately:**

- Loss of consciousness lasting more than 5 minutes (witnessed).

- **Amnesia (antegrade or retrograde) lasting more than 5 minutes.**

- **Abnormal drowsiness.**

- **Three or more discrete episodes of vomiting.**

- **Clinical suspicion of non-accidental injury.**

- **Post-traumatic seizure but no history of epilepsy.**

- **GCS less than 14, or for a baby under 1 year GCS (paediatric) less than 15, on assessment in the emergency department.**

- **Suspicion of open or depressed skull injury or tense fontanelle.**

- **Any sign of basal skull fracture (haemotympanum, 'panda' eyes, cerebrospinal fluid leakage from the ear or nose, Battle's sign).**

- **Focal neurological deficit.**

- **If under 1 year, presence of bruise, swelling or laceration of more than 5 cm on the head.**

- **Dangerous mechanism of injury (high-speed road traffic accident either as pedestrian, cyclist or vehicle occupant, fall from a height of greater than 3 metres, high-speed injury from a projectile or an object).**

3.5.4 Urgency in performing CT imaging of the head

3.5.4.1 [Amended] 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 less than 15 at 2 hours after the injury.**

- **Suspected open or depressed skull fracture.**

- **Any sign of basal skull fracture (haemotympanum, 'panda' eyes, cerebrospinal fluid leakage from the ear or nose, Battle's sign).**

- **More than one episode of vomiting in adults; three or more episodes of vomiting in children.**

- **Post-traumatic seizure.**

- **Coagulopathy (history of bleeding, clotting disorder, current treatment with warfarin) providing that some loss of consciousness or amnesia has been experienced; patients receiving antiplatelet therapy may be at increased risk of intracranial bleeding, though this is currently unquantified – clinical judgement should be used to assess the need for an urgent scan in these patients.**

- **Focal neurological deficit. (B)**

3.5.4.2 [Amended] 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 events more than 30 minutes before impact (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).

- Age 65 years or older providing that some loss of consciousness or amnesia has been experienced.

- 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. (B)

3.5.5 ***Investigation for injuries to the cervical spine***

3.5.5.1 **[Amended] The current initial investigation of choice for the detection of injuries to the cervical spine is the plain radiograph. Three views should be obtained and be of sufficient quality for reliable interpretation. However, in certain circumstances CT is preferred. (B)**

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

3.5.5.3 **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)**

3.5.5.4 **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)**

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

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

3.5.5.7 **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)**

3.5.5.8 **In patients who have sustained high energy trauma or are showing signs of lower cranial nerve palsy, 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 [Amended] Adult patients should have three-view radiographic imaging of the cervical spine requested immediately if any of the following points apply:

- There is neck pain or midline tenderness with:

o Age 65 years or older, or

o 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; rollover motor accident; ejection from a motor vehicle; accident involving motorized recreational vehicles; bicycle collision).

- It is not considered safe to assess the range of movement in the neck for reasons other than those above.

- It is considered safe to assess the range of movement in the neck and, on assessment, the patient cannot actively rotate the neck to 45 degrees to the left and right; safe assessment can be carried out if the patient:

o was involved in a simple rear-end motor vehicle collision

o is comfortable in a sitting position in the emergency department

o has been ambulatory at any time since injury with no midline cervical spine tenderness

o presents with delayed onset of neck pain.

- A definitive diagnosis of cervical spine injury is required urgently (for example, before surgery). (A)

3.5.6.2 [NEW] Adult patients who have any of the following risk factors should have CT imaging of the cervical spine requested immediately:

- GCS below 13 on initial assessment

- Has been intubated

- Plain film series is technically inadequate (for example, desired view unavailable), suspicious or definitely abnormal

- Continued clinical suspicion of injury despite a normal X ray.

- The patient is being scanned for multi-region trauma.

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

3.5.6.5 [NEW] 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 be used only in cases where patients have a severe head injury (GCS ≤ 8), or where there is a strong

clinical suspicion of injury despite normal plain films (for example, focal neurological signs or paraesthesia in the extremities), or where plain films are technically difficult or inadequate.

3.5.7 Urgency in performing cervical spine imaging

3.5.7.1 [NEW] Children under 10 years of age with GCS of 8 or less should have CT imaging of the cervical spine within 1 hour of presentation or when they are sufficiently stable.

3.5.7.2 [Amended] Imaging of the cervical spine should be performed within 1 hour of a request having been received by the radiology department or when the patient is sufficiently stable. Where a request for urgent CT imaging of the head (that is, within 1 hour) has also been received, the cervical spine imaging should be carried out simultaneously. (D)

3.5.8 Investigations of non-accidental injury in children

3.5.8.1 [Amended] A clinician with expertise in non-accidental injuries in children should be involved in any suspected case of non-accidental injury in a child. Examinations/investigations that should be considered include: skull X-ray as part of a skeletal survey, ophthalmoscopic examination for retinal haemorrhage, and examination for pallor, anaemia, and tense fontanelle or other suggestive features. Other imaging such as CT and MRI may be required to define injuries.

3.5.9 Radiation exposure managment

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)

3.5.10 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 shown 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 ≤ 8) after initial resuscitation.**
- **unexplained confusion which persists for more than 4 hours**
- **deterioration in GCS 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 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 cooperative to allow scanning.**
- **Continuing worrying signs (for example, persistent vomiting, severe headaches) of concern to the clinician.**
- **Other sources of concern to the clinician (for example, drug or alcohol intoxication, other injuries, shock, suspected non-accidental injury, meningism, cerebrospinal fluid leak). (D)**

3.5.11.2 [Amended] Some patients may require an extended period in a recovery setting because of the use of general anaesthesia during CT imaging. (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 [Amended] In circumstances where a patient with a head injury requires hospital admission, it is recommended that the patient be admitted only under the care of a team led by a consultant who has been trained in the management of this condition during his/her higher specialist training. The consultant and his/her team should have competence (defined by local agreement with the neuroscience unit) in assessment, observation and indications for imaging (see recommendations 3.7); inpatient management; indications for transfer to a neuroscience unit (see recommendations 3.6); and hospital discharge and follow up (see recommendations 3.8). (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 [Amended] Local guidelines on the transfer of patients with head injuries should be drawn up between the referring hospital trusts, the neuroscience unit and the local ambulance service, and should recognise that:

- **transfer would benefit all patients with serious head injuries (GCS ≤ 8), irrespective of the need for neurosurgery**
- **if transfer of those who do not require neurosurgery is not possible,**

ongoing liaison with the neuroscience unit over clinical management is essential. (D)

3.6.1.2 **[NEW] The possibility of occult extracranial injuries should be considered for the multiply injured adult, and he or she should not be transferred to a service that is unable to deal with other aspects of trauma.**

3.6.1.3 **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)**

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

3.6.1.5 **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)**

3.6.1.6 **[Amended] Although it is understood that transfer is often urgent, initial resuscitation and stabilisation of the patient should be completed and comprehensive monitoring established before transfer to avoid complications during the journey. A patient who is persistently hypotensive, despite resuscitation, should not be transported until the cause of the hypotension has been identified and the patient stabilised. (D)**

3.6.1.7 **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 recommendation 3.6.1.8. (D)**

3.6.1.8 **[Amended] Intubation and ventilation should be used immediately in the following circumstances:**

- **Coma – not obeying commands, not speaking, not eye opening (that is, GCS ≤ 8).**
- **Loss of protective laryngeal reflexes.**
- **Ventilatory insufficiency as judged by blood gases: hypoxaemia (PaO_2< 13 kPa on oxygen) or hypercarbia ($PaCO_2$ > 6 kPa).**

- **Spontaneous hyperventilation causing $PaCO_2$ < 4 kPa.**

- **Irregular respirations. (D).**

3.6.1.9 **[Amended] 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.**

- **Unstable fractures of the facial skeleton.**

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

- **Seizures. (D)**

3.6.1.10 **[Amended] An intubated patient should be ventilated with muscle relaxation and appropriate short-acting sedation and analgesia. Aim for a PaO_2 greater than 13 kPa, $PaCO_2$ 4.5 to 5.0 kPa unless there is clinical or radiological evidence of raised intracranial pressure, in which case more aggressive hyperventilation is justified. If hyperventilation is used, the inspired oxygen concentration should be increased. The mean arterial pressure should be maintained at 80 mmHg or more by infusion of fluid and vasopressors as indicated. In children, blood pressure should be maintained at a level appropriate for the child's age. (D)**

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

3.6.1.12 **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. (D)**

3.6.2 **Transfer of children**

3.6.2.1 **The recommendations in section 3.6.1 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 3.6.1. (D)**

3.6.2.3 **[NEW] The possibility of occult extracranial injuries should be considered for the multiply injured child, and he or she should not be transferred to a service that is unable to deal with other aspects of trauma.**

3.6.2.4 **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)**

3.6.2.5 **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)**

3.7 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.

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.

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 the emergency department:

- **half-hourly for 2 hours**
- **then 1-hourly for 4 hours**
- **then 2-hourly thereafter.**

3.7.3.2 Should a patient with GCS equal to 15 deteriorate at any time after the initial 2-hour period, observations should revert to half-hourly and follow the original frequency schedule. (D)

3.7.4 Observationof children and infants

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

3.7.5 Patients changes requiring review while under observation

3.7.5.1 [Amended] 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 (greater weight should be given to a drop of one point in the motor response score of the Glasgow Coma Scale).**
- **Any drop of three or more points in the eye-opening or verbal response scores of the Glasgow Coma Scale, or two or more points in the motor response score.**

- Development of severe or increasing headache or persisting vomiting.

- New or evolving neurological symptoms or signs such as pupil inequality or asymmetry of limb or facial movement. (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 confimed patient deterioration**

3.7.6.1 **[Amended] If any of the changes noted in 1.7.5.1 above are confirmed, an immediate CT scan should be considered, and the patient's clinical condition should be re-assessed and managed appropriately. (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 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 Glasgow Coma Scale status**

3.8.1.1 **No patients presenting with head injury should be discharged until they have achieved GCS equal to 15, or normal consciousness in infants and young children as assessed by the paediatric version of the Glasgow Coma Scale. (D)**

3.8.2 **Discharge advice**

3.8.2.1 **All patients with any degree of head injury who are deemed safe for appropriate discharge from an emergency department 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 emergency department 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 the emergency department 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)**

<u>Discharge of specific patient groups:</u>

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 discharge 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 discharge, 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 discharge 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 discharge, 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 discharge 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 discharged after resolution of all significant symptoms and signs providing they have suitable supervision arrangements at home (see also recommendation 3.5.2.6 for those admitted out of hours but who require a CT scan). (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 discharged 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 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 General Practitioner 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 [Amended] 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 if they experience long-term problems. Details of support services should be included on patient discharge advice cards. (D)

3.8.11 Communication with community services

3.8.11.1 A communication (letter or email) should be generated for all patients who have attended the emergency department with a head injury, and sent to the patient's GP within 1 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 [Amended] A communication (letter or email) should be generated for all school-aged children who received head or cervical spine imaging, and sent to the relevant GP and school nurse within 1 week of the end of the hospital episode. This letter should include details of the clinical history and examination. (D)

3.8.11.3 **[Amended] A communication (letter or email) should be generated for all pre-school children who received head or cervical spine imaging, and sent to the GP 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**

3.9.1.1 Pain should be managed effectively because it can lead to a rise in intracranial pressure. Reassurance and splintage of limb fractures are helpful; catheterisation of a full bladder will reduce irritability. Analgesia as described in 3.5.1.9 should be given only under the direction of a doctor.

3.9.2 **Investigations for clinically important brain injuries**

3.9.2.1 Plain X-rays of the skull should not be used to diagnose significant brain injury without prior discussion with a neuroscience unit. However, they are useful as part of the skeletal survey in children presenting with suspected non-accidental injury.

3.9.2.2 Unless the CT result is required within 1 hour, it is acceptable to admit a patient for effective overnight observation and delay the CT scan until the next morning if the patient presents out of hours and any of the following risk factors are present in addition to a period of loss of consciousness or amnesia:

- age 65 years or older
- amnesia for events more than 30 minutes before impact
- dangerous mechanism of injury (a pedestrian or cyclist struck by a motor vehicle, an occupant ejected from a motor vehicle or a fall from a height of greater than 1 metre or five stairs).

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

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

3.9.3.1 Children (under 16 years) who have sustained a head injury and present with any one of the following risk factors should have CT scanning of the head requested immediately:

- Loss of consciousness lasting more than 5 minutes (witnessed).
- Amnesia (antegrade or retrograde) lasting more than 5 minutes.
- Abnormal drowsiness.
- Three or more discrete episodes of vomiting.
- Clinical suspicion of non-accidental injury.
- Post-traumatic seizure but no history of epilepsy.
- GCS less than 14, or for a baby under 1 year GCS (paediatric) less than

15, on assessment in the emergency department.

- Suspicion of open or depressed skull injury or tense fontanelle.

- Any sign of basal skull fracture (haemotympanum, 'panda' eyes, cerebrospinal fluid leakage from the ear or nose, Battle's sign).

- Focal neurological deficit.

- If under 1 year, presence of bruise, swelling or laceration of more than 5 cm on the head.

- Dangerous mechanism of injury (high-speed road traffic accident either as pedestrian, cyclist or vehicle occupant, fall from a height of greater than 3 metres, high-speed injury from a projectile or an object).

3.9.4 Selection of patients for imaging of the cervical spine

3.9.4.1 Adult patients who have any of the following risk factors should have CT imaging of the cervical spine requested immediately:

- GCS below 13 on initial assessment

- Has been intubated

- Plain film series is technically inadequate (for example, desired view unavailable), suspicious or definitely abnormal

- Continued clinical suspicion of injury despite a normal X ray.

- The patient is being scanned for multi-region trauma.

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 be used only in cases where patients have a severe head injury (GCS $\leq$ 8), or where there is a strong clinical suspicion of injury despite normal plain films (for example, focal neurological signs or paraesthesia in the extremities), or where plain films are technically difficult or inadequate.

3.9.6 Urgency in performing cervical spine imaging

3.9.6.1 Children under 10 years of age with GCS of 8 or less should have CT imaging of the cervical spine within 1 hour of presentation or when they are sufficiently stable.

3.9.7 Urgency in performing cervical spine imaging

3.9.7.1 Children under 10 years with GCS of 8 or less should have CT imaging of the cervical spine within 1 hour of

presentation or when they are sufficiently stable.

3.9.8 Transfer of adults

3.9.8.1 The possibility of occult extracranial injuries should be considered for the multiply injured adult, and he or she should not be transferred to a service that is unable to deal with other aspects of trauma.

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 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 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 should be followed as they pass through the care system with mortality and morbidity outcomes collected. These should be compared to allow, using sub-group analysis, the identification of patients for whom direct transfer is most beneficial.

3.10.1.1 Why this research is important

Limited evidence in this area has shown that patients do better in terms of outcome if they are transported directly to a neurosciences centre when compared to those who are taken to the nearest district general hospital. This evidence however does not appear to have influenced current practice. For people working in the prehospital arena, it is important to define which patients who have sustained a head injury would do better by being transported directly to a neurosciences centre.

Currently patients are either always transported to the nearest district general hospital 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 district general hospital may suffer a significant delay in receiving definitive treatment for their head injury. Information from such research can help to define which patients should be transported direct to a neurosciences centre bypassing the nearest hospital.

Guidance will be required to define the patient population 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. Researchers should look at the impact of the duration of transport on study outcome. So for a journey time to the neurosciences unit of less than 20 minutes, direct transport might improve outcomes, (as concluded by the London Severe Injury Working Group) but beyond this time, direct transport might worsen outcomes.

In addition to measuring changes in morbidity and mortality, the cost-effectiveness of direct transport should be modelled in terms of the cost per quality-adjusted life-year gained. A protype model was produced for the 2007 update of this guideline (1.1.1).

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.

3.10.2.1 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 children 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.

3.10.3.1 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 (BtO_2) or microdialysis. When the patient deteriorates, he or she 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 before 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 their care should be managed there. There is no level 1 evidence about what to do with these patients and the need for such a PRCT in head injured patients is urgent. This research question should immediately be put to UK research funding bodies.

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?

3.10.4.1 Why this research is important

Traumatic brain injury (TBI) is amongst the most important causes of death in young adults, with an overall mortality for severe TBI of over 50%. TBI care consumes one million acute hospital bed-days, and over 15,000 ICU bed-days annually, and patients who do survive significant TBI experience an enormous burden of long term physical disability, neurocognitive deficits, and neuropsychiatric sequelae. The financial impact is significant: the NHS spends over £1 billion on just the acute hospital care of the 10,000 patients with significant TBI. The costs of rehabilitation and community care are difficult to estimate, but probably total many multiples of the figure provided for acute care. These considerations make TBI a national healthcare priority and its outcome impact is consistent with its inclusion in the National Service Framework for Long Term Neurological Conditions.

Current referral of patients with acute traumatic brain injury practice is still dominated in many parts of the United Kingdom by the need for operative neurosurgical intervention at presentation. This may be inappropriate, since many patients with severe head injury have evidence of raised intracranial pressure in the absence of surgical lesions, and suffer morbidity and mortality equal to those with

surgical lesions. Further, several studies provide strong circumstantial evidence that managing such "non-surgical" patients in specialist neurosciences centres may result in substantial improvements in mortality and functional outcome, probably due to specialist expertise in areas of non-operative management, such as neurocritical care. However, these results may be confounded by case-mix effects and referral bias, and the cost-effectiveness of such specialist management remains uncertain. There is a strong case to address this question in the context of a formal study, since a change in practice could have a major impact on death and disability in a condition that is a major contributor to mortality in healthy young adults. Importantly, the results of such a study could fundamentally alter the recommendations made by NICE, in terms of where patients with head injury are treated within the healthcare system, and result in better optimised (and potentially more cost-effective) patient flows within the NHS.

The available evidence in this area has been addressed in the systematic review that contributed to the revision of NICE Guidelines on the early management of head injury. This review could find no high quality clinical evidence on the topic. This is unsurprising, since any study that addressed these issues would have to be undertaken within the context of a healthcare system and include ambulance services, district general hospitals and neuroscience referral centres. Such a study would therefore require the organisational backing of a body such as NICE and careful design to account for confounds and biases. However, we believe that given careful design, such a study would be both ethically and logistically feasible. The patient group is well defined, and adequate numbers would be available to provide a definitive result within a reasonable time frame. While circumstantial evidence may support transfer of such patients to neurosciences centres, current practice is not influenced by this view in many regions, and many would argue that there is still clinical equipoise in this area. There are clear risks from transfer, and there could be clear harm, both in terms of clinical outcome and health economics, if the anticipated benefits were not realised. On the other hand, if the benefits from observational studies were confirmed by the trial, the resulting changes in management 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.

