WORK IN PROGRESS: PLEASE DO NOT QUOTE

WHAT IS THE BEST IMAGING STRATEGY FOR STROKE? THE CHALLENGE OF MODELLING THE COST-EFFECTIVENESS OF CT SCANNING STROKE PATIENTS

Janelle Seymour and John Cairns

Health Economics Research Unit (HERU), University of Aberdeen, Scotland

Paper presented to the Health Economists' Study Group Conference, Oxford 2001

Abstract

Computerised axial tomography (CT) often provides important information for the diagnosis and subsequent management of acute stroke patients. Specifically, distinguishing patients who have suffered a primary intracerebral haemorrhage (PICH) from patients who have had a cerebral infarction is important as primary treatment and secondary prevention for each type of stroke are markedly different and administering inappropriate treatment can potentially cause serious harm. While there is general agreement concerning the importance of CT scanning in the diagnosis of stroke, there is some uncertainty as to the role it should play in the routine investigation of stroke patients.

The NHS HTA programme has funded a research project to identify the best imaging strategy for stroke in the UK. The project considers under what circumstances is routine imaging, using CT scanning, cost effective in the management of stroke. This paper describes the decision model developed to examine the effect of CT scanning of stroke patients incorporating costs and patient outcomes. Challenges such as identifying imaging strategies, constructing decision trees, identifying current resource use data, modelling survival and incorporating utility weights will also be discussed.

Acknowledgements

This study is funded by the NHS HTA Programme. The Health Economics Research Unit (HERU) is funded by the Chief Scientist Office of the Scottish Executive Health Department. The views expressed in this paper are those of the authors and not the funders. The assistance of Dr Joanna Wardlaw, Dr Sarah Keir, Dr Peter Sandercock, Stephanie Lewis and Dr Paul Dorman in developing the model and obtaining data are gratefully acknowledged.

Introduction

Imaging techniques such as computerised axial tomography (CT) can provide important information for the diagnosis and subsequent treatment of acute stroke patients. While there is general agreement concerning the importance of CT scanning in the diagnosis of stroke, there is some uncertainty as to the role it should play in the routine investigation of stroke patients (Wolfe et al, 1996).

The NHS HTA programme has funded a research project to identify the best imaging strategy for stroke patients in the United Kingdom (UK). One of the main objectives of the study is to assess the cost effectiveness of routine CT imaging of acute stroke patients using decision analysis. The purpose of this paper is, firstly to describe the model currently being developed to examine the effect of CT scanning of stroke patients in terms of costs and patient outcomes. Secondly, to outline a number of challenges we face in developing the model, some of which we have been able to address and others we have yet to overcome.

Background

Stroke is a major cause of morbidity and mortality in the UK. The incidence of first stroke is reported to be 2 per 1,000 population and the overall incidence of stroke is 2.4 per 1,000 population (Bamford et al, 1988; Wade, 1994). Stroke is currently the second most common cause of death in the UK (OHE, 2000). Approximately 30% of patients who suffer a stroke, die within the first three weeks, and those who survive have an increased risk of recurrence of 7% and a 10% per annum risk of myocardial infarction (Wade, 1994).

Stroke can be separated into two main pathological sub-types, cerebral infarction (also referred to as ischaemic stroke) and primary intracerebral haemorrhage (PICH) (Wade, 1994). A cerebral infarction is caused by either clotting (thrombosis) or a detached clot in an artery (an embolisim). Haemorrhages (also referred to as 'bleeds'), are completely different in nature, as they occur as a result of a rupture of an artery wall. Data from stroke registers in the UK indicated that the majority of first strokes are cerebral infarctions. The Oxford Community Stroke Project reported that over 80% of first strokes are infarcts, where as haemorrhages account for approximately 10% (Sandercock et al, 1989).

Stroke treatments are aimed at preventing complications, reversing the effects of acute stroke and preventing recurrent stroke (Alberts, 1999). It is important to be able to distinguish between patients who have suffered a PICH and patients who have had a cerebral infarction, as primary treatment and secondary prevention for the two types of strokes are markedly different. Long term antiplatelet therapy (chiefly given as aspirin) is generally started a few weeks after a cerebral infarction in order to reduce the risk of serious vascular events (Antiplatelet Trialist' Collaboration, 1994). Evidence suggests that there is also an additional benefit of administering aspirin as primary treatment for cerebral infarction (IST, 1997; CAST, 1997). Cerebral infarction can also be treated with anticoagulation therapies and research is ongoing to determine whether patients treated within three hours of the onset of stroke symptoms benefit from new hyperacute therapies such as thrombolysis (Wade, 1994). In contrast, patients who have had a haemorrhage may suffer serious harm if administered these therapies, therefore highlighting the importance of making an accurate diagnosis.

CT brain scans can provide information to assist in the diagnosis of stroke patients. Importantly, CT scans can be used to distinguish patients who have suffered a PICH from a cerebral infarction. There are, however, two factors which can influence the accuracy of CT scans in the diagnosis of stroke. Firstly, the accuracy of the CT scan decreases over time as the hyperdensity associated with PICH deteriorates, making it difficult to distinguish the lesion from a cerebral infarction or normal brain density. CT scanning can only reliably exclude PICH if performed within 7 to 14 days after the onset of stroke symptoms (Dennis et al, 1987). In addition, the accuracy of CT scans may also be affected by the level of clinical skill of the person interpreting the scan (Norris and Hachinski, 1982).