3.10.5.1 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 tool 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.[15,46]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.[15,46]Amnesia is usually defined as post-traumatic (anterograde – for events after the trauma) in the literature but a recent important study has suggested that retrograde amnesia (**that is**, for memories before the

trauma) is a more important risk factor.[25] 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[47] 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.[48,49]

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.[23] There is variation in diagnostic practice for skull fracture. Some guidelines advocate the use of skull X-ray in the diagnosis of skull fracture,[13] while others advocate the use of signs alone (for example, cerebrospinal fluid leak, periorbital haematoma, depressed or open skull injury, penetrating injury).[25]

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.[50] Commonly used thresholds are 60 years[19,51] and 65 years[25,50]. To avoid confusion, the GDG chose to adopt a standard age threshold throughout these guidelines of greater than or equal to 65 years. An odds ratio of 4.1 (95% CI: 2.8-6.1) for clinically important brain injury has been quoted with this threshold, providing the patient has experienced loss of consciousness or amnesia.[25]

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

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[25]. A further study has defined 'axial load to head' as a high risk factor for cervical spine injury after an accident[19,52]. This covers the following areas: diving; high-speed motor vehicle collision; rollover motor accident; ejection from a motor vehicle; accident involving motorized recreational vehicles; bicycle collision. In addition, there are many other high energy mechanism injuries which cannot be covered in an exhaustive list (for example, the variety of blunt instruments that could be used in a violent assault) which were considered to be important by the GDG.

UPDATE 2007:

The height threshold for a high-risk fall is sometimes defined as greater than three feet, and sometimes as greater than 1 metre. For the sake of consistency, this guideline will use the term '1 metre'. The recent CHALICE[53] 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 (for example, vomiting, headache, amnesia, impaired consciousness) but have also been identified as independent risk factors following head injury, making a differential diagnosis difficult. [19,54]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 [19,55] but not in others.[25,56] 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.[19,25,55,56] Vomiting is also quite common in infants and children and its predictive power is controversial in this age group. It has been estimated that around 16% of infants and children aged 12 years or less vomit after minor head injury, and the cause of vomiting often seems to be related to individual intrinsic factors (for example, previous tendency to vomit) rather than specific features of the head injury[57]. 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.[13] 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 GDG 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

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

- 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 motorized recreational vehicles, bicycle collision, or any other potentially high-energy mechanism).

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

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

- 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 under 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 ≥ 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 under 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 (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.

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***

[Amended] Community health services (general practice, ambulance crews,

NHS walk-in centres, dental practitioners) and NHS minor injury clinics should refer patients who have sustained a head injury to a hospital emergency department, using the ambulance service if deemed necessary (see section 4.17), if any of the following are 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.

- 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, 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 motorized recreational vehicles, bicycle collision, or any other potentially high-energy mechanism).

- History of bleeding or clotting disorder.

- Current anticoagulant therapy such as warfarin.

- Current drug or alcohol intoxication.

- Age 65 years or older.

- Suspicion of non-accidental injury.

- Continuing concern by the professional about the diagnosis.

In the absence of any the above factors, the professional should consider referral to an emergency department 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 and pre-hospital management

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

- 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

There is some evidence that ambulance crews using written triage guidelines in a United States context may fall short of acceptable levels of triage accuracy.[58] The GDG is under the impression that the triage skills of other community professionals may sometimes be below a desirable standard.

[Amended] It is recommended that General Practitioners, nurses, dentists and ambulance crews should receive training, as necessary, to ensure that they are capable of assessing the presence or absence of the risk factors listed in section 4.16.

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.

- [Amended] Adults who have sustained a head injury should initially be assessed and their care managed according to clear principles and standard practice, as embodied in: the Advanced Trauma Life Support (ATLS) course/European Trauma course; the International Trauma Life Support (ITLS) course; the Pre-hospital Trauma Life Support (PHTLS) course; the Advanced Trauma Nurse Course (ATNC); the Trauma Nursing Core Course (TNCC); and the Joint Royal Colleges Ambulance Service Liaison Committee (JRCALC) Clinical Practice Guidelines for Head Trauma. For children, clear principles are outlined in the Advanced Paediatric Life Support (APLS)/European Paediatric Life Support (EPLS) course, the Pre-hospital Paediatric Life Support (PHPLS) course and the Paediatric Education for Pre-hospital Professionals (PEPP) course materials.

- Ambulance crews should be fully trained in the use of the adult and paediatric versions of the GCS.

- Ambulance crews should be trained in the detection of non-accidental injury and should pass information to emergency department personnel when the relevant signs and symptoms arise.

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

- [Amended] Patients who have sustained a head injury should be transported directly to a facility that has been identified as having the resources necessary to resuscitate, investigate and initially manage any patient with multiple injuries. It is expected that all acute hospitals and all neuroscience units accepting patients directly from an incident will

have these resources, and that these resources will be appropriate for a patient's age.

- **[Amended] 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 by the healthcare professional**
  - **neck pain or tenderness**
  - **focal neurological deficit**
  - **paraesthesia in the extremities**
  - **any other clinical suspicion of cervical spine injury.**

- **[Amended] 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 emergency 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.**

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

- **[New] Pain should be managed effectively because it can lead to a rise in intracranial pressure. Reassurance and splintage of limb fractures are helpful; catheterisation of a full bladder will reduce irritability. Analgesia as described in 6.13 should be given only under the direction of a doctor.**

5.2 Glasgow Coma Score

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[59,60].

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[47,61,62]. 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.**

- **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.**

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.[15,25,46] 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.[62] 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.[63]

5.4 Immediate management of patients with severe head injuries

There are specific questions regarding the early management of patients with severe head injuries (that is, GCS less than or equal to 8). Exhaustive systematic reviews have examined evidence on the management of severe traumatic brain injury.[64,65] These reviews found evidence for only a small number of "standards" (that is, recommendations generally based on class one evidence or strong class two evidence of therapeutic effectiveness) and concluded that there was a paucity of well designed studies examining the efficacy of pre-hospital interventions in severe head injury.

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

5.5 The benefits of direct transport from the scene to a specialist neurosciences centre compared to transport to the nearest district general hospital

5.5.1 Introduction and rationale for the clinical question

This question has been included in this update because many healthcare professionals, especially ambulance staff, may be uncertain when deciding on the most appropriate destination for a patient with severe head injury. This is pertinent as the severity of head injury may not be known at the scene and the nearest neuroscience unit may be further

away than the emergency department. There is also some confusion amongst hospital staff with regards to interhospital transfer of head injured patients. This is because patients who do not require surgery but do require neurosurgical care may remain in the district general hospital (DGH) and receive treatment there, when they actually require specialist treatment at a neuroscience unit. For interhospital transfers please see Chapter 7.

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

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

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

5.5.2 Clinical evidence

The first study[66] was a retrospective observational cohort study (evidence level 2+), that obtained data from the New York State Trauma Registry from 1996-1998. This study examined patients who were transported to a regional/area trauma centre compared with patients transferred to non trauma centre. The patients in the latter group were assessed via the American Triage system (pre hospital care) and referred directly to a non trauma centre. The population were adults (over 13 years) with a GCS less than 14. Sub group data of 2763 head injured patients from a data set of 5419 trauma patients were analysed. Group 1 (n=2272 (82.2%)) patients were transported to regional/area trauma centre. These patients were assessed via American Triage system (pre hospital care) and referred directly to the emergency department of either a regional or area trauma centre. Group 2 (n=491 (17.8%)) patients were assessed via American Triage system (pre hospital care) and referred directly to a non trauma centre. The limitations of this study were that patients were categorised as head injured from data reported in trauma registry however the extent of head injury was unknown, because the GCS was classified as less than 14. The results of this study[66] showed that the mortality rate of immediate transfer to a neurosciences centre versus transfer to a non trauma centre were in favour of transfer to neuroscience centre with an odds ratio 0.88, CI (0.64-1.22) which did not reach statistical significance.

The second study[67] (evidence level 2+) described a cohort of paediatric patients aged under 20 years old using a large national US paediatric trauma registry, admitted to one of ninety

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

5.5.3 Economics Evidence from 2007 update

See economics chapter 11.6

5.5.4 Summary of evidence from 2007 update

With one study[67] it is difficult to draw rational conclusions as to the benefits of direct transport of patients from the scene to either a neurosciences unit or a DGH as there is doubt over the definition of head injured patients. The other study[66] showed that the mortality rate of immediate transfer to a neurosciences centre versus DGH were in favour of transport to a neuroscience centre. From this evidence review there is limited evidence for direct transport of head injured patients from the scene to a neurosciences unit being beneficial.

A simulation model[68] showed improved survival from directly transporting patients to a neurosciences hospital. However, a number of parameters were based on expert judgement rather than strong evidence. A cost-effectiveness analysis based on this model showed that direct transport is likely to be cost-effective.

5.5.5 Rationale behind recommendation

There is no strong evidence to suggest a change in the previous recommendation (see bullet 5 within section 5.1). The GDG recognises that the transported patients with head injury directly to a neuroscience unit rather than a DGH would require a major shift of resources of between an additional 84,000 and 105,000 bed days to neurosurgery from the existing general surgical, orthopaedic, emergency department, paediatric and geriatric services that currently care for these patients. The GDG recognize that further research is needed in this area in order to identify benefits in transporting patients with head injury to a neuroscience unit or a district general hospital. Therefore the GDG propose a research recommendation for this question (see section 5.5.7).

5.5.6 Recommendation

[Amended] Patients who have sustained a head injury should be transported directly to a facility that has been identified as having the resources necessary to resuscitate, investigate and initially manage any patient with multiple injuries. It is expected that all acute hospitals and all neuroscience units accepting patients directly from an incident will have these resources, and that these resources will be appropriate for a patient's age. (Same as the recommendation in section 5.1)

5.5.7 Recommendations for research

The GDG identified the following priority area for research.

5.5.7.1 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 of patient outcomes (mortality/morbidity) for those 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 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 should be followed as they pass through the care system with mortality and morbidity outcomes collected. These should be compared to allow, using sub-group analysis, the identification of patients for whom direct transfer is most beneficial.

5.5.7.2 Why this research is important

Limited evidence in this area has shown that patients do better in terms of outcome if they are transported directly 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. For people working in the prehospital arena, it is important to define which patients who have sustained a head injury would do better by being transported directly 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 may suffer a significant delay in receiving definitive treatment for their head injury. Information from such research can help to define which patients should be transported direct to

a neurosciences centre bypassing the nearest hospital.

Guidance will be required to define the patient population 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. Researchers should look at the impact of the duration of transport on study outcome. So for a journey time to the neurosciences unit of less than 20 minutes, direct transport might improve outcomes, (as concluded by the London Severe Injury Working Group) but beyond this time, direct transport might worsen outcomes.

5.6 *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.[69]

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.

5.7 *Priority dispatch of emergency ambulances*

The use of an emergency medical dispatch (EMD) system is controversial. The EMD system requires a form of telephone assessment carried out by ambulance dispatchers to determine the urgency of the emergency. A recent systematic review found little evidence on the effectiveness of EMD in terms of improved clinical outcomes.[70] 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.[71]

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 the emergency department

UPDATE 2007:

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

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

- A Trauma Response Team (trained to Advanced Trauma Life Support standards) and medical and nursing staff who have the ability to provide a full range of acute resuscitation procedures and who have all necessary equipment for resuscitation and monitoring.

- A clinician trained in the emergency care of head injured children

- Direct access to 24 hour CT scanning on site.

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

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

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

6.1 Focus of emergency department 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 (for example, intracranial haematoma requiring evacuation) but the life threatening nature of the injury makes early detection essential. Other clinically important brain injuries do not provide an immediate threat to the patient and may produce late sequelae. Early identification of these latter injuries may assist in rehabilitation.

The main focus of emergency department assessment for patients

who have sustained a head injury should be the risk of clinically important brain injuries and injuries to the cervical spine and the consequent need for imaging. Due attention should also be paid to co-existing injuries and to other concerns the clinician may have (for example, 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[17,72].

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 studies[19,22,24,55,73,74] 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'[23] and a level two study that reported on the first part of a project likely to produce level one evidence.[25]

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%.[23] While it is true that a finding of skull fracture on radiography significantly elevates the risk of ICH one cannot rule out ICH on the basis of a negative radiograph (sensitivity was 0.38, see section 1.5).

Second, patients with a negative CT scan and no other body system injuries or persistent neurological findings can be safely discharged[22]. 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.[73,74]The task is therefore to derive a more sophisticated clinical decision rule for patient selection that will improve specificity without impairing sensitivity.

6.3 *What is the best initial diagnostic technique to determine which patients have sustained damage to the brain and require further assessment of the head?*

6.3.1 Introduction and rationale for the clinical question

In the 2003 guideline the GDG recommended CT imaging for the head as the primary investigation of choice for the detection of acute clinically important brain injuries (see 6.3.6). In this update a review was carried out to ascertain whether CT is still in 2007 the

most accurate tool for use in the initial diagnosis of head injury. This review also investigates whether there are other imaging tools that have been compared to CT and are accurate in identifying head injury. The outcome measures for including studies for this review were sensitivity and specificity of the imaging technique with or without mortality, disability, neurological outcome, hospital duration, and cost.

6.3.2 Clinical evidence

In the earlier version of the head injury guideline no evidence was found that addressed this question. However in this update one study was retrieved[75] in children and no evidence was retrieved for adults. This study[75] examined the diagnostic value of physical examination (including neurological exam) for positive CT scan findings in 98 children (2-16 years) children with closed head injury. This prospective diagnostic study (level II evidence) evaluated physical examination using CT as the reference standard. This study was based in San Diego, USA. Halley et al conclude that physical examination cannot identify all cases of brain injury that are demonstrated on CT imaging. Physical examination was demonstrated in this study as having poor sensitivity of 0.69 (CI: 0.42-0.87) and specificity of 0.4 (CI: 0.30-0.51) for identifying patients with brain injury but this presupposes that CT is 100% accurate.

6.3.3 Economics Evidence from 2007 update

See discussion of clinical decision rules (6.5.3 and 6.5.4) and economic section chapter (11.3.7).

6.3.4 Summary of evidence from 2007 update

The evidence is relatively weak as the Halley et al[75] study included a limited sample size with 9 out of the 98 subjects not being contactable.

A decision model[76] estimated that CT scanning all patients was more effective and cost saving than x-raying all patients. It also showed that selective CT scanning could be just as effective as routine CT with lower cost (see also 6.5). However, the setting was the USA where costs are quite different to the NHS and the estimates of effectiveness were derived from case series.

6.3.5 Rationale behind recommendation

Generally speaking, CT is more sensitive than x-ray at detecting clinically important lesions, although evidence specific to head trauma was not retrieved. CT is likely to be cost-effective but only if a) the extra lesions found by CT pose a significant health risk, b) identification leads to earlier/better treatment and c) early/modified treatment improves survival. For these variables there is no high quality evidence. However, a decision model[76] based on case series evidence estimated that CT scanning all patients would be more effective and cost saving than x-raying all patients in a US context.

The GDG felt based on their expertise that CT is the most appropriate tool for diagnosing life-threatening conditions resulting from head injury. The GDG also felt that a recommendation was required to emphasize that x-ray is not

a suitable substitute for CT. However, it was necessary to acknowledge that plain x-rays are useful adjuvant to CT in managing children with suspected non-accidental injury and therefore a new recommendation was developed (see update 2007 recommendation).

6.3.6 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, magnetic resonance imaging (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.[77]

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.

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

Update 2007 Recommendation-

[NEW] Plain X-rays of the skull should not be used to diagnose significant brain injury without prior discussion with a neuroscience unit. However, they are useful as part of the skeletal survey in children presenting with suspected non-accidental injury.

[NEW] Unless the CT result is required within 1 hour, it is acceptable to admit a patient for effective overnight observation and delay the CT scan until the next morning if the patient presents out of hours and any of the following risk factors are present in addition to a period of loss of consciousness or amnesia:

- **age 65 years or older**

- **amnesia for events more than 30 minutes before impact**

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

[NEW] If CT imaging is unavailable because of equipment failure, patients with GCS 15 may be admitted for

observation. Arrangements should be in place for urgent transfer to a centre with CT scanning available should there be a clinical deterioration that indicates immediate CT scanning is necessary.

6.4 What are the effects on patient outcomes of providing an immediate CT versus observation?

6.4.1 Introduction and rationale for the clinical sub question

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

6.4.2 Clinical evidence

One study (level 1++ evidence) was identified[78] for this review. This recent large, randomised controlled trial[78] investigated CT compared with admission to hospital for observation. This study included hospital patients aged ≥6 years of age with mild head injury within the past 24hrs who attended emergency departments. The main findings from this trial were that at 3 months, 21.4% (275/1316) of patients in the CT group had not recovered completely compared with 24.2% (300/1286) admitted for observation. The difference was found to be not significant in favour of CT (95%CI: -6.1%-0.6%). The worst outcomes like mortality and severe loss of function were similar between the groups. None of the patients with normal findings on immediate CT had complications later.

6.4.3 Economics Evidence from 2007 update

See economic section chapter 11.3.

6.4.4 Summary of evidence from 2007 update

The Af Geijerstam study[78] showed that the use of CT in the management of patients with mild head injury leads to similar clinical outcomes compared with observation in hospital.

The associated economic evaluation[79] showed that for these mild head injured patients CT scanning and then discharge after a negative scan was cost saving compared with admission with no adverse effect on health outcome.

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

6.5.1 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 decision making tool that incorporates 3 or more variables from the history, examination or simple tests[25,80,81]. This review was carried out to examine which

clinical prediction rule was the best for selecting patients for CT imaging who had 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. The interventions included within this review were any prediction rule ranging from NEXUS, NOC, CHR and any other new rules. The studies were included if the outcomes included sensitivity and specificity of prediction rules.

6.5.2 Clinical evidence

In the previous guideline, 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).[19,24,25,55]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[24] 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.[55] The sensitivity of these rules have been questioned in another study.[82]

The remaining two sets of rules, the Canadian CT-rules[25] and the 'New Orleans' criteria are now considered.[19] 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).

The Canadian sample[25] for a derivation sample, was much larger with 3,121 patients than the New Orleans sample[19] with 520 patients in the derivation phase and 909 patients in the validation phase. This led to statistical power problems with certain key variables (for example, 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 emergency 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 (that is, 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 emergency departments 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 emergency departments with GCS equal to 15,[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.

UPDATE 2007: Adult rules

Three new studies[81,83,84] were retrieved for this review looking at clinical prediction rules in adults in addition to the studies in the previous guidleline (see section 6.5.2).

One of the 3 new studies looking at clinical prediction rules in adults was Stiell et al[81], a prospective cohort validation study (diagnostic study level I evidence) of 1822 blunt head trauma patients in nine Canadian emergency departments. In the previous guideline the derivation study was included. The inclusion criteria were defined as blunt trauma to the head resulting in witnessed loss of consciousness, definite amnesia or witnessed disorientation, a 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 detecting 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 a prospective cohort study (diagnostic study level II evidence) by Smits et al[84] comprising 3181 Dutch patients with blunt head injury and compared the NOC and CCHR rules. The inclusion criteria were patients age older than 16 years, GCS of 13 to 14 and presentation within 24 hours. Patients with a GCS score of 15 were included if they had 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 findings 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[83] was a prospective cohort derivation study (diagnostic study level II evidence) for the NEXUS II rules by Mower et al which has not yet been validated in a separate sample. This study comprised 13,728 blunt trauma patients in 21 participating centres who had undergone a head CT scan. 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%).

UPDATE 2007: Child rules

Four new studies in children[53,85-87] were retrieved in this update.

Oman at el[85] studied a prospective cohort (diagnostic study level II evidence) of 1666 children (under 18 years) with blunt head trauma. 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 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 prospective cohort study (diagnostic study level I evidence) by Haydel et al[86] comprised 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 and a normal GCS score, or modified coma scale for infants and children and normal brief neurological examination. The reference standard was a 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[87] reported a prospective cohort study (diagnostic study level II evidence) of 2,043 children (under 18 years) presenting with blunt head trauma of all severities at a paediatric emergency department at a 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 25.8% (95% CI 23.3% to 28.4%). This prediction rule missed one patient with a traumatic brain injury identified on CT. This is a derivation study, not yet 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 haematoma in children aged 2 years or younger
- Headache

The final study by Dunning[53] which is a prospective multi-centre cohort (diagnostic study level II evidence) 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. Significant predictors of intracranial haemorrhage were determined and the Children's 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, not yet validated.

The CHALICE Prediction Rule:

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

History

- Witnessed loss of consciousness of more than 5 min duration
- History of amnesia (either antegrade or retrograde) of more than 5 min duration
- Abnormal drowsiness (defined as drowsiness in excess of that expected by the examining clinician)
- 3 or more 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) less than 14, or GCS less than15 if less than 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, Battle's 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 more than 5 cm if less than 1 year old

Mechanism

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

- Fall of more than 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.

6.5.3 Economics Evidence from 2007 update

See economic section chapter 11.3

6.5.4 Summary of evidence from 2007 update

Adult Rule

Three new studies[81,83,84] were identified for this review which compared different decision rules in adults. One study[81] 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 detecting the need for neurosurgical intervention and clinically important brain injury. The second study[84] showed that 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[83] included the NEXUS II rule which had a sensitivity of 98.3% and specificity of 13.7%.

When we updated the unit costs in the guideline's cost analysis, the results were even more favourable towards the Canadian head CT rule, since radiology costs had fallen. Two studies[16,88] of the impact of our recommendation for head imaging showed opposite results; there is still great uncertainty about the rates of imaging and admission nationally and therefore the overall economic impact of the guideline is unclear. A published economic evaluation[76] using cohort study evidence suggested that the Canadian head CT rule is more cost-effective in a US context than a number of alternative strategies based on CT, X-ray or

admission. However, none of the economic evidence has taken into account the impact of the increased radiation exposure.

Child Rules

The 4 new studies[53,85-87] within this review compared different decision rules in children. One study[85] 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[86] found that CT use in children aged 5 years 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[87] derived a clinical decision rule for the identification of children who should undergo CT after head injury. The final study[53] derived a highly sensitive clinical decision rule for the identification of children who should undergo CT scanning after head injury.

We did not find any economic evidence specific to children.

6.5.5 Rationale behind recommendation

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 (that is, 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 (that is, 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 1 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 (that is, aged under 5 years). See section 4.8.

- Clinical judgement regarding the cause of vomiting in those aged under 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 under 5 years.

The 2003 Guideline Development Group considered these recommendations see below 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)[89].

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 under 2 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.[90]

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 (that is, the absence of skull fracture does not predict absence of intra-cranial complications).[20,91,92] 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.[93] The evidence regarding the safety of adult rules with infants is inconclusive.[19,24,55]

UPDATE 2007: Adult rules

Based on the three adult prediction rule studies[81,83,84], the GDG decided that no change in recommendation was required as they felt there was not enough evidence to warrant a change. The case for selective CT scanning was strengthened by a cost-effectiveness model, although it was conducted from a US perspective and the UK evidence showed great variability between centres. One study had drawn attention to difficulties in scanning and discharging patients out of hours[16], in particular, it is often not practical to discharge elderly patients during the night for social reasons. The GDG agreed that patients age 65 years or older presenting out of hours who are fully conscious and have no other indication for an immediate CT can be safely managed by admission for overnight observation without immediate CT. Admitting these patients overnight could be cheaper than out of hours CT scanning, especially as it would not be possible to discharge many of these patients. Furthermore the Af Geijerstam study showed that for head injured patients generally, observation was not associated with a significant increase in morbidity or mortality compared with immediate CT (see 6.4). The GDG also recognize that any centre which receives head injured patients should have 24 hour CT scanner availability however there may be situations where due to failure of CT scanning equipment this may not be possible. It is then important

to make sure that patients are transferred to a centre which does have the relevant equipment (see recommendation 6.5.6).

UPDATE 2007: Child rules

The original recommendation stated that validated adult rules (Canadian head CT rule) on imaging of the head may be safely used in children and infants. 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 study in this update (CHALICE)[53].

The CT ordering rates for both rules are similar[53] and therefore the rule that is most accurate is likely to be the most cost-effective.

The GDG considers that the CHALICE rule for children is derived from the best current 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.

6.5.6 Recommendation

For Adults -

[Amended] 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 requested immediately:

- GCS less than 13 on initial assessment in the emergency department.

- GCS less than 15 at 2 hours after the injury on assessment in the emergency department.

- Suspected open or depressed skull fracture.

- Any sign of basal skull fracture (haemotympanum, 'panda' eyes, cerebrospinal fluid leakage from the ear or nose, Battle's sign).

- Post-traumatic seizure.

- Focal neurological deficit.

- More than one episode of vomiting.

- Amnesia for events more than 30 minutes before impact.

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

- Age 65 years or older.

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

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

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

For Children -

[NEW] Children (under 16 years) who have sustained a head injury and present with any one of the following risk factors should have CT scanning of the head requested immediately:

- **Loss of consciousness lasting more than 5 minutes (witnessed).**
- **Amnesia (antegrade or retrograde) lasting more than 5 minutes.**
- **Abnormal drowsiness.**
- **Three or more discrete episodes of vomiting.**
- **Clinical suspicion of non-accidental injury.**
- **Post-traumatic seizure but no history of epilepsy.**
- **GCS less than 14, or for a baby under 1 year GCS (paediatric) less than 15, on assessment in the emergency department.**
- **Suspicion of open or depressed skull injury or tense fontanelle.**
- **Any sign of basal skull fracture (haemotympanum, 'panda' eyes, cerebrospinal fluid leakage from the ear or nose, Battle's sign).**
- **Focal neurological deficit.**
- **If under 1 year, presence of bruise, swelling or laceration of more than 5 cm on the head.**
- **Dangerous mechanism of injury (high-speed road traffic accident either as pedestrian, cyclist or vehicle occupant, fall from a height of greater than 3 metres, high-speed injury from a projectile or an object).**

6.6 Investigation of cervical spine injuries

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

6.6.1 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.

6.6.1.1 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%.[94-96]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.[97] If fractures that are clinically important are used as the gold standard then sensitivity is approximately 94%[98] and overall specificity 96% in a low risk group.[99]

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.[100] The use of a lateral view alone will miss a significant proportion of injuries detected by a three-view series.[101]

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.

6.6.1.2 Lateral flexion/extension views

In alert symptomatic patients, lateral flexion/extension views can be safely performed over the pain-free range. Studies have shown significant false positive and false negative rates.[102] Ten per cent of 'normals' may have 'abnormal' flexion/extension views.[103]

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

6.6.1.3 CT imaging of the cervical spine

CT imaging of the cervical spine may be localised (for example, 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.[97] If CT imaging of the head has been requested the cost of cervical CT is reduced and can be accomplished quickly without patient transfer.

6.6.1.4 Magnetic Resonance Imaging (MRI) of the cervical spine

There is evidence that MRI detects a higher proportion of soft tissue abnormalities when performed within 48 hours of injury than plain film and CT[104] but the clinical significance of these injuries is unclear. MRI is less effective than CT in the detection of bony injury.[105] It has also been demonstrated that MRI can miss ligamentous injuries if delayed.[106] Injuries of the mid-cervical spine, especially subluxation and lateral

fractures are associated with vertebral artery injury which may be detected by MRI.[107]

6.6.1.5 Occipital condyle injuries

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

6.7 *What is the best diagnostic imaging technique to determine which patients have sustained damage to the cervical spine and require further assessment of cervical spine*

6.7.1 Introduction and rationale for the clinical question

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

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

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

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

6.7.2 Clinical evidence

We included one meta-analysis[108] which compared plain X-rays with CT. This meta-analysis included seven diagnostic cohort studies. The studies varied in the number of views (3 and 5) and some were retrospective and others prospective. Another prospective diagnostic cohort study[109] was also retrieved comparing 3 view X-ray with CT. The final prospective diagnostic cohort study[110] compared helical CT and X-rays (single cross-table lateral). All 3 studies were graded as diagnostic studies level II evidence. All these studies included patients over 16 years of age. We found no studies in children and infants.

A meta-analysis[108] was retrieved which included seven diagnostic cohort studies. This study comprised 3834 patients with blunt trauma events requiring imaging. The reference standard was either CT or all imaging scans and clinical follow-up. CT scans had a higher sensitivity of 98% (95% CI, 96-99) compared to X-rays which were 52% (95% CI, 47-56). The test for heterogeneity for the sensitivity of CT was 0.99 and for X-rays was 0.07. As there was a high variation in

the sensitivities for X-rays we reviewed the seven studies[95,111-116] individually. The patient populations varied between the studies. Three studies[95,112,115] selected only the most severely injured patients (altered mental status or those requiring admission to the intensive care unit). One study[116] selected only high risk blunt trauma patients. Another study's[113] inclusion criteria was for blunt trauma patients with physical findings of posterior midline neck tenderness, altered mental status or neurological deficit. The final two studies[111,114] reviewed patients that had suffered a cervical spine fracture or patients that had both CT and X-ray imaging for suspected cervical spine fracture. The later study[111] reported a prevalence of cervical spine injury of 76% (19 of 25 included patients). The sensitivities in these seven studies ranged from 39 to 76%. The studies varied in the number of X-ray views (3 and 5) and three were retrospective and four prospective. The meta-analysis[108] evidence supports the use of cervical spine CT as the initial screening test in high risk patients.

A prospective cohort study[109] was retrieved. This was a small study (N=34) that selected high risk blunt trauma patients in a US trauma centre. The study used X-rays to identify fractures of the cervical spine and CT scans were used as the reference standard. The sensitivity of X-rays (3 view) was 93.3% and the specificity was 95.0%.

The final prospective cohort study[110] comprised 442 unconscious intubated blunt trauma patients in the UK. The reference standard was MRI and/or clinical outcome. The interventions tested were helical CT (n=381) and X-rays (single cross-table lateral) (n=421). Only 421 patients had a cross table lateral film as 21 patients went straight to CT for clinical reasons. 381 patients had a CT scan that was followed up by MRI or clinical outcome. Cervical spine injuries were found in 14% of the patients. CT scans were more sensitive than X-rays (98.1% vs 72.1% respectively). X-rays had a lower specificity (94.2%) than CT scans (98.8%). Only 200 of the X-rays were adequate.

6.7.3 Economics Evidence from 2007 update

See Economics section in chapter 11.4

6.7.4 Summary of evidence from 2007 update

The meta-analsyis[108] found that CT had a higher sensitivity than X-rays. Nygren[109] found that X-rays had a sensitivity of 93.3% in high risk blunt trauma patients (CT was used as the reference standard). Brohi et al[110] found that CT scans had a higher sensitivity than X-rays in a group of unconscious intubated blunt trauma patients.

The economic evidence[117-120] suggests that CT scanning of the cervical spine is cost-effective in higher risk groups who are already undergoing head CT. However, the costs and health consequences associated with the increased radiation exposure were not taken into account, and the settings of these studies were outside the UK NHS.

6.7.5 Rationale behind recommendation

There is no evidence at present to suggest that cervical spine CT scanning is required for everyone regardless of head injury severity; the economic evidence suggests that it would not be cost-effective for head injury patients with a low risk of spinal damage. The GDG previously recommended that X-rays should be the initial imaging modality of choice supplemented with CT when appropriate.

The new evidence[108-110] indicates that in severely head injured patients, CT is the best initial diagnostic tool for assessment of the cervical spine.The GDG suggested a change in wording of the recommendation to add that patients with head injury (GCS ≤ 13) and intubated patients should have CT scans of the cervical spine rather than plain radiographs.

If CT detects more unstable fractures then potentially it will lead to health gain and cost savings by averting paralysis. The cost-effectiveness evidence[117-121] suggests that CT scanning of the cervical spine is cost-effective in higher risk groups but not in all head injured patients. These studies were conducted from a US perspective and therefore are not directly applicable to the UK NHS. Logically, as long as CT is picking up more unstable fractures, cervical spine CT will be cost-effective for those NHS patients at the very highest risk; the threshold at which it becomes not cost-effective is, however, difficult to determine.

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

6.7.6 Recommendation

[Amended] The current initial investigation of choice for the detection of injuries to the cervical spine is the plain radiograph. Three views should be obtained and be of sufficient quality for reliable interpretation. However, in certain circumstances CT is preferred.

[NEW] Adult patients who have any of the following risk factors should have CT imaging of the cervical spine requested immediately:

- **GCS below 13 on initial assessment**
- **Has been intubated**
- **Plain film series is technically inadequate (for example, desired view unavailable), suspicious or definitely abnormal**
- **Continued clinical suspicion of injury despite a normal X ray.**
- **The patient is being scanned for multi-region trauma.**

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 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, 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.

6.8 Cervical spine imaging of Infants and children

6.8.1 Recommendation

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

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 plain films without an anterior/posterior peg view.

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

[NEW] 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 be used only in cases where

patients have a severe head injury (GCS ≤ 8), or where there is a strong clinical suspicion of injury despite normal plain films (for example, focal neurological signs or paraesthesia in the extremities), or where plain films are technically difficult or inadequate.

This recommendation is based on GDG opinion and evidence on risks of irradiation (see 10).

6.9 The best clinical prediction rule for selecting patients that have sustained damage to the cervical spine for the imaging technique selected in section 6.7?

6.9.1 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 three or more variables from the history, examination or simple tests[25,80,81]. 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. The interventions included within the studies were any prediction rule ranging from NEXUS, NOC, CCR and any other new rules. The outcomes included sensitivity and specificity of prediction rules.

6.9.2 Clinical evidence

In the 2003 guideline, a systematic review of clinical decision rules for selection of patients who 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.[52,122] 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.

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 (that is, 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[122] 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 (that is, 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 argued that 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 assessment 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 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.

6.9.3 Clinical evidence from update 2007

In the update two diagnostic studies[123,124] were identified (level I evidence) that examined patients with head injury and suspected cervical spine injury.

One prospective cohort study[123] comprised 7438 consecutive adult patients in nine Canadian emergency departments with acute trauma to the head or neck who were in a stable and alert (GCS 15) condition. These patients had neck pain or no neck pain but visible injury above the clavicle and were non-ambulatory and had a dangerous mechanism of injury. This study sought to validate 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. 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[124] compared the CCR and physicians judgement. This study comprised 6265 adult patients in ten Canadian emergency departments who were in a stable and alert (GCS 15) condition and had neck pain or no neck pain but visible injury above the clavicle and were non-ambulatory and had a dangerous mechanism of injury. 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 cervical spine injury. Patients received X-rays as requested by judgement of the treating physician or were followed up at 14 days by structured telephone interview. There were 64 (1%) clinically important cervical 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.

6.9.4 Economics Evidence from 2007 update

There were no new published economic evidence for this question found in the update. We updated the unit costs in our cost analysis. The cost savings from the Canadian Cervical Spine Rule compared with the NEXUS rule were still present but were now more modest since radiology costs are lower.

6.9.5 Summary of evidence from 2007 update

The Canadian Cervical Spine Rule had a higher sensitivity than NEXUS low risk criteria and physician judgement. It should be noted that both studies[123,124] came from the Canadian Cervical Spine Rule group. There is no new evidence to support CT spine for people with mild head injuries.

The Canadian Cervical Spine Rule still appears to be less costly than the NEXUS rule.

6.9.6 Rationale behind recommendation

In the 2003 guideline two evidence based decision rules for selection of patients who 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 (that is, 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.

UPDATE 2007:

The GDG decided that no change should be made to the original recommendation that the Canadian Cervical Spine Rule (CCR) should be used for selecting patients with cervical spine damage for the most accurate imaging technique. The GDG agreed that in cases where there is a severe head injury to an adult, a CT cervical spine examination is required. Adults and children age 10 or over should have a CT cervical spine if they are having a CT of the head. CT of all cervical spines is not recommended as there is no evidence to support this practice.

6.9.7 Recommendation

For Adults -

[Amended] Adult patients should have three-view radiographic imaging of the cervical spine requested immediately if any of the following points apply:

- **There is neck pain or midline tenderness with:**

o **Age 65 years or older, or**

o **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; rollover motor accident; ejection from a motor vehicle; accident involving motorized recreational vehicles; bicycle collision).**

- **It is not considered safe to assess the range of movement in the neck for reasons other than those above.**

- **It is considered safe to assess the range of movement in the neck and, on assessment, the patient cannot actively rotate the neck to 45 degrees to the left and right; safe assessment can be carried out if the patient:**

o **was involved in a simple rear-end motor vehicle collision**

o **is comfortable in a sitting position in the emergency department**

o **has been ambulatory at any time since injury with no midline cervical spine tenderness**

o **presents with delayed onset of neck pain.**

- **A definitive diagnosis of cervical spine injury is required urgently (for example, before surgery).**

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.

For Children -

[NEW] Children under 10 years of age with GCS of 8 or less should have CT imaging of the cervical spine within 1 hour of presentation or when they are sufficiently stable.

The recommendation is based on GDG opinion.

6.10 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 spinal injuries in children and infants with head injury is much lower than in adults but to date no clearly defined rules with acceptable sensitivity and specificity have been produced.[125,126]

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.

6.10.1 Recommendations for research

The GDG identified the following priority areas for research.

6.10.1.1 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.

6.10.1.2 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 children 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.

UPDATE 2007:

[Amended] A clinician with expertise in non-accidental injuries in children should be involved in any suspected case of non-accidental injury in a child. Examinations/investigations that should be considered include: skull X-ray as part of a skeletal survey, ophthalmoscopic examination for retinal haemorrhage, and examination for pallor, anaemia, and tense fontanelle or other suggestive features. Other imaging such as CT and MRI may be required to define injuries.

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.[127] 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 emergency department assessment*

The following should be practised during emergency department assessment.

- **The priority for all emergency department patients is the stabilisation of airway, breathing and circulation (ABC) before attention to other injuries.**

- **Depressed conscious level should be ascribed to intoxication only after a significant brain injury has been excluded.**

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

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

- **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 7.8.6, and to assist with resuscitation.**

- **All patients presenting to an emergency departments with a head injury should be assessed 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 cervical spine – see previous recommendations).**

[Amended] In patients considered to be at high risk for clinically important brain injury and/or cervical spine injury, assessment should be extended to full clinical examination to 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. See recommendations 3.5.3.1 to 3.5.4.2 (imaging of the head) and 3.5.5.1 to 3.5.7.2 (imaging of the cervical spine).

[Amended] Patients who, on initial assessment, are considered to be at low risk for clinically important brain injury and/or cervical spine injury should be re-examined within a further hour by an emergency department clinician. Part of this assessment should fully establish the need to request CT imaging of the head and/or imaging of the cervical spine. 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 3.5.5.1 to 3.5.7.2 (imaging of the cervical spine).

[NEW] Pain should be managed effectively because it can lead to a rise in intracranial pressure. Reassurance and splintage of limb fractures are helpful; catheterisation of a full bladder will reduce irritability. Significant pain should be treated with small doses of intravenous opioids titrated against clinical response and

baseline cardiorespiratory measurements.

[Amended] Throughout the hospital episode, all healthcare professionals should use a standard head injury proforma in their documentation when assessing and observing patients with head injury. This form should be of a consistent format across all clinical departments and hospitals in which a patient might be treated. 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 proformas that should be used in patients with head injury are provided in Appendices J, K1 and K2).

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

Patients who returned to an emergency department within 48 hours of discharge 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.

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.[14] On the basis of consensus, the Guideline Development Group has made the following recommendations.

- **All CT scans of the head should be reviewed by a clinician who has been deemed competent to review such images.**
- **All plain radiographs of the cervical spine should be reviewed by a clinician who has been deemed competent to review such images.**
- **Where necessary, transport or transmission of images should be used to ensure that a competent clinician review the images.**
- **All imaging performed on patients with head injury should have a full or interim written report for the patients' notes within an hour of the procedure having been performed.**
- **Imaging of any kind should not delay neurosurgical or anaesthetic referral in patients with severe head injury. (D)**

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

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 neurosurgical intervention (the five point rules) and those at high risk for non-neurosurgical clinically

important brain injuries (the seven point rules). The former set of patients will need CT imaging to be performed urgently (that is, within one hour of the request having been received) whereas the latter patients can wait for a reasonable period (8 hours) before imaging.

[Amended] 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 less than 15 at 2 hours after the injury.

- Suspected open or depressed skull fracture.

- Any sign of basal skull fracture (haemotympanum, 'panda' eyes, cerebrospinal fluid leakage from the ear or nose, Battle's sign).

- More than one episode of vomiting in adults; three or more episodes of vomiting in children.

- Post-traumatic seizure.

- Coagulopathy (history of bleeding, clotting disorder, current treatment with warfarin) providing that some loss of consciousness or amnesia has been experienced; patients receiving antiplatelet therapy may be at increased risk of intracranial bleeding, though this is currently unquantified – clinical judgement should be used to assess the need for an urgent scan in these patients.

- Focal neurological deficit.

[Amended] Patients who have any of the following risk factors and none of the risk factors above 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 events more than 30 minutes before impact (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).

- Age 65 years or older, providing that some loss of consciousness or amnesia has been experienced.

- 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.

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.

[Amended] Imaging of the cervical spine should be performed within 1 hour of a request having been received by the radiology department or when the patient is sufficiently stable. Where a request for urgent CT imaging of the head (that is, within 1 hour) has also been received, the cervical spine imaging should be carried out simultaneously.

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 .[13].

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.[25] 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.

7.4.1 Recommendations for research

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

7.4.1.1 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.

7.4.1.2 Why this research is important

One option in the management of traumatic intracerebral haemorrhage (TICH) and cerebral contusions (CC) is to

monitor the patient clinically or with intracranial pressure monitoring and other forms of brain tissue monitoring such as brain tissue oxygen (BtO_2) or microdialysis. When the patient deteriorates, he or she 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 before surgery in all such cases. The principle of early surgical evacuation of spontaneous intracerebral haemorrhage (SICH) has been investigated in the surgical trial in intracerebral haemorrhage (STICH) and reported in the Lancet (2005). The results of such a PRCT in TICH would fundamentally alter the recommendations made by NICE, in terms of which patients should be referred to neurosurgery and, more importantly, how they should be managed there. There is no level 1 evidence about what to do with these patients and the need for such a PRCT in head injured patients is urgent. This research question should immediately be put to UK Research Funding bodies.

7.5 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.[13]

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.

7.6 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.

7.7 Transfer from secondary to tertiary care settings

The risk of a further injury to patients during transfer to tertiary care is well established.[128] 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.[129] 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 $PaCO_2$ targets recommended for intubated patients are based on recent literature in this area.[130-132] Since the original guideline there has been an update of the guidance from the Association of Anaesthetists[133] which has been reviewed in this update and recommendations have been revised accordingly see section 7.8.6.

7.8 *What are the benefits for patients of receiving treatment at a neurosciences centre who have suffered a clinically important brain injury that does not require surgical intervention?*

7.8.1 Introduction and rationale for the clinical question

There is no uncertainty about the management of patients with operative lesions; they must be transferred to the neurosciences unit for their operation. However, there is concern that patients who have suffered a clinically important brain injury, who are initially referred to an emergency department but do not have an operable lesion, may have a poorer outcome if they are not referred to a neurosciences centre. The dilemma for hospital staff at the DGH is whether to keep the patients at that location or to transfer them to a neurosciences unit to continue with their treatment. This question is relevant for clinicians at both types of hospitals. It is important to address whether the patient will receive better non – operative treatment if they are transferred to a specialist neurosciences centre than if they remained at the initial DGH.

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

The main outcome measures for including studies in this review were mortality, neurological outcome, disability and hospital duration and at least one of these outcomes were reported in the studies. Studies were excluded where;

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

7.8.2 Clinical evidence

One study[134] was identified that looked at interhospital transfer (secondary transfer from one hospital to another). Three additional studies[66,135,136] looked at direct transport from the injury scene to a DGH or transfer to a neurosciences unit from a DGH.

The first study[134] a prospective observational study (level 2+ evidence) included patients of any age who were injured by blunt trauma between 1996-

2003 (n=6921). These patients were treated by participating hospitals in the Trauma Audit and Research Network (TARN), in the United Kingdom. The intervention group (n=4616) patients received care at a neurosurgical centre (including those who had been transferred which was 53% (2677/4982)). The control group (n=2305) patients received all their care in hospitals without neurosurgical facilities on site. The mortality rate for all patients that were transported to a neurosciences unit was 35% (95% CI, 34-37%) and for those that were transported to the emergency department was 61% (95% CI, 59-63%). The mortality rate for the subgroup (n=894) of patients with isolated, non-surgical severe head injury who were transported to a neurosciences unit was 26%, (95% CI, 22-29%) and for those that were transported to the emergency department the rate was 34% (95% CI, 39-40%), p=0.005.

The second study[66] a retrospective observational cohort study (level 2+ evidence) examined the issue of bypass, which obtained data from the New York State Trauma Registry from 1996-1998. The population consisted of adults more than 13 years of age with a GCS less than 14. A sub group of 2763 head injured patients from the data set of 5419 trauma patients was analysed. The patients in the intervention group (n=1430 (51.8%)) were transported to a regional trauma centre. These patients were assessed via the American Triage system (pre hospital care) and referred directly to the emergency department of a regional centre. The comparison group (n=1333 (48.2%)) were transferred to an area/non trauma centre. These patients were assessed via the American Triage system (pre hospital care) and referred directly to either an area centre or a non trauma centre. The mortality for transfer to regional centre versus non trauma centre was OR of 0.67 (95% CI, 0.53-0.85).

In another study[135], a low quality study (level 3 evidence), where patients were directly transported to neurosurgical care or secondarily transferred from a DGH, the population group were neurosurgical unit patients with an extradural haematoma requiring surgery (n=104). Group 1 patients (n=71) had a mean age of 22 years (±2SE) were directly transported to a neurosurgical centre. Group 2 patients (n=33) had a mean age 20years (±3SE) and were transferred from the DGH to a neurosurgical centre. The results using the Glasgow Outcome Scale (GOS) show that mortality in group 1 was 4% (3/71) and in group 2 was 24% (8/33). The moderate/severe disability in group 1 was 10% (7/71) and group 2 was 27% (9/33). Recovery was good in 86% (61/71) of group 1 patients and 49% (16/33) in group 2, with $p \leq 0.0002$.

The final study[136] was a well designed cohort study (level 2++ evidence) looking at mortality outcomes between patients directly transferred to a trauma centre and those who were transferred first to a non-trauma centre, and then on to a trauma centre. This cohort study included severely traumatic brain injured patients. The data was collected as part of a multi-centre online database

designed to track pre-hospital and in-hospital severe TBI patient data, called TBI-trac. All patients passing through the trauma centres were included, and selection criteria were applied. Therefore, out of 1449, only 1123 patients were included; the remainder were excluded on the basis of a well-defined criterion, which included the mechanism of injury, death, brain death, or otherwise not benefiting from the care on offer. The authors compared, using a logistic regression model, two-week mortality outcomes between patients directly transferred to a trauma centre (n=864, 77.3%), and those who were transferred first to a non-trauma centre, and then on to a trauma centre(n=254, 22.7%). The model controlled for baseline characteristics and clinical data including hypotension status on day one, if the patient was less than or more than 60 years old, pupil status on day 1, and the initial GCS. Admission time and time by transport status were found to not affect the significance of the results. Patients were found to have a significantly lower chance of mortality with direct transfer with an odds ratio of 1.48 (CI 1.03-2.12) and p=0.04.

7.8.3 Economics Evidence from 2007 update

There was no new economic evidence for this question found in the update.

7.8.4 Summary of evidence from 2007 update

Only one study[134] provides some good evidence that all patients with severe head injuries (GCS 8 or less) would benefit from receiving treatment in a neurosurgical unit irrespective of any need for a neurosurgical operation instead of receiving treatment at the emergency department. This study found data which suggests that treatment in a neurosciences centre offers a better strategy for the management of severe head injury. This study did not address direct transfer from the scene, only inter-hospital transfers. There is evidence[135,136] which suggests good recovery, better mortality and morbidity rates amongst severely injured patients who bypass the DGH and go to the neurosciences unit. However another study[66] suggests very little difference.

7.8.5 Rationale behind recommendation

A slight amendent to the previous recommendation was required (see 7.8.6). The GDG felt that there is evidence to support a recommendation for severely head injured to receive treatment in a neurosurgical unit irrespective of any need for a neurosurgical operation and have included an amendent to the recommendation below 7.8.6. The GDG agreed that the studies[66,135,136] did not provide enough evidence for this question to demonstrate that <u>all</u> patients should be sent directly to receive treatment in a neurosurgical unit irrespective of any need for a neurosurgical operation. This is because the GDG recognises that this would require a major shift of resources of between an additional 84,000 and 105,000 bed days to neurosurgery from the existing general surgical, orthopaedic, emergency department, paediatric and geriatric services that

currently care for these patients. The GDG agreed that whilst there are not enough resources for all head injury patients to go to a neurosciences centre, we should aspire to improve the rate of transfer. The GDG opinion therefore is to propose this area for further research (see section 7.9.1).

7.8.6 Recommendation

For adults:

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

- transfer would benefit all patients with serious head injuries (GCS ≤ 8), irrespective of the need for neurosurgery

- if transfer of those who do not require neurosurgery is not possible, ongoing liaison with the neuroscience unit over clinical management is essential.

[NEW] The possibility of occult extracranial injuries should be considered for the multiply injured adult, and he or she should not be transferred to a service that is unable to deal with other aspects of trauma.

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.

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

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).

[Amended] Although it is understood that transfer is often urgent, initial resuscitation and stabilisation of the patient should be completed and

comprehensive monitoring established before transfer to avoid complications during the journey. A who is patient persistently hypotensive, despite resuscitation, should not be transported until the cause of the hypotension has been identified and the patient stabilised.

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 the recommendation below.

[Amended] Intubation and ventilation should be used immediately in the following circumstances:

- Coma – not obeying commands, not speaking, not eye opening (that is, GCS ≤ 8).

- Loss of protective laryngeal reflexes.

- Ventilatory insufficiency as judged by blood gases: hypoxaemia (PaO_2< 13 kPa on oxygen) or hypercarbia ($PaCO_2$ > 6 kPa).

- Spontaneous hyperventilation causing $PaCO_2$ < 4 kPa.

- Irregular respirations.

[Amended] 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.

- Unstable fractures of the facial skeleton.

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

- Seizures.

[Amended] An intubated patient should be ventilated with muscle relaxation and appropriate short-acting sedation and analgesia. Aim for a PaO_2 greater than 13 kPa, $PaCO_2$ 4.5 to 5.0 kPa unless there is clinical or radiological evidence of raised intracranial pressure, in which case more aggressive hyperventilation is justified. If hyperventilation is used, the inspired oxygen concentration should be increased. The mean arterial pressure should be maintained at 80 mmHg or more by infusion of fluid and vasopressors as indicated. In children, blood pressure should be maintained at a level appropriate for the child's age.

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

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.

7.9 Transfer of children

The recommendations in section 7.8.6 above 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 7.5 above[137] .

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.

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

[NEW] The possibility of occult extracranial injuries should be considered for the multiply injured child, and he or she should not be transferred to a service that is unable to deal with other aspects of trauma.

7.9.1 Recommendations for research

The GDG also identified the following priority areas for research.

7.9.1.1 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?

7.9.1.2 Why this research is important

Traumatic brain injury (TBI) is amongst the most important causes of death in young adults, with an overall mortality for severe TBI of over 50%. TBI care consumes one million acute hospital bed-days, and over 15,000 ICU bed-days annually, and patients who do survive significant TBI experience an enormous burden of long term physical disability, neurocognitive deficits, and neuropsychiatric sequelae. The financial impact is significant: the NHS spends over £1 billion on just the acute hospital care of the 10,000 patients with significant TBI. The costs of rehabilitation and community care are difficult to estimate, but probably total many multiples of the figure provided for acute care. These considerations make TBI a national healthcare priority and its outcome impact is consistent with its inclusion in the National Service Framework for Long Term Neurological Conditions.

Current referral of patients with acute traumatic brain injury practice is still dominated in many parts of the United Kingdom by the need for operative neurosurgical intervention at presentation. This may be inappropriate, since many patients with severe head injury have evidence of raised intracranial pressure in the absence of

surgical lesions, and suffer morbidity and mortality equal to those with surgical lesions. Further, several studies provide strong circumstantial evidence that managing such "non-surgical" patients in specialist neurosciences centres may result in substantial improvements in mortality and functional outcome, probably due to specialist expertise in areas of non-operative management, such as neurocritical care. However, these results may be confounded by case-mix effects and referral bias, and the cost-effectiveness of such specialist management remains uncertain. There is a strong case to address this question in the context of a formal study, since a change in practice could have a major impact on death and disability in a condition that is a major contributor to mortality in healthy young adults. Importantly, the results of such a study could fundamentally alter the recommendations made by NICE, in terms of where patients with head injury are treated within the healthcare system, and result in better optimised (and potentially more cost-effective) patient flows within the NHS.

The available evidence in this area has been addressed in the systematic review that contributed to the revision of NICE Guidelines on the early management of head injury. This review could find no high quality clinical evidence on the topic. This is unsurprising, since any study that addressed these issues would have to be undertaken within the context of a healthcare system and include ambulance services, district general hospitals and neuroscience referral centres. Such a study would therefore require the organisational backing of a body such as NICE and careful design to account for confounds and biases. However, we believe that given careful design, such a study would be both ethically and logistically feasible. The patient group is well defined, and adequate numbers would be available to provide a definitive result within a reasonable time frame. While circumstantial evidence may support transfer of such patients to neurosciences centres, current practice is not influenced by this view in many regions, and many would argue that there is still clinical equipoise in this area. There are clear risks from transfer, and there could be clear harm, both in terms of clinical outcome and health economics, if the anticipated benefits were not realised. On the other hand, if the benefits from observational studies were confirmed by the trial, the resulting changes in management 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 emergency department. At the same time it is anticipated that patients admitted for in-hospital observation will on average have sustained a more severe head injury than is currently the case. These changes to current admission practice will increase the need to ensure that patient discharge from hospital is safe and carefully planned. A very small number of patients will develop late complications despite normal CT results and an absence of signs and symptoms. A well designed system of high quality discharge advice and post-discharge observation by a carer is required to ensure that these patients receive appropriate care as soon as possible. The role of carers at home in the early post-discharge observation of patients is important and should be guided by clear and detailed information. There should be clearly defined pathways back to hospital care for patients who show signs of late complications. 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 discharge 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 discharge, 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 discharge 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 discharge, 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 discharge 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 discharged after resolution of all significant symptoms and signs providing they have suitable supervision arrangements at home (see also recommendation 6.3.6 for those admitted out of hours but who require a CT scan).

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 discharged until assessed by a clinician experienced in the detection of non-accidental injury.

It is expected that all personnel involved in the 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.[138]

8.7 Discharge and Glasgow Coma Scale status

No patients presenting with head injury should be discharged until they have achieved GCS equal to 15, or normal consciousness in infants and young children as assessed by the paediatric version of the Glasgow Coma Scale.

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 discharge from an emergency department 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 emergency department 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.

Patients who presented to the emergency department 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 guidleine.[33,36,139-141]However from these papers, only one paper[139] explicitly constructed a decision rule that could be used in the acute setting to identify patients at risk of PCS. This rule identifies a high-risk group that has an 89% risk of PCS and a low risk group with a risk of PCS of 9%. Unfortunately 50% of patients then fall into a medium risk category, where the risk is 47% for PCS. Therefore the only category that may be of use for excluding patients from follow up is the low risk category, but this category was derived from only eleven patients. Therefore this study, although being the only paper to attempt the derivation of a rule is still really only of use to researchers looking to improve on their findings.

Of the remaining papers: length of post-traumatic amnesia, period of loss of consciousness, abnormal initial GCS, gender, age, positive radiological findings and various neuropsychometric tests have been advocated as being associated with an increased risk of PCS, but there is no data as to how these variables might combine as a decision rule for the safe exclusion of low risk patients from follow-up.

In the original guideline, there was insufficient evidence for the recommendation of any decision rules that can safely exclude a patient from follow up although several high-risk variables have been reported.

UPDATE 2007:

In this update, no clinical evidence review was carried out due to a vast amount of evidence in this area and the limited framework of this update. Therefore a thorough evidence map was conducted to aid future research in this area.

8.10.2 Clinical evidence

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 who 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 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 less than 1 year, adults are over 18. Injury severity was defined using the GCS system or if the authors used the words 'mild', 'moderate', or 'severe' in the abstract.

- Study design – type of study.

- Variables considered – these were categorised into certain groups. Every piece of information explicitly collected about the patient was categorised and noted. Therefore variables included predictors, outcomes, demographics, classifying information and so on.

Ninety two studies were identified as being explicitly about tools for referral. However, the remaining 302 studies were included as in a complete systematic review they would contain useful information; for example, the authors may have investigated variables which could be used to form a clinical prediction rule without making this explicit in the abstract.

A wide spread of variables was identified which included; GCS/GOS or other measure of injury severity, S100B, Tau protein, Interleukin, other blood marker, other clinical data, cognitive measure, behavioural measure, disability measure, sensory measure, imaging measure, quality of life measure, social functioning, employment outcomes, length of stay, mortality, motor skills, demographics, psychosocial measure and somatosensory evoked potentials (SEPs)

The population characteristics of age and injury **severity were not reported in the majority of the reports**. However, the most commonly studied populations appeared to be children (93 studies) and severely head injured patients (133 studies).

8.10.3 Economics Evidence from 2007 update

A full literature review for this question was not conducted. However, below is an overview of relevant papers retrieved:

Economic evaluations of early versus late/no rehabilitation:

- 3 studies published since 2002: Berg2004[142], Worthington2006[143], Hashimoto-Keiji2006[144]

- 3 studies found from reviews: Aronow1987[145], Cope1982[146], Wood1999[147]

Economic evaluations of intensive versus less intensive rehabilitation

- 1 study published since 2002: Ponsford2006[148]

- 2 studies found from reviews: Ashley1997[149], Salazar2000[150]

Reviews of economic evaluations

- 4 studies published since 2002: Turner2004[151], Berg2004[142], Wehman2005[152], Turnerstokes2004[153]

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

8.10.4 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 propose a research recommendation on this topic.

8.10.5 Recommendations for research

The GDG identified the following priority area for research.

8.10.5.1 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.

8.10.5.2 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.

8.11 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 General Practitioner 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.

8.12 Prognosis in severe head injury

A recent systematic review focusing only on severe head injuries examined evidence on early indicators of prognosis.[154] 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[155] and include information on the rehabilitation of patients following acquired brain injury. The contents of this guideline are therefore beyond the scope of this guideline.

8.13 Advice about long term problems and support services

[Amended] 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 if they experience long-term problems. Details of support services should be included on patient discharge advice cards.

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

8.14 Communication with community services

A communication (letter or email) should be generated for all patients who have attended the emergency department with a head injury, and sent to the patient's GP within 1 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.

[Amended] A communication (letter or email) should be generated for all school-aged children who received head or cervical spine imaging, and sent to the relevant GP and school nurse within 1 week of the end of the hospital episode. This letter should include details of the clinical history and examination.

[Amended] A communication (letter or email) should be generated for all pre-school children who received head or cervical spine imaging, and sent to the GP and health visitor within 1 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.

8.15 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.[156]

Patients who returned to an emergency department within 48 hours of discharge 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.

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 the emergency department or after admission following abnormal imaging results. As noted above, all care professionals should use a standard head injury proforma in their documentation when assessing and observing patients with head injury. Separate adult, and child/infant specific proformas should be used. Again, the adult and paediatric GCS and derived scores should form the basis of observation, supplemented by other important observations.

An important result of these guidelines will be that the typical patient admitted for in hospital observation after head injury will have a more severe profile. It is presumed that the guidelines will lead to a substantially lower number of patients requiring admission, but these patients will have either confirmed abnormal imaging, have failed to return to normal consciousness or have other continuing signs and symptoms of concern to the clinician. The emphasis will shift therefore from vigilance for possible deterioration, to active care of patients where an ongoing head injury complication has been confirmed.

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 cooperative to allow scanning.**

- **Continuing worrying signs (for example, persistent vomiting, severe headaches) of concern to the clinician.**

- **Other sources of concern to the clinician (for example, drug or alcohol intoxication, other injuries, shock, suspected non-accidental injury, meningism, cerebrospinal fluid leak).**

[Amended] Some patients may require an extended period in a recovery setting because of the use of general anaesthesia during CT imaging.

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 Emergency Deparment 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.[157] There have also been concerns about the experience and skills of staff on general and orthopaedic acute wards in head injury care.[12] This lead to a recommendation by the Royal College of Surgeons of England in 1999 that adult patients needing a period of observation should be admitted to a dedicated observation ward within or adjacent to an emergency department.[12]

[Amended] In circumstances where a patient with a head injury requires hospital admission, it is recommended that the patient be admitted only under the care of a team led by a consultant who has been trained in the management of this condition during his/her higher specialist training. The consultant and his/her team should have competence (defined by local agreement with the neuroscience unit) in assessment, observation and indications for imaging (see recommendations 3.7); inpatient management; indications for transfer to a neuroscience unit (see recommendations 3.6); and hospital discharge and follow up (see recommendations 3.8).

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.

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 6 hours after a head injury, observations should have greatest frequency in this period.[158]

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 the emergency department:

- **half-hourly for 2 hours;**
- **then 1-hourly for 4 hours;**
- **then 2-hourly thereafter.**

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

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*

[Amended] 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 (greater weight should be given to a drop of one point in the motor response score of the Glasgow Coma Scale).**
- **Any drop of three or more points in the eye-opening or verbal response scores of the Glasgow Coma Scale, or two or more points in the motor response score.**
- **Development of severe or increasing headache or persisting vomiting.**
- **New or evolving neurological symptoms or signs such as pupil inequality or asymmetry of limb or facial movement.**

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

[Amended] If any of the changes noted in recommendation 1.7.5.1 are confirmed, an immediate CT scan should be considered, and the patient's clinical condition should be re-assessed and managed appropriately.

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

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 above.

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 emergency 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.

[Amended] Healthcare 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 long peiods at the bedside. If they wish to stay with the patient, they should be encouraged to take regular breaks.

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.[159] By 2002 these figures had risen to 7% and 47% respectively.[160]

National patient dose surveys for CT examinations have been carried out in the UK in 1989[161] and in 2003[162]. 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[163-165]. 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[162] 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[166], 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[161]. 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 are 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 [161] 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[167] 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[161] 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[166].

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.

	Effective dose (mSv)			
	Head		Cervical spine	
Patient Age (y)	Radiographs*	CT	Radiographs**	CT
0-1	0.06	2.5	0.07	6.0
5	0.06	1.5	0.07	3.9
10	0.06	1.6	0.07	3.1
Adult	0.06	1.5	0.07	2.6

* 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.[168] 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. [169]

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)[170]. 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.[171]This is due to both an increased dose for children having CT scans in the USA at the time (2001) compared to adults, and an estimated increase in risk per unit dose of about a factor of 3 for a one year old child. While this paper calculates a projected 500 additional cancer deaths per year in the USA from the number of paediatric CT examinations performed in 2001, this only represents a 0.35% increase in the background cancer death rate.

In summary, the best available evidence suggests that paediatric CT will result in increased lifetime risks of cancer compared to adult CT due to both the higher radiation doses currently delivered to children and their increased sensitivity to radiation-induced cancer over a longer life span.

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.

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.[172] In the UK, the remit of NICE is to produce national clinical guidelines that address cost-effectiveness as well as clinical effectiveness.

The reasoning behind the application of economic criteria to clinical guidelines is that no health system anywhere in the world has enough resources to provide every potentially beneficial preventative, diagnostic, curative and palliative procedure. Therefore, there is a need to re-deploy resources to those procedures where the potential health gain is greatest. This requires abandoning practices that are relatively poor value for money.

There is a well-developed methodological literature for assessing the relative cost-effectiveness (value for money) of different healthcare procedures.[173-175] There is still some debate over some of the specific methods of economic evaluation in healthcare but essentially there are six

steps to evaluating the relative efficiency of any procedure.

1. Identify the target group (for example, patients attending emergency departments with GCS greater than 12), the procedure to be evaluated (for example, head CT scanning) and its alternative strategy (for example, skull X-ray).

2. Identify all the important health and resource outcomes that are likely to differ between the procedure and its alternative.

3. Measure the differences in identified health and resource outcomes.

4. Estimate the value of the health gain and the value of the resource use. (Resource use is valued in terms of its monetary value, its economic cost. Health gain is sometimes valued in monetary terms but more often a non-pecuniary measure such as the quality-adjusted life-year, QALY, is used).

5. Estimate the ratio of net health gain to net resource cost (for example, the cost per QALY gained) and compare this with the ratios estimated for other commonly used health programmes to assess its relative efficiency. The estimation of net health gain and net cost requires some kind of model (such as a decision analysis) to combine probability and outcome information.

6. Consider the robustness of the cost-effectiveness estimate in terms of statistical precision and generalisability to other settings.

Ideally one would repeat each of these steps for each procedure considered within the guideline (and within each procedure, for each relevant patient subgroup). This would allow us to see for which group of patients the procedure is good value for money. In practice we are limited by the availability of data.

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.

UPDATE 2007:

For both of the identified areas, a review of the literature was conducted followed by simple economic modelling of the cost-effectiveness in England and Wales of different strategies. The costs in these models were updated to 2005-6 prices for the 2007 update and the evidence summaries were modified accordingly.

A full literature review for the rehabilitation question was not conducted during the 2007 update either. The list of the relevant papers retrieved can be found in 8.10.3

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

- Health Economic Evaluations Database (HHED) - http://www.ohe-heed.com.

- NHS Economic Evaluations Database (NHS EED) - http://nhscrd.york.ac.uk/nhsdhp.htm.

These strategies were designed to find any economic study related to head injury. Abstracts and database reviews of papers found were reviewed by the health economist and were discarded if they appeared not to contain any economic data or if the focus of the paper was not imaging after trauma. Relevant references in the bibliographies of reviewed papers were also identified and reviewed.

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 (that is, GCS greater than 12) but some loss of consciousness or amnesia at the time of the impact or thereafter. The reason for selecting this group is that it is assumed that those patients with a more significant loss of consciousness receive CT scanning automatically or are referred to neurosurgery. It is assumed that those who do not experience loss of consciousness or amnesia will not receive CT scanning. These assumptions mirror the methods used to derive the Canadian CT-head rule.

Four alternative strategies were selected for the model (Table 11.1). The first is an approximation of the current (pre-2003) UK system, based on skull X-ray for patients who have experienced loss of consciousness or amnesia. The second and third are the Canadian head rules, which avoid skull X-ray, but allow greater access to CT scanning. Patients with a negative CT scan would be discharged. The fourth strategy is comprehensive scanning and admission of all patients, essentially what happens in the US system.

Table 11.1 - Description of different strategies for the target group

	Indications for test		
	Skull X-ray	24 hour admission	CT
1. Current (pre-2003) UK system[176]	All	headache, vomiting or other neurological indication	skull fracture or deterioration in 24 hours
2. Canadian CT Head 5-rule[25]	None	+ve CT scan	suspected fracture (open, depressed, basal), age greater than or equal to 65 years, GCS of 13 or 14 at 2 hours, 2 or more vomiting episodes
3. Canadian CT Head 7-rule[25]	None	+ve CT scan	As for 5-rule but also CT if pre-impact amnesia greater than 30mins or dangerous mechanism
4. 4. US system	None	All	All

The cost per patient for each strategy was calculated on the basis of the expected usage of skull X-ray, head CT scan and 24 hour observation. It was not possible to quantify differences in health outcomes and other cost outcomes (Table 11.2, outcomes 4-10).

Table 11.2 - Health and resource consequences of Canadian CT head rule versus current (pre-2003) UK system

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

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 [176] for the current (pre-2003) UK system and from Stiell et al [25] 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

	Proportion of target group		
	Skull X-ray	24 hour admission	CT
1. Current (pre-2003) UK system[176]	100%	26% (24%, 27%)	4% (3%, 5%)
2. Canadian CT Head 5-rule[25]	0%	9%* (8%, 10%)	32% (30%, 34%)
3. Canadian CT Head 7-rule[25]	0%	9%* (8%, 10%)	54% (52%, 56%)
4. US system	0%	100%	100%

* Stiell et al[25] propose discharging patients that have a negative CT scan, although they are only half way through their validation study, which applies this strategy. This figure is based on their prevalence of complications.

Stiell et al have not yet put their model into practice; therefore the admission rate figure is provisional. For this model it was assumed that only those with a positive CT scan (ICH or other complication) would be admitted. Another problem was that Stiell et al had already excluded patients without any loss of consciousness or amnesia, whereas the UK paper had not. This problem was tackled by assuming that patients in the UK study who were discharged without a skull X-ray or CT scan were also very low risk (that is, had no loss of consciousness or amnesia).

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 [122]
- Canadian cervical spine rule [52]

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 [122] and that these are followed up with a CT scan.

Table 11.4 - Outcomes from cervical spine scanning

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

11.2.4 Unit costs

Average unit costs for X-ray, CT scan and 24 hour observation were taken from the NHS Reference Costs 2005-6[177]. A unit cost of 24-hour observation was estimated approximately using the median cost of an excess bed day for a 'Head injury without significant brain injury: uncomplicated'.

Table 11.5 - Unit cost estimates for the UK NHS (updated in 2007)

	Cost per patient tested (2005-6 UK£):*		
	Lower	Mid	Upper
X-ray	15	19	23
CT scan	62	77	100
24 hour observation**	183	224	277

*NHS Reference costs 2005-6[177] 25th, 50th and 75th centiles. Costs include staff time, equipment cost and consumable cost and overheads.

** Cost per day of an inpatient stay for a 'Head injury without significant brain injury: uncomplicated' (n=1563 excess bed days).

The NHS reference cost database contains accounting cost data from every NHS hospital trust. Each trust reports an average cost per hospital episode, categorised by type of visit (for example, out-patient, elective in-patient, etc) clinical specialty and Healthcare Resource Group (HRG). Accounting practices do vary between hospitals but the costs should reflect the full cost of the service (including direct, indirect and overhead costs), as described in the NHS Costing Manual.

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

- for the unit costs, the inter-quartile range was used,
- for the probabilities, the confidence intervals were used.

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 (that is, 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.[178-180]

Three overseas studies have compared CT scanning with alternative strategies. Ingebrigtsen and Romner [181] 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 [182] and Stein et al [183] 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 (pre-2003) 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

	Component costs (£)			Total cost (£)
	Skull X-ray	24 hour admission	CT	
1. Current (pre-2003) UK system	19	57	3	79
2. Canadian CT Head five point rule	0	20	25	45
3. Canadian CT Head seven point rule	0	20	42	62
4. US system	0	224	77	301

Both Canadian rules could save the NHS money. It would require investment in additional CT scanning facilities but these costs would, be offset by the freeing up of ward space and X-ray capacity.

These results were largely insensitive to the unit costs and probabilities used (Table 11.7). Only when both costs and probabilities were set to favour the current (pre-2003) UK system was the Canadian seven point rule more costly.

Table 11.7 - Sensitivity analysis for head CT scanning rules

	Additional cost per patient (£) - Canadian seven point rule compared with current (pre-2003) UK system
Baseline	-17.72
Sensitivity to unit costs*	-38.05, 4.62
Sensitivity to proportion of patients scanned**	-25.55, -9.89
Sensitivity to both unit costs and proportions	-46.89, 11.96

* Lower limit: High skull X-ray cost, High admission cost, Low CT cost. Upper limit: Low skull X-ray cost, Low admission cost, High CT cost (see table 11.5)
** Lower limit: using confidence limits that favour the Canadian seven point rule. Upper limit: using confidence limits that favour the UK system (see Table 11.3).

This cost analysis was limited because the frequency of testing and admission for each strategy could only be estimated approximately given the currently available data. The Canadian head rule is less costly than the current (pre-2003) UK system because it is assumed that it reduces the number of admissions. In fact Stiell et al [25] 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).

Table 11.8 Additional cost per patient (£) - Canadian seven point rule compared with current (pre-2003) UK system - two-way sensitivity analysis. (Updated 2007)

Reduction in admissions	CT Scanning rate in current (pre-2003) UK system							
	0%	2.5%	5%*	10%	20%	40%	60%	80%
0%	22.82	20.89	18.97	15.12	7.42	-7.98	-23.38	-38.78
2.5%	21.39	19.46	17.54	13.69	5.99	-9.41	-24.81	-40.21
5%	19.96	18.04	16.11	12.26	4.56	-10.84	-26.24	-41.64
10%	17.10	15.18	13.25	9.40	1.70	-13.70	-29.10	-44.50
20%	11.39	9.47	7.54	3.69	-4.01	-19.41	-34.81	-50.21
40%	-0.03	-1.96	-3.88	-7.73	-15.43	-30.83	-46.23	-61.63
60%*	-11.46	-13.38	-15.31	-19.16	-26.86	-42.26	-57.66	-73.06
80%	-22.88	-24.81	-26.73	-30.58	-38.28	-53.68	-69.08	-84.48

* 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.[184]

UPDATE 2007:

However, there is cohort study evidence suggesting reduced mortality associated with prompt surgery[185,186]. A paper retrieved during the 2007 update[76] 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 10).

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 [187] have estimated that only one in 10,000 patients subsequently turn out to have an intracranial haematoma after being discharged without a CT. Therefore the potential costs saved per patient screened are likely to be small. It should also be born in mind that successful litigation usually arises out of organisations not abiding by guidelines.

11.3.7 Update 2007

We found three new studies that evaluated diagnostic tools: a decision analysis[188] and an RCT[79] were comparing admission with CT scanning, and a case series[189] was evaluating the use of head MRI as an addition to CT.

A further three new studies evaluated diagnostic decision rules. We found two studies evaluating the implementation of the head CT rule recommended in the original edition of this guideline. A third study compared the Canadian Head CT Rule with various imaging strategies.

A decision analysis[188] compared CT scanning (and discharge after a negative scan) with admission in head injury patients with a GCS of 15 (mild head injury). They found the CT strategy to be cost saving compared with admission. The same team confirmed the results of this study with a randomised controlled trial of 2600 mild head injury patients[791]. 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[189] 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[16] 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[88] of 992 patients, costs were found to increase by £77 per patient. Table 1 shows the resource use observed in both studies compared with the predictions in the original edition of this guideline. The evidence from the cohorts suggests that compared with our

predictions there was a more modest increase in CT and a more modest decrease in X-ray.

The variation in impact between centres could be due to a number of factors including variation in the baseline position and completeness of adherence to the NICE guideline in the after period of the studies. In the centre that showed an increase in cost, X-rays were very low in number to start with and therefore there was less scope for cost savings; furthermore admissions had inexplicably increased slightly compared with the reductions seen at the other centres. The large amount of variation between centres means that the impact of our recommendations at a national level remains uncertain.

Table 11.9: Resource use before and after implementation of NICE head CT rule

	NCC-AC2003 Model		Shravat2006 DGH	
	Before	After	Before	After
CT	2%	29%	2%	8%
SXR	54%	0%	11%	0%
admission	14%	4%	8%	9%

	Hassan2005 Neurosciences		Hassan2005 DGH	
	Before	After	Before	After
CT	3%	18%	1%	9%
SXR	37%	4%	19%	1%
admission	9%	4%	7%	5%

One of the centres in the Hassan study[16] had modified the protocol so that elderly patients with a GCS of 15 seen out of hours could be admitted instead of getting urgent CT. The reasoning involves a combination of factors: a) the cost of out-of-hours radiology was relatively high, b) the elderly represent quite a large group and there are often difficulties in trying to discharge them over night. Hence, the modification is lower cost since out-of-hours radiology is avoided and most would needed admission anyway. We don't have evidence of effectiveness for this specific patient group but the randomised evidence for the general population showed no difference in outcomes between observation and CT scan[79]. The GDG agreed that this was an acceptable deviation from the head rule and the guideline recommendations were modified accordingly.

A decision analysis[76]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 [190] 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 [191] 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 [121], using test sensitivities pooled from the published literature, compared CT scanning of the cervical spine with conventional cervical spine X-ray. Using their own risk rating scale, they found CT scanning to be a cost-effective strategy ($16,000 per quality-adjusted life-year gained) for the 'high' and 'moderate' risk groups (high energy mechanism and age under 50 or moderate energy mechanism and age greater than 50) but not for the low risk group ($84,000 per QALY gained). Unlike the other studies, incorporated into these figures are the costs and morbidity associated with paralysis.

- In addition, two more studies estimated the costs that could be saved by moving from current practice at a particular institution to a particular scanning protocol.[122,192]

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 10).

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 £14 per patient (Table 11.10).

Table 11.10 – Comparison of the Canadian and NEXUS cervical spine rules (Updated 2007)

Strategy	Proportion of patients receiving test		Cost of testing (£) per patient		
	X-ray	CT	X-ray	CT	Total
Canadian	58.2%	22.8%	11.05	17.53	28.58
NEXUS	87.4%	34.2%	16.60	26.31	42.91
Increment					14.33

The assumption that a CT scan will be performed after all inadequate X-rays may over-estimate the actual cost savings; if we omit them then the cost-savings are £4 per patient scanned. Sensitivity ranges are presented in Table 11.11.

Table 11.11 - Sensitivity analysis for cervical spine scanning rules

	Incremental cost per patient (£) of NEXUS rule compared with Canadian cervical spine rule	
	X-ray costs only	X-ray and CT cost
Baseline estimate	5.54	14.33
Sensitivity to unit costs	4.38, 6.71	11.45, 18.12
Sensitivity to proportions tested	5.28, 5.80	13.65, 15.01
Sensitivity to both unit costs and proportions	4.17, 7.02	10.91, 18.95

The Canadian cervical spine rule could save valuable health service resources but it is yet to be validated and if it was found to be less sensitive it might not be the most cost-effective strategy due to the morbidity and high costs associated with paralysis. This cost analysis was limited because of the use of overseas data and the simplified assumptions regarding dealing with inadequate X-rays. Furthermore the analysis did not include outcomes 3-8 from Table 11.4.

11.4.3 Update 2007

Five new studies were found: a non-randomised controlled trial[117], two cohort studies[118,193], a case series[119] and a decision model[120]. One study[193] was evaluating the role of MRI scanning in children, another study [117] was comparing helical CT scanning with X-ray in children, and the rest were comparing CT scanning with X-ray in adults.

A non-RCT [117] compared the costs of helical CT with those of X-ray in a population of 136 children who required cervical spine radiography in addition to cranial CT. The imaging costs including follow-up tests were £100 and £130 respectively for the radiography and CT diagnostic strategies (significance not reported).

A retrospective cohort study [118] 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 [119], 407 adult patients in a trauma centre underwent both X-ray and helical CT (again the proportion with head injury was not reported). The reference standard was represented by two radiologists independently reviewing both the HCT and plain X-ray results together with hospital case notes. The sensitivity yielded by X-ray was 45% while the sensitivity yielded by the helical CT intervention was 98%. The helical CT strategy was more costly than a strategy of helical CT after inadequate X-ray. From their figures, we calculate that this strategy costs an extra £7,300 per fracture detected. Using the model by Blackmore and colleagues[121], as follows, we can see that this is highly cost-effective. The model estimated that 5% of fractures would lead to paralysis and that paralysis is associated with 16 QALYs lost. Hence £7,300 per fracture detected would translate to only £9,125 per QALY gained and that is without taking in to account the considerable cost savings from averting paralysis.

The decision analysis of helical CT vs X-ray of the cervical spine in patients undergoing cranial CT for head injury by Grogan et al[120] was based on an earlier model by Blackmore and colleagues[121] looking at conventional CT vs X-ray. It considered only patients at medium and high risk:

- Focal neuro-deficit or severe head injury or high energy impact, or

- Moderate energy impact and age more than 50

Helical CT cost an additional £37,000 per paralysis averted in this group. This would imply that the helical CT strategy is cost saving when the very high cost of treating paralysis is taken into account.

A retrospective cohort study with a historical control published in 2002 [193] evaluated a protocol of MRI scanning patients whose cervical spine had not been cleared within 72 hours. The control strategy was not clearly defined. This study was conducted in a specific population of patients consisting of 102 children (age 0 to 17) who were intubated at the time of hospital admission and who remained in the intensive care unit for at least 3 days. Among the 51 patients in the control group, 19 underwent MRI, whereas it was required for 31 patients in the post-protocol group.

The MRI group had reduced hospital charges (£18,000 vs £24,000; significance not reported) attributable to reduced stay in hospital and in intensive care. However, sample variation and a general trend over time towards reduced stay might explain this difference.

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, there are health outcomes and some additional changes to resource use that cannot be quantified using currently available data – notably those associated with the impact of radiation exposure.

Table 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 emergency departments per year.

We would like to emphasise the tentativeness of these estimates. There is uncertainty over these figures for a number of reasons. Data were taken from four different sources to estimate the number of scans (currently and with the new system). [25,52,122,176] Various assumptions had to be made to make the denominator of the estimates from these studies comparable. Some of the evidence was not from a UK population. Empirical studies found in the 2007 update (Table 11.9) show great variation between centres and therefore help little to reduce the uncertainty about the numbers of each scan before and after the guideline.

The reduction in skull X-rays is likely to be an overestimate, as some skull X-rays may still have to take place for non-accidental injuries and other reasons. The reduction in in-patient observation is also uncertain. This assumes that clinicians are able to discharge patients who have had a negative CT scan. This will not be the case for patients who

have other comorbid traumatic symptoms.

Table 11.12 – Imaging and admission volumes and costs England and Wales associated with different clinical decision rules (updated 2007)

	Number per year (000)			Cost per year (£m)		
	Current (pre-2003)	New (post-2003)	Change	Current (pre-2003)	New (post-2003)	Change
Head						
Skull X-ray	378	0	-378	7.2	0.0	-7.2
Head CT	16	205	189	1.2	15.8	14.6
24-hr Obs	96	33	-63	21.6	7.5	-14.1
Cervical spine						
X-ray	330	220	-110	6.3	4.2	-2.1
CT	129	86	-43*	10.0	6.6	-3.3
All				46.2	34.1	-12.1

* Note that the 2003 recommendations should lead to reduced spine imaging generally (including CT), as given here. However the 2007 update should lead to increased CT scanning compared with the 2003 recommendations (figures not given).

The Canadian head CT rule, adopted by the consensus of the Guideline Development Group is expected to reduce costs. There are also likely to be improvements in quality of care. In the short term this will mean fewer patients being diagnosed on 'deterioration', patients getting reassurance sooner rather than later and hopefully improvements in long term outcomes (although this is not based on high quality evidence). If patient outcomes are improved then this in turn might lead to additional cost-savings. It was the decision of the Guideline Development Group that the potential benefits of adopting this rule are likely to outweigh the potential costs.

The NEXUS cervical spine rule and the Royal College of Radiologists guidelines appear to be almost identical. Given this, on the basis of a simple cost model, the adoption of the Canadian cervical spine rule could save valuable health service resources. This rule is yet to be validated, however, and if it was found to be less sensitive it might not be the most cost-effective strategy due to the morbidity and high costs associated with paralysis. On the other hand, the thyroid is known to be susceptible to radiation damage and strategies that reduce the need for radiological examination of the neck may reduce subsequent morbidity and health service cost.

Our simple analyses estimated an additional scanning cost of £17 per head trauma patient associated with adopting the Canadian head CT and a cost saving of £14 associated with adopting the Canadian cervical spine rule. This suggests a combined impact of £31 saved per patient. For England and Wales, assuming an incidence of head injury of around 700,000 cases a year, of which 54% satisfy the criteria for scanning, a modest saving of £12.1m that could be reinvested in the health service would result. However, we should be very cautious about this figure. The longer term impact of changing imaging strategies on health outcomes and health service costs is even less certain. Staff shortages in radiology mean that implementation of these changes could take some time or else use up extra resources. Another reason why these cost savings might not be realised in the short term is that they are likely to require investment in new CT scanning equipment.

It is probable that we have not taken into account fully the implementation costs of the guideline. To some extent this is true, as our remit does not include the details of implementation. For example, we acknowledge that full implementation of the guideline will require staff training, the cost of which we have not been in a position to quantify.

It is also possible that the costs incorporated into our cost analyses do not reflect the real costs of the services. For example, the increased utilisation of CT scanners may necessitate the purchase of additional scanners, although the capital cost of CT scanners should be incorporated into the unit costs that we have used in our cost-effectiveness model. There is also a possibility of the expansion of out of

hours practice, which may push up the unit cost of scanning. The shortage of radiology and radiography staff, especially those with appropriate experience in CT scanning of the head, may again mean that the real cost of increasing CT scanning is greater than our calculations would suggest or at least that implementation will have to be delayed.

One issue raised throughout the guideline consensus process was the need for additional staff training at many levels. Achieving this goal, nationally, could require substantial resources, especially when shortages in specialist staff (for example, radiographers) are already constraining the system.[194]

We have suggested a number of reasons in the guideline document why the cost savings we have predicted might not occur. These include:

- in-patient observation may not be reduced despite the increase in CT scanning (evidence since 2003 is mixed – see Table 11.9);

- cervical spine CT might be quite rare at present and therefore the reductions won't take place;

- some skull X-rays will still have to take place for penetrating injury and other reasons (for example, suspected non-accidental injury);

- we have postulated that the similarity between the NEXUS guidelines and those of the RCR suggests that the NEXUS study represents current practice for cervical spine imaging in the UK. If this is not the case then a move to the Canadian cervical spine rule might not lead to cost savings.

It is clear that the long term morbidity associated with injury to the head and cervical spine and the lack of evidence concerning suitable rehabilitation are a major problem. Not only does it reduce the quality of life for these individuals and their carers but also it places a substantial burden on society in general through time off work and social security payments.[195] 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.

Updating the costs to 2005-6 prices makes the Canadian CT head rule even more cost-effective, since the cost of imaging has fallen.

A modification of the rule so that elderly patients with a GCS of 15 seen out of hours could be admitted instead of getting urgent CT is a safe strategy and could be cost saving for services where out of hours radiography costs are prohibitively high.

The new studies add to existing evidence, in suggesting that CT scanning of the cervical spine is cost-effective in higher risk groups who are already undergoing head CT. However, none of these studies have taken into account the costs and health consequences associated with the increased radiation exposure – it is possible that CT is no longer cost-effective when these are taken into account. It is difficult to model the impact of radiation exposure on cost-effectiveness since there are a large number of uncertainties: a) the amount of radiation received at different parts of the body, b) the relationship between exposure and cancer, c) the types of cancer caused, d) the pattern of resource use in the diagnosis and treatment of the cancer, and e) the timing of cancer, treatment and death. Another limitation with regard to cervical spine imaging is that all the studies were conducted in the USA; the observed healthcare costs and savings might not be transferable to a UK NHS setting. As the cost of CT scanning, as with most medical care, is lower in the UK, if it is cost-effective in the USA then it is likely to be cost-effective for the NHS. However, the cost savings from paralysis care averted are also likely to be lower.

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 two simulation models, which we will refer to as the London and Staffordshire models. We have reviewed these models in some detail, as follows.

11.6.2 London model

The report[196] summarises the findings of a review conducted by the London Severe Injury Working Group focusing on the Trauma services provided in London, including care, treatment and transfer of severely injured patients. Severe injury was defined as the need for Intensive Care.

The analysis of the current service highlights some key issues:

- high secondary referral rate (two thirds of the severely injured patients group),
- evidence of problems associated with such transfers (adverse clinical events during transfer, delay to definitive intervention, low level of staff and standard of care), and

- difficulties for hospitals in transferring patients for specialist care, especially for neurosurgery (stabilisation of patient first, co-ordination between the first hospital and the specialist hospital and consequent long delays).

Methods

A modelling of the flow of trauma patients was carried out to determine the best trauma service configuration for adult trauma patients with severe injury in the London area. The model was designed to estimate the time from injury to:

- Critical Intervention (urgent life saving interventions such as intubation); these interventions are crucial for all trauma patients
- Definitive Intervention (specialist interventions such as neurosurgery); these interventions vary according to the site of the trauma

The specific aims of the modelling exercise were to evaluate the effect on time to intervention of:
(a) different bypass strategies
(b) improving the current system by reducing time taken in pre-hospital and in-hospital trauma management.
(c) a doctor in the pre-hospital phase provided by the London Helicopter Emergency Medical Service (HEMS).

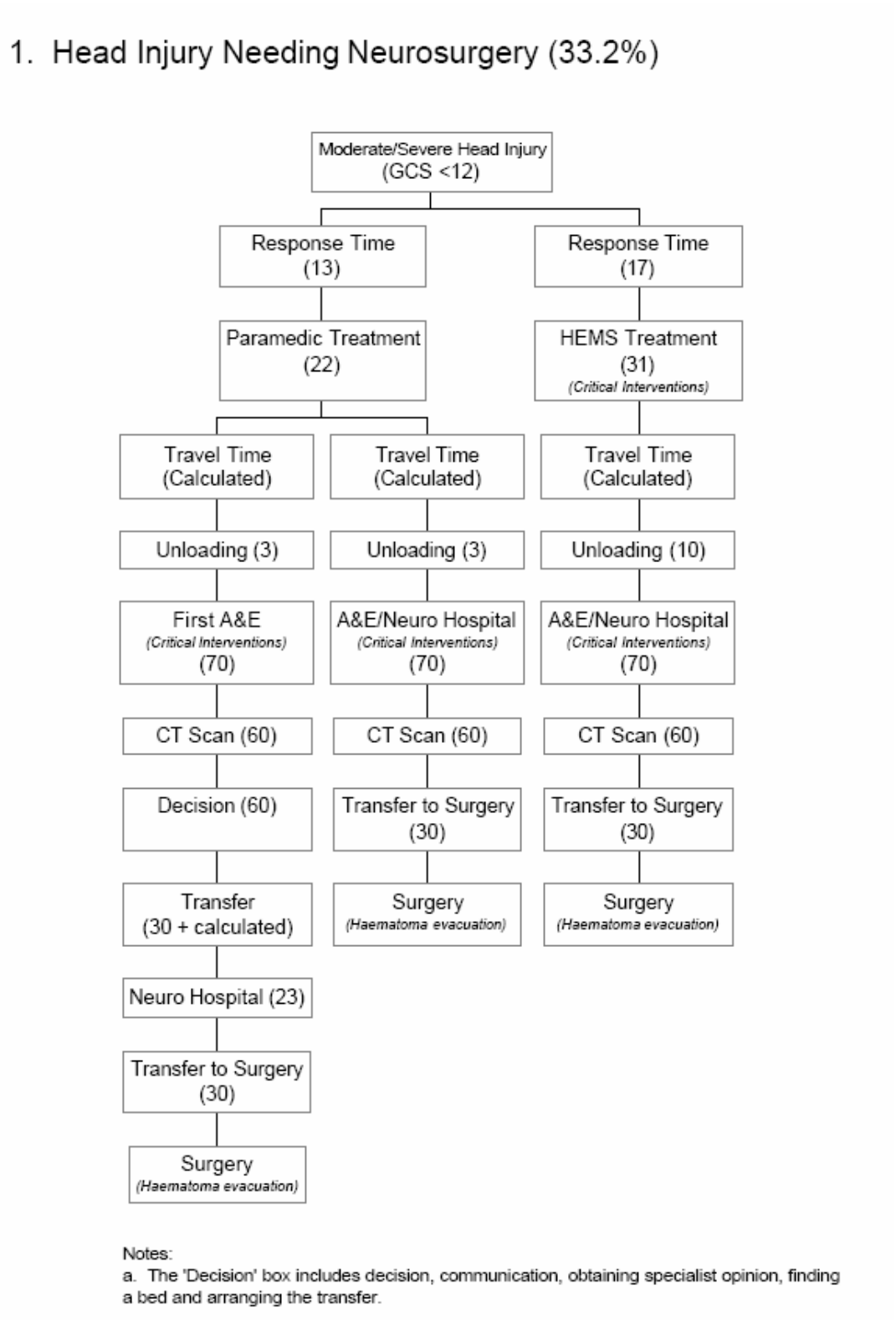
The model simulated results based on about 10,000 actual severe injuries from the London region. Of these 33% had isolated head injury and a further 18% had non-isolated head injury.

The model estimates time to intervention using flow charts. Figure 1**Error! Reference source not found.** shows the flowchart for an isolated head injury patient with the average times based on current practice. Similar flowcharts were devised for the different types of trauma. The timings were based on ambulance service records and expert opinion.

For each type of injury, a group of clinical experts decided on a target time for intervention. For head injury, it was considered that it was crucial to carry out neurosurgery within 4 hours of the injury, based on some evidence[186]. For each service configuration scenario, the primary outcomes were:

- the median times to critical and definitive interventions.
- the proportion of patients receiving critical and definitive interventions within the relevant time target.

Figure 1: London Model flowchart for isolated head injury patients (figures in parentheses are average time in minutes)



Notes:
a. The 'Decision' box includes decision, communication, obtaining specialist opinion, finding a bed and arranging the transfer.

Table 11.13: London Model: Median time (hours) to critical/definitive interventions, by bypass strategy

	Current timings			Timings improved at LAS* & hospitals		
Bypass strategy	**none**	**15**	**20**	**none**	**15**	**20**
critical intervention (*minutes*)	*41*	*43*	*45*	*32*	*34*	*36*
head injury	4.8	3.7	3.4	3.8	2.9	2.7
head and chest injury	4.9	3.8	3.5	3.9	3.0	2.7
head, chest and orthopaedic injury	6.9	5.9	5.6	6.0	5.2	4.9
chest injury	4.6	3.8	3.4	3.7	3.0	2.7
orthopaedic injury	2.2	2.3	2.3	1.7	1.7	1.7
head and orthopaedic injury	6.8	5.8	5.5	5.8	5.1	4.8
chest and orthopaedic injury	6.7	5.9	5.5	5.7	5.1	4.8
head, chest and abdominal injury	7.0	5.9	5.6	6.0	5.2	4.9
chest and abdominal injury	6.6	5.9	5.5	5.7	5.1	4.8
orthopaedic and abdominal injury	3.2	3.2	3.2	2.5	2.5	2.6
abdominal injury	3.2	3.2	3.2	2.5	2.5	2.6
facial injury	3.8	3.8	3.5	3.0	3.0	2.7
head and facial injury	4.8	3.8	3.5	3.8	3.0	2.7
spinal injury	5.7	4.8	4.4	4.6	4.0	3.6
head and spinal injury	4.8	3.8	3.4	3.8	3.0	2.7
head, orthopaedic and abdominal injury	6.8	5.8	5.5	5.8	5.1	44.8
orthopaedic and vascular injury	6.9	5.9	5.6	5.9	5.2	4.9
traumatic amputation	4.7	3.8	3.5	3.7	3.0	2.7

* LAS=London Ambulance Service

Table 11.14: London Model: Proportion of patients receiving critical/definitive interventions within target time, by bypass strategy

	Current timings			Timings improved at LAS* & hospitals		
Bypass strategy	**none**	**15**	**20**	**none**	**15**	**20**
critical intervention (within 60 minutes)	91%	88%	84%	98%	97%	96%
head injury (within 4hs)	23%	60%	74%	63%	81%	90%
head and chest injury (within 2hs)	0%	0%	0%	2%	4%	5%
head, chest and orthopaedic injury (within 2hs)	0%	0%	0%	0%	0%	0%
chest injury (within 2hs)	0%	0%	1%	3%	6%	8%
orthopaedic injury (within 2hs)	30%	27%	25%	84%	82%	79%
head and orthopaedic injury (within 4hs)	0%	1%	1%	3%	8%	10%
chest and orthopaedic injury (within 2hs)	0%	0%	0%	0%	0%	0%
head, chest and abdominal injury (within 2hs)	0%	0%	0%	0%	0%	0%
chest and abdominal injury (within 2hs)	0%	0%	0%	0%	0%	0%
orthopaedic and abdominal injury (within 2hs)	1%	0%	0%	9%	8%	7%
abdominal injury (within 2hs)	1%	0%	0%	9%	8%	7%
facial injury (within 3hs)	23%	22%	27%	49%	50%	63%
head and facial injury (within 3hs)	9%	22%	27%	19%	50%	63%
spinal injury (within 6hs)	62%	79%	88%	93%	96%	97%
head and spinal injury (within 4hs)	21%	55%	70%	61%	78%	88%
head, orthopaedic and abdominal injury (within 2hs)	0%	0%	0%	0%	0%	0%
orthopaedic and vascular injury (within 4hs)	0%	1%	1%	3%	7%	9%
traumatic amputation (within 4 hs)	30%	55%	70%	66%	78%	87%

* LAS=London Ambulance Service

Model Results

11.13 shows the median time to critical/definitive intervention by type of injury and by bypass strategy used. On the left side of the table the results are based on current timings. On the right hand side the results are based on improved timings. In the case of the isolated head injury patient the median time to neurosurgery is 4.8 hours currently but would fall to 3.4 hours when bypassing patients who are less than 20 minutes from a specialist centre. Table 11.14 shows the proportion of patients that receive interventions within the target time. In the case of the isolated head injury patient the number receiving neurosurgery within 4 hours would increase from 23% with no bypass to 74% with bypassing patients who are less than 20 minutes from a specialist centre. However, on the negative side with this bypass strategy only 84% (compared with 91%) would receive critical intervention within 60 minutes. The group that is made worse off by bypass is those patients with isolated orthopaedic injury: only 25% would receive their definitive intervention within their 2 hour target (compared with 30% without bypass).

For the injuries that can be treated in every hospital the most rapid movement to Definitive Intervention was achieved by the models without bypass, and with improvement in hospital times.

For injuries requiring specialist management the best models for providing early Definitive Intervention included 20 minutes bypass, improvement in hospital times and use of the London HEMS.

Report conclusions

The bypass protocol proposed is based on the 20 minutes of distance from a Multi-Specialty Centre, as this time gives the best trade-off between longer time to Critical Interventions, and shorter time to Definitive Intervention. However, the best balance between these opposing effects had to be struck by clinical judgement, as little evidence was available.

The report recommended that within a 20 minute drive time of an appropriate specialist unit, a patient should be driven directly to the specialist unit rather than to the local hospital, and that a triage system for London should be gradually introduced, allowing training of pre-hospital personnel and evaluation of the effectiveness of each of the triage criteria. For head injury the initial criterion could be based on GCS and additional criteria could then be added. This would avoid the flooding of Multi-Specialty Centres.

Review

The report has a number of limitations:

- The model, especially the target times, was based more on expert judgement than hard evidence of clinical effectiveness.
- In reality there will be a continuum of risk rather than a time cut-off.
- The model assumes that the specialist hospital has a range of different

specialist services in addition to neurosciences.

- The trade-off between the need for immediate access to critical interventions (e.g. intubation) and the need for faster access to definitive interventions (e.g. surgery) was made on the basis of expert judgement rather than health outcomes.

11.6.3 Staffordshire model

The link between time and health outcomes missed by the London model was captured to some extent in the Staffordshire model[68].

It evaluated the impact of 10 different transport strategies on survival of patients with serious or worse HI (AIS more than 2). In the model, survival was determined by a number of variables including: a) head AIS score, b) non-head AIS score, c) time to surgery, d) grade of staff during transfer, e) incidence of hypoxia and hypotension, g) distance from hospitals. Some of these variables are patient-specific (a,b,g), some are service-specific (d) and some are determined by the transport strategy (c,e). The data used in the model came from a variety of sources including a large trauma database, the published literature and expert opinion. Monte Carlo simulation (that is repeatedly generating new results by simultaneously drawing at random from the distribution of each model parameter) was used to simulate 10,000 head injury patients and their outcomes under each strategy.

Table 11.15 shows the results for each strategy. All direct transport strategies had higher expected survival than a strategy of sending all patients to the nearest emergency department but strategies 2-6 were the most effective. Among these strategies, strategy 4 (direct transport of patients with critical head injury, AIS=5) required the least number of patients being diverted to specialist centres. The results were not sensitive to the parameters that were determined by expert opinion.

An important limitation that was acknowledged by the authors was that AIS score is determined after treatment and therefore assessment of patients at the scene of the injury is less accurate. The implication is that the survival gain observed in this model is probably larger than can be achieved in reality, although the pattern should be the same. There are different costs associated with each strategy and therefore a cost-effectiveness analysis is needed to assess which of the 10 strategies is the most cost-effective.

In conclusion, the simulation study shows that survival of severe head injury patients could be substantially improved by transporting patients directly from the injury scene to a hospital with a specialist neurosciences centre. Cost-effectiveness of these strategies was determined as described in 11.6.4.

Comparison with the London model

The Staffordshire model went a step further than the London model by estimating the impact of different strategies on survival (as well as time) in order to trade-off the different outcomes.

Both models rely on evidence combined with expert opinion to estimate the time to intervention. For the Staffordshire model, expert opinion is also used to estimate the survival rates. For the London model, expert opinion is also used to estimate the target times. Thus there must still be uncertainty around the results of both studies as they are not based on hard evidence.

Both research teams recommend bypass if the specialist hospital is ≤20 minutes from the injury scene. The Staffordshire model estimated substantial survival gains from bypass even if the specialist hospital is much further away (53 minutes). There are no obvious contradictions between the two models but the authors of the London report have been more cautious in recommending bypass over longer distances.

Table 11.15: Stevenson's Transport model - results

Criteria for transporting patients directly to Neurosciences Hospital	Percentage of patients bypassing DGH	Survival gain vs 1) (Neurosciences Hospital far)	Survival gain vs 1) (Neurosciences Hospitla near)
1) None	0%	0.00%	0.00%
2) HI AIS>2	100%	3.40%	4.50%
3) HI AIS>3	78%	3.50%	4.60%
4) HI AIS=5	44%	3.40%	4.30%
5) Non-HI AIS<4	89%	3.30%	4.00%
6) Non-HI AIS<5	95%	3.40%	4.50%
7) Isolated head injury	75%	2.80%	3.60%
8) Intubated pre-hospital	20%	1.70%	1.90%
9): 7) *and* 8)	5%	1.30%	1.50%
10) Out of hours	40%	1.50%	2.00%

11.6.4 Cost-effectiveness model – Direct transport

We conducted a cost-effectiveness analysis of transporting patients with serious head injury directly from the injury scene to a specialist neurosciences hospital (NSH). This was compared to initially transporting such patients to the nearest emergency department and then later transferring them to the NSH after stabilising the patient.

The following general principles were adhered to:

- The GDG was consulted during the construction and interpretation of the models.
- The sources of data are published studies and expert opinion.
- Model assumptions were reported fully and transparently.
- The results were subject to sensitivity analysis and limitations were discussed.
- We followed the methods of the NICE reference case. Therefore costs were calculated from a health services perspective. Health gain was measured in terms of quality-adjusted life-years (QALYs) gained.

11.6.4.1 General method

The model is represented by a decision tree (Fig.2): once the ambulance crews arrive at the accident scene, the patient can be transported either to the nearest District General Hospital (DGH) or to a Neurosciences Hospital (NSH). Severe head injury patients initially admitted to the DGH will be subsequently referred to the NSH. Patients that survive will require rehabilitation and frequently some kind of long term care. The number of survivors is different in the different strategies.

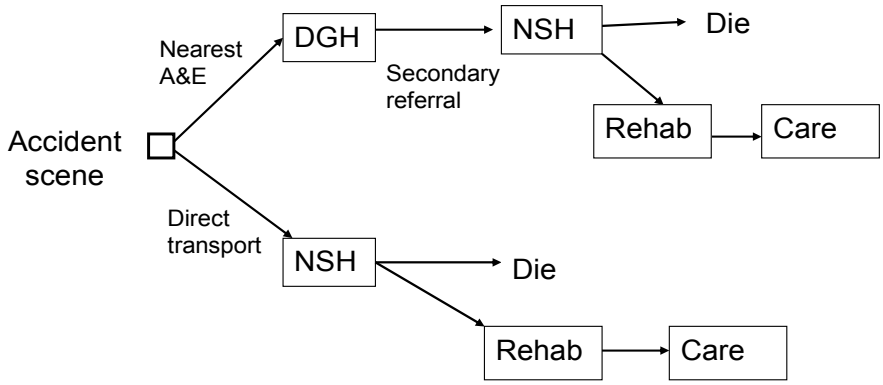
To assess the cost-effectiveness of direct transport we need to assess not just changes to ambulance and emergency department costs associated with each strategy but also any changes in rehabilitation and long term care costs arising from the different strategies. These have to be balanced against the health gain.

We could not find evidence of effectiveness that perfectly suits this question. We therefore constructed two similar models based on different empirical studies:

Model A: We based this model on the only study in the clinical literature review that reported both mortality and health status (Glasgow Outcome Scale, GOS) in head injury patients– Poon et al 1991[135]. 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[68] (see 11.6.3). Model B does not take into account health gain for patients who survive under both strategies but have an improved health status with the direct transport strategy.

Fig.2: Transport model decision tree



Each model has advantages and limitations (Table 11.16).

Table 11.16: Summary of the models

	Description	Advantages	Limitations
Model A	Mortality & GOS: Cohort study - NSH direct vs NSH secondary referral (Poon1991).	Both mortality and health state outcomes considered. Data coming from the same study.	Poon data seems overly optimistic and did not control for case-mix.
Model B	Mortality: Simulation study – NSH direct vs DGH (Stevenson 2001) GOS: retrospective cohort study (Patel 2002).	More conservative and hopefully less biased than Poon data.	Outcomes include only mortality, not differences in health status.

For each strategy in both models, the expected healthcare costs and the expected QALYs were calculated by estimating the costs and QALYs for each GOS state and then multiplying them by the proportion of patients that would be in that state as determined by the strategy taken. Health state defined by the GOS state was assumed to be fixed over the lifetime.

The base case models assume that only patients with serious head injury would be transported. A concern is the ability of ambulance crews to determine the severity of the head injury at the scene. There might be a risk of overestimating the number of severely injured patients and therefore of sending too many patients to the NSH, which would mean that cost-effectiveness is reduced and would be risky for patients with multiple trauma. For this purpose, we conducted a sensitivity analysis on the number of false positives (patients erroneously deemed having a serious head injury) that would be transported to the specialist centre without requiring neurosurgical care.

11.6.4.2 Methods: Effectiveness

In Model A, the mortality rate together with the outcomes were derived from a study by Poon at al [135] 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 11.17). The mortality and the outcomes were assessed six months after the injury.

Table 11.17: GOS score and death rate after neurosurgical care in a NSH (Model A)

GOS	% DGH then NSH patients 6 months after injury Poon 1991	% NSH patients 6 months after injury Poon 1991
Good Recovery	49%	86%
Moderate Disability/Severe Disability	27%	10%
Death	24%	4%

The survival gain in Model B was derived from the results of a simulation model by Stevenson et al[68], where the target patient population were adults with a serious head injury (AIS of 3 or more) – see 11.6.3.

The model evaluated 10 different strategies of transporting patients directly to the NSH, which selected patients by different criteria (relating to level of AIS score, presence of multiple injuries, possibility of pre-hospital intubation, out of hours). Directly transporting all serious head injury patients to the NSH led to an estimated increase in survival of 4.5% for injury scenes near to the NSH and 3.4% for more distant injury scenes.

Stevenson et al estimated only mortality and not health status. We assumed that health status in the additional survivors would be similar to the general population of patients with serious head

injury treated in a NSH. We used 6-month GOS data from the surviving patients in a UK study, Patel 2002[197] (Table 11.18). 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 11.18: GOS score after neurosurgical care in a NSH (Model B)

GOS	% NSH patients 6 months after injury Patel 2002
Good Recovery	49.6%
Moderate Disability	27.1%
Severe Disability	20.3%
Vegetative State	3.0%

We estimated the health loss associated with false positives. In fact, for these patients the longer the journey from the accident scene to the hospital, the higher is the risk of death from hypotension. In the case of a distant NSH (53 minutes, as reported in Stevenson's model), the mortality increases by 0.05%, while it increases by 0.03% if the NSH is near (20 minutes). These figures derived from the calculation of the probability of death based on clinical estimates (see 11.6.4.7).

11.6.4.3 Methods: Estimating QALYs

For each health state we estimated QALYs (Quality-Adjusted Life Years) by multiplying the discounted life expectancy by the utility score associated with each state. The expected QALYs for each strategy are then estimated by summing up the QALYs for each state weighted by the proportion of patients in that state.

In order to calculate the QALYs we combined data on life expectancy with data on quality of life.

Life expectancy

The life expectancy of patients in a vegetative state (VS) was assumed to be 10 years [198],[199]. 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 [200], to the general population of England and Wales, using the Life Tables. According to Shavelle, the SMR decreases during the first 4 years post-injury but remains constant afterwards. In Shavelle 2001 the SMR was distinguished according to three levels of ambulation: a) none, b) some, c) stairs, which we matched approximately to the levels of disability of the GOS (a=SD, b=MD and c=GR).

Life expectancy was discounted at a rate of 3.5% per year, as required by NICE.

For our base case analysis we estimated life expectancy for men aged 40 (the average age of a patient in the Stevenson study). For our sensitivity analysis, we also calculated life-years for patients aged 20 and 60.

Quality of life

The utility scores in Table 11.19 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 [201]. The other utility scores were taken from a decision analysis, Aoki 1998 [202]. The mean utilities for each GOS score were elicited from a sample of 140 subjects with a clinical background using the standard-gamble method. The GOS states in this study were expressed as the degree of disability due to brain damage caused by subarachnoid haemorrhage.

The Poon et al study (Model A) did not distinguish between patients that were severely disabled (SD) and those that were moderately disabled (MD). For these patients we used the simple average of the two SMRs and the simple average of the two utilities.

Another study was found, Tsauo 1999[203], which reported the utility scores associated with each GOS score obtained from health professionals in the UK using the standard gamble method. We did not use this study in our base case model for the following reasons:

- scores were presented for a number of time points and there seemed to be inconsistency between the estimates

- the figures were skewed towards high values (i.e. the utility associated with a moderate disability was higher than the average EQ5D utility score for the general population in the UK[201])

- the value for the vegetative state was missing

- the number of the health professionals interviewed for the elicitation of the utility scores was not reported.

Therefore, we used this study only for the purpose of sensitivity analysis.

Table 11.19: Health Utilities by Glasgow Outcome Scale (GOS) state

GOS	Utility score (base case analysis)	Source	Utility score (sensitivity analysis) Tsauo 1999
Model A			
Good Recovery	0.83	,Kind 1998 (UK general population)	0.931
Moderate Disability/Severe Disability	0.45	Aoki 1998 (mean of two states)	0.788
Death	0		0
Model B			
Good Recovery	0.83	Kind 1998 (average utility in the UK)	0.931
Moderate Disability	0.63	Aoki 1998	0.908
Severe Disability	0.26	Aoki 1998	0.668
Vegetative State	0.08	Aoki 1998	0.08
Death	0		0

In the sensitivity analysis on the assessment at the scene, we assumed that the false positives, if they survive the longer transport, would have had the same expected QALYs as the good recovery (GR) patient.

Calculating QALYs gained

For Model A, the QALYs gained are calculated as follows:
QALYs gained= Q_1-Q_0
Q_i = (P^i_{GR} x LE_{GR} x U_{GR}) + (P^i_D x LE_D x U_D)
where
Q_i =the expected QALYs per patient (i=1: with bypass, i=0: without bypass)
P^i_{GR}, P^i_D, = proportion of patients in each of the GOS states at 6 months by strategy (where D is both mild disability and severe disability combined).
LE_{GR}, LE_D, = the discounted life expectancy of patients by GOS states at 6 months
U_{GR}, U_D, = the utility score for each GOS state.

For Model B, the QALYs gained are calculated as follows:
QALYs gained=Q_i-Q_0= ES_i x ((P_{GR} x LE_{GR} x U_{GR}) + (P_{MD} x LE_{MD} x U_{MD}) + (P_{SD} x LE_{SD} x U_{SD}) + (P_{VS} x LE_{vs} x U_{vs}))
where
Q_i =the expected QALYs per patient associated with bypass strategy i,
Q_0 = the expected QALYs per patient associated with no bypass,
ES_i = extra survivors=the proportion of patients surviving under strategy i that would not have survived under the no bypass strategy
P_{GR}, P_{MD}, P_{SD}, P_{VS}, = the proportion of extra survivors in each of the GOS states at 6 months
LE_{GR}, LE_{MD}, LE_{SD}, LE_{VS}, = the discounted life expectancy of patients by GOS states at 6 months
U_{GR}, U_{MD}, U_{SD}, U_{VS}, = the utility score for each GOS state.

11.6.4.4 Methods: Ambulance and emergency department costs

Emergency department costs in our models are the staff costs associated with secondary referral. While the cost of the primary transport to the DGH or to the NSH is similar, an inter-hospital transfer would be more costly than transport from the injury scene because it requires additional staff and tasks. In fact, an anaesthetist and a nurse would always accompany a patient who required urgent transfer, which constitutes 90% of the transfers for head injury. The GDG experts estimated the total cost of the transfer as equal to three-hour time of a nurse and an anaesthetist, given the time necessary to activate a secondary transfer team at the DGH, the time spent in stabilising the patient, and the actual transfer time. Moreover, on arrival at the NSH the patient would need other treatment for complications due to the transfer. With the average cost of a nurse at £19 per hour, and the cost of an anaesthetist (specialist registrar) of £34 per hour [204]; the total cost per patient transferred was estimated to be £159.

The cost of patient management at the Emergency Department in the two hospitals was not expected to be different, according to the GDG experts' estimates, since the staff grades would not be different.

All the cost figures are expressed in 2006 Pound Sterling. Costs related to previous years were inflated using the Hospital and Community Health Services Prices Index [204].

We have not calculated transportation and emergency department costs in much detail but would argue that this is not a major flaw since these costs are

small compared with the additional rehabilitation and care costs incurred by survivors.

We calculated the increased transport cost associated with false positives, as they will be transported to a more distant hospital. The cost was obtained from the unit cost of an ambulance per minute, £6.50 [204], multiplied by the distance of the accident scene to the hospital, which was 20 minutes (near) or 53 minutes (far) in the simulation study[68].

11.6.4.5 Methods: Rehabilitation and care costs

We derived the cost of rehabilitation from two UK studies: one, Wood 1999[147], applicable to the severely disable patients and the other one, Nyein 1999[205], applicable to the moderately disabled patients (Table 11.20). The length of rehabilitation for the severely disabled group was 14 months, while it was 75 days for the moderately disabled group. We assumed patients who had a good recovery to undergo the same intensity of rehabilitation as the moderately disabled group, given the fact that the good outcome was assessed six months post-injury. Patients in a vegetative state were assumed not to receive any specific rehabilitative therapy. If any rehabilitation service was provided to them, its cost was assumed to be incorporated in to the cost of long term care.

The same two UK studies were used to calculate the annual care costs (Tab.11.20); 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 11.20: Cost of rehabilitation and long term care

	total cost of rehabilitation	annual care costs
GR	19,575	0
MD	19,575	7,472
SD	108,874	45,450
VS	0	45,450

Thus the model takes into account the increased costs of rehabilitation and care due to people surviving under direct transport, who would not survive under the current system. It could be that costs of neurosurgery and intensive care are also increased if patients are now making it to the NSH who would have died in transit. Since we do not have data on the timing of deaths, we have not included such costs in the base case. However, for a sensitivity analysis we added on the cost of 3 days of level 3 neurosurgical intensive care for each additional survivor. The costs of care in an ICU were calculated from the NHS Reference Costs 2005-2006[177] at £1,338 per day.

Calculating incremental cost

For Model A the incremental cost is calculated as follows:
Incremental cost = $Cost_{NSU}$ - $Cost_{DGH}$
$Cost_{NSU}$ = (P^{NSU}_{GR} x (RH_{GR} + LE_{GR} x ACC_{GR}))
+ (P^{NSU}_{D} x (RH_{D} + LE_{D} x ACC_{D}))
$Cost_{DGH}$ = (P^{DGH}_{GR} x (RH_{GR} + (LE_{GR} x ACC_{GR})))
+(P^{DGH}_{D} x (RH_{D} + (LE_{D} x ACC_{D})))
+ TC
where
$Cost_{NSU}$ = the expected cost per patient associated with direct transport to the NSU
$Cost_{DGH}$ = the expected cost per patient associated with a secondary referral to the NSU from a DGH
P^{NSU}_{GR}, P^{NSU}_{D} = the proportion of survivors in good recovery or mild/severe disability at 6 months with direct transport to the NSU
P^{DGH}_{GR}, P^{DGH}_{D} = the proportion of survivors in good recovery or mild/severe disability at 6 months with a secondary referral
RH_{GR}, RH_{D} = the cost of rehabilitation by GOS state at 6 months (where D is both mild disability and severe disability combined)
LE_{GR}, LE_{D} = the discounted life expectancy of patients by GOS state at 6 months
ACC_{GR}, ACC_{D} = annual care cost by GOS state at 6 months
TC = cost of transport in secondary referral

For Model B the incremental cost is calculated as follows:
Incremental cost = $Cost_{i}$ - $Cost_{0}$
= ES_i x ((P_{GR} x (RH_{GR} + (LE_{GR} x ACC_{GR})))
+ (P_{MD} x (RH_{MD} + (LE_{MD} x ACC_{MD})))
+(P_{SD} x (RH_{SD} + (LE_{SD} x ACC_{SD}))) + (P_{VS} x (RH_{VS} + (LE_{VS} x ACC_{VS}))))
– (TC x P_{DT})
where
$Cost_i$ = the expected cost per patient associated with bypass strategy i
$Cost_0$ = the expected cost per patient associated with secondary referral
ES_i = the proportion of patients surviving under strategy i that would not have survived under the no bypass strategy
P_{GR}, P_{MD}, P_{SD}, P_{VS}, = the proportion of extra survivors in each of the GOS states at 6 months
RH_{GD}, RH_{MD}, RH_{SD}, RH_{VS} = the cost of rehabilitation by GOS states at 6 months
LE_{GR}, LE_{MD}, LE_{SD}, LE_{VS}, = the discounted life expectancy of patients by GOS states at 6 months
ACC_{GR}, ACC_{MD}, ACC_{SD}, ACC_{VS} = annual care cost by GOS states at 6 months
TC = cost of transport in secondary referral
P_{DT} = proportion of patients directly transported to the NSU

11.6.4.6 Probabilistic sensitivity analysis

A probabilistic sensitivity analysis was performed to assess the robustness of the model results to plausible variations in the model parameters.
This analysis was applied exclusively to the strategy of transporting all patients to the NSU (strategy 2) compared no bypass in the conservative model B.

Probability distributions were assigned to each model parameter, where there was some measure of parameter variability (11.21). We then re-estimated the main results 5000 times,

each time each of the model parameters were set simultaneously selecting from the respective parameter distribution at random.

Table 11.21: Parameters used in the probabilistic sensitivity analysis

Description of variable	Mean value	Probability distribution	Parameters	Source
Percentage of patients with good recovery at 6months	49.6%	Dirichlet		Patel 2002
Percentage of patients with mild disability at 6 months	27.1%	Dirichlet	44, 24, 18,3 where each parameter refers to the number of people in each category	Patel 2002
Percentage of patients with severe disability at 6 months	20.3%	Dirichlet		Patel 2002
Percentage of patients in a vegetative state at 6 months	3.0%	Dirichlet		Patel 2002
SMR up to 4 years post-injury (GR)	1.5	Lognormal	SE = 0.402	Shavelle 2001
SMR up to 4 years post-injury (MD)	4.5	Lognormal	SE= 0.254	Shavelle 2001
SMR up to 4 years post-injury (SD)	16.4	Lognormal	SE= 0.249	Shavelle 2001
SMR up to 4 years post-injury (VS)	16.4	Lognormal	SE= 0.249	Shavelle 2001
SMR after 4 years (GR)	1.3	Lognormal	SE= 0.245	Shavelle 2001
SMR after 4 years (MD)	2.4	Lognormal	SE= 0.178	Shavelle 2001
SMR after 4 years (SD)	6.4	Lognormal	SE= 0.168	Shavelle 2001
SMR after 4 years (VS)	6.4	Lognormal	SE= 0.168	Shavelle 2001
Utility value of GR	0.83	none		Aoki1999
Utility value of MD	0.63	Gamma of 1-U	SE= 0.27, α= 1.878 , β=0.197	Aoki1999
Utility value of SD	0.26	Gamma of 1-U	SE= 0.25, α= 8.762, β= 0.084	Aoki1999
Utility value of VS	0.08	Gamma of 1-U	SE= 0.16, α= 33.063, β= 0.028	Aoki1999

Cost of rehabilitation (GR)	19,575	Gamma	SE= 7986, α= 6.01, β= 3258	Nyein 1999
Cost of rehabilitation (MD)	19,575	Gamma	SE= 7986, α= 6.01, β= 3258	Nyein 2000
Cost of rehabilitation (SD)	108,874	none		Wood 1999
Cost of rehabilitation (VS)	0	none		
Annual care costs (GR)	-	none		
Annual care costs (MD)	7,472	Gamma	SE= 12347, α= 0.37, β= 20402	Nyein 1999
Annual care costs (SD)	45,450	none		Wood 1999
Annual care costs (VS)	45,450	none		Wood 1999
Survival gain (all patients taken to the NSU if within 20minutes)	4.50%	Gamma	SE= 0.32%, α= 198, β= 0.0002	Stevenson's model

11.6.4.7 Results of the cost-effectiveness analysis

According to Model A there are large QALY gains and large cost savings associated with direct transport to the NSH – direct transport is dominant (Table 11.22). With Model B – the conservative model - the QALYs gained are smaller and costs are not decreased overall (Table 11.23 and Table 11.24). 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 11.22, Table 11.23 and Table 11.24). In the tables we report the results for the groups of patients of 20 and 60 of age as well. In these cases, direct transport was the dominant strategy in Model A and the incremental cost-effectiveness ratio was still below the threshold of £ 20,000 per QALY in Model B.

After running the Model B 5,000 times, the probability that directly transporting all the patients to the NSU is cost-effective (i.e. probability that the cost-effectiveness ratio is below £20,000 per QALY gained) is 73% when the NSU near the incident scene (within 20 minutes). In the cases of a patient aged 20 or 60, the probability falls to 66%.

For Model B, we performed a sensitivity analysis on the length of stay in the ICU: assuming that the most costly level 3 of care applies to all the outcome grades, the analysis shows that the direct transport would still be cost-effective as long as the increased length of stay does not exceed 3 days per additional survivor. Furthermore, even if the LOS were longer than this, these costs could be counteracted by additional complications in those patients who are secondarily transported to the NSH and had delayed surgery.

Table 11.22: Results - Model A.

	Mean cost	QALYs	Incremental cost per QALY gained vs 1)
Base case – Age 40			
1) First to DGH	225,109	9.99	-
2) Direct to NSH	93,422	14.99	NSH dominates DGH
Age 20			
1) First to DGH	297,236	13.06	-
2) Direct to NSH	120,136	18.35	NSH dominates DGH
Age 60			
1) First to DGH	76,069	3.02	-
2) Direct to NSH	38,222	4.76	NSH dominates DGH

Table 11.23: Results - Model B – Far from NSU

	Incremental cost	QALYs gained	Incremental cost per QALY gained
Direct to NSH vs First to DGH (base case age 40)	7,058	0.41	17,228
Direct to NSH vs First to DGH (age 20)	9,382	0.51	18,343
Direct to NSH vs First to DGH (age 60)	2,259	0.12	18,367

Table 11.24: Results - Model B - Near NSU

	Incremental cost	QALYs gained	Incremental cost per QALY gained
Direct to NSH vs First to DGH (base case age 40)	9,393	0.54	17,323
Direct to NSH vs First to DGH (age 20)	12,469	0.68	18,419

Direct to NSH vs First to DGH (age 60)	3,041	0.16	18,683

Using model B, we conducted a threshold sensitivity analysis to take into account the negative effects of overestimating the number of patients to be taken to the NSH. We define the positive predictive value as the proportion of patients transported directly to the NSH who are correctly diagnosed with a severe head injury. It is the number of true positives divided by the sum of both the true positives and false positives. In the case that the NSH is far from the accident scene (53 minutes), the strategy of taking all the patients directly to the NSH is cost-effective as long as the positive predictive value is more than 28%. If the NSH is near the accident scene (20 minutes), the direct transport to the NSH is marginally cost-effective strategy even if the positive predictive value is as low as 10%.

Using model B we performed a sensitivity analysis by using an alternative set of utility scores. The result was that direct transport strategy proved to be even more cost-effective than in the original model (Table 11.25).

Table 11.25: Results of the sensitivity analysis on the utility – Model B

	Incremental cost	**QALYs gained**	**Incremental cost per QALY gained**
Far NSU – Direct to NSH vs First to DGH (base case age 40)	7,058	0.53	13,369
Near NSU – Direct to NSH vs First to DGH (base case age 40)	9,393	0.70	13,442

11.6.4.8 Discussion

We found that direct transport is potentially cost saving if the health status of patients are substantially improved as was indicated by the Poon study. Even in our conservative model we find that direct transport is cost-effective. But our analysis is limited for a number of reasons.

First, some of our assumptions regarding cost and survival were based on proxies or were extrapolated in to the long term.

Our conservative model, Model B, was based on the mortality results of a previous simulation model. Some of the parameters in the simulation model were based on expert judgement (those listed in Table 11.26). The main clinical outcomes from which the probability of death derives were estimated by experts. In particular, experts were asked to estimate the number of patients that would have survived assuming they received the appropriate care (critical intervention or neurosurgery) at time zero. The actual time elapsed since the accident and its related probability

of death was taken from the database. Having these two points on the probability of death graph, a straight line was drawn. The authors found that the results were not sensitive to the slope of the line. However, the curve representing the real relationship between time to intervention and probability of death could have a different shape.

Table 11.26: Parameters for which the value was estimated by clinicians.

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

For simplicity, neither model considers the change in health status during the patient's lifetime - they assume that the GOS score (assessed six months after the head injury) remains constant. If instead patients continue to improve after 6 months then our conservative model is underestimating the health gain and cost-effectiveness associated with direct transport. Likewise, our assumption that mortality is increased compared with the general population for survivors over their entire lifetime is a conservative one.

We have probably underestimated the cost savings attributable to direct transport because we included only hospital personnel (one anaesthetist and a nurse), omitting for the costs of drugs, equipment and ambulance. However, we have also omitted additional acute costs associated with direct transport in the treatment of complications such as hypoxia and hypotension, which are less likely if the patient has been stabilised earlier. This would require additional treatments such as volume replacement, blood transfusion, and in some extreme cases they would require surgery or ventilatory support for weeks.

A strategy of direct transport from the injury scene to an NSH will inevitably mean that the unit sees more patients than previously, even though many patients currently being taken to the nearest emergency department are subsequently transferred to the NSH. From the viewpoint of the NSH there will be a substantial cost impact in particular in terms of ITU beds.

In the long-term, this should not represent an increase in cost to the NHS since patients and their treatment costs are merely being shifted from one hospital to another. Furthermore we have no reason to believe that ITU costs are higher at the NSH; indeed according to the 2006 Reference Costs[177], the cost of a bed in a neurosurgical ITU is lower than the cost of a bed in a general ITU. Hence we did not include ITU costs in our base case analysis.

In the short-term, the resource impact is less clear and will depend on local circumstances. A DGH might not achieve the full cost savings from seeing fewer patients as typically it would be losing only ¼ of an ITU bed. However, staff costs and consumables would be re-deployed almost immediately. The bed could also be re-deployed if there is currently under-capacity. If so more patients would be treated in ITU as a result of the increased capacity at DGHs but this would not necessarily produce a reduction in costs to the Trust. However, this increase in ITU capacity could lead to cost savings from reduced transfers.

To implement a direct transport strategy, NSH units will need to invest in extra ITU beds. This will be offset by cost savings at DGHs. However the cost savings will not necessarily offset the cost fully in the short-term. The implementation costs associated with shifting patients will have to be taken in to account in any cost impact analysis conducted for the purposes of implementation.

A US study[206] reports a successful rate of GCS assessment (410/412 patients)

by ambulance crews at the incident site, after an 8-hour training course. Hence, training for ambulance staff in the assessment of head injury patients would be necessary to safeguard the effectiveness and cost-effectiveness of the direct transport strategy.

Since we do not have survival outcomes for the other simulation model based in London (see 11.6.2) we could not use it to estimate cost-effectiveness. However, there is no reason to believe that it would effect our conclusions for near hospitals: if the specialist hospital is ≤20 minutes from the injury scene then direct transport is likely to be cost-effective. For distances greater than 20 minutes, the authors of the London model have erred on the side of caution by not recommending bypass. It seems logical that the further away is the specialist hospital the more risky is direct transport. Given the uncertainty of the evidence in this area, if we are to recommend direct transport at all then it probably is better to use some kind of cut-off but it is unclear how the authors of the London model made this decision since analyses based on transport times longer than 20 minutes are not present in the report.

The London model assumed that not just neurosciences but also other specialist services were available at the specialist centres. If specialist centres contain the whole range of services then the issue of whether ambulance crews can diagnose isolated head injury becomes less of an issue (this problem had been raised by several stakeholders), as long as specialist hospitals have adequate provision of beds, etc. Perhaps we should be recommending that bypass strategies are developed at a regional level to take into account local service configurations.

11.6.4.9 Direct transport model: Conclusions

- A simulation model and some empirical studies have shown reduced mortality associated with directly transporting patients with serious head injury to an NSH.

- If ambulance crews can assess patients accurately then a policy of direct transport to an NSH is likely to produce a net cost saving to emergency department services (because of the resources involved with stabilising and transferring patients).

- Long term care costs might increase or decrease depending on the extent that health status (quality of life) is improved by direct transport.

- We found that even with conservative estimates about long term care costs, direct transport is likely to be cost-effective in spite of the very high costs of caring for patients with severe disability.

- If ambulance crews (unintentionally) overestimate the number of patients to be treated in the Neurosciences Centre, some patients will experience journeys that are longer than necessary and may incur complications– in which case health gain might be decreased and costs increased for these patients.

Nevertheless, a sensitivity analysis showed that the number of overestimated patients would have to be quite high for the direct transport strategy to be no longer cost-effective.

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