Estimating the cost effectiveness of CT scanning stroke patients

One method of assessing the effectiveness or cost effectiveness of an intervention is to conduct randomised controlled trial (RCT). In this study, there were two main reasons why this was not feasible. Firstly, it was estimated that in order to conduct an RCT with sufficient power to detect a difference in death or recurrent stroke, the study would require a sample of more than 40,000 patients. Secondly, given current knowledge regarding treatments for stroke, the randomisation of patients to CT prior to the commencement of antiplatelet therapy was considered unethical if PICH had not been reliably excluded prior to treatment.

In circumstances such as these, it is considered appropriate to use a modelling approach to estimate the expected costs and outcomes associated with routine CT scanning stroke patients. This approach involves developing a decision tree, incorporating key decisions and uncertain events which occur over time. The model is then analysed using decision analysis to enable the impact of different CT scanning strategies on treatment decisions and their effect on costs and health outcomes to be assessed. This will enable the relative cost effectiveness of each of the scanning strategies to be assessed and the strategies to be ranked in order to identify what is the best imaging strategy for stroke.

Type of model

The cost effectiveness of a range of routine CT imaging strategies is examined using a deterministic model and conventional approach to decision analysis. Given the limitations in the availability of the data and the complex nature of the scenario faced by patients suspected of having suffered a stroke which had to be modelled, it was considered appropriate to use a simple model rather than a Markov model.

Imaging strategies

A series of meetings were held with clinicians (including a neuroradiologist, stroke physician and neurologist) to identify routine imaging strategies for CT scanning patients admitted to hospital suspected of suffering a stroke. The clinicians identified 19 CT scanning strategies to be evaluated in the study (see Table 1).

There were four main types of CT scanning strategies. The first strategy (S1) is a broad policy requiring all patients admitted to hospital suspected of having suffered a stroke to be scanned immediately. Strategies S2 to S9 involve prioritising scanning in terms of a number of criteria within a specified time period. The criteria include, severity of the stroke, 'high risk' patients (for example patients on anticoagulation therapies at the time of the stroke, which are potentially harmful if the patient has suffered a haemorrhage) or candidates for hyperacute therapies. Scanning strategies S10 to S17 involve scanning select groups of patients within 7 days of admission to hospital. In the final strategy (S18), patients suspected of having suffered a stroke are not scanned at all.

Both the Scottish Intercollegiate Guidelines Network (SIGN) and the Royal College of Physicians (RCP) have developed a set of guidelines for the assessment, investigation, immediate management and secondary prevention of stroke patients (SIGN, 1997; RCP, 2000). Both sets of guidelines recommend that patients admitted to hospital with suspected stroke be given a CT scan within 48 hours of admission. In this study these guidelines are assumed to represent 'current practice' and are therefore identified as the main comparator in the model.

There were a number of difficulties associated with identifying the list of potential CT scanning strategies. Firstly, the clinicians in the project team found it difficult to reach an agreement identifying the list of scanning strategies. After a series of meetings however, they settled on the scanning strategies listed above. It was difficult to convey to the clinicians that while it is important to identify a comprehensive list of strategies, they will only be able to be included in the model if the data is available for each individual strategy. It is thought that a number of scanning strategies will be omitted from the final analysis due to insufficient data.

It is also acknowledged that there are a number of scanning strategies which will not be relevant for a number of hospitals in the UK. For example, strategies which require patients to be scanned either immediately or within a very short period of time, assume that radiological departments have the resources to undertake emergency or 'out of hours' CT scanning. While this may be feasible for radiological departments in large teaching hospitals, smaller hospitals may often not have the resources to offer these types of strategies, while other hospitals will not have CT scanning facilities on site. In order to explore this issue further, a survey is currently being conducted to assess access to imaging facilities for patients suspected of having suffered a stroke in Scotland. One of the aims of the survey is to use the results to classify hospital in terms of access to CT scanning facilities. The different strategies will then be reviewed in the light of this classification.

Table 1: CT scanning strategies

Strategies	Imaging strategies
Comparator	Scan all within 48 hours of admission to hospital.
S 1	Scan all immediately
S 2	Scan patients on anticoagulants or in life a threatening condition immediately and scan all of the remaining patients within 24 hours of admission to hospital.
S 3	Scan patients on anticoagulants or in life a threatening condition immediately and scan all of the remaining patients within 48 hours of admis sion to hospital.
S 4	Scan patients on anticoagulants or in life a threatening condition immediately and scan all of the remaining patients within 7 days of admission to hospital.
S 5	Scan patients on anticoagulants or in life a threatening condition immediately and scan all of the remaining patients within 14 days of admission to hospital.
S 6	Scan patients on anticoagulants, in life a threatening condition or are candidates for hyperacute treatment immediately and scan all of the remaining patients within 24 hours.
S 7	Scan patients on anticoagulants, in life a threatening condition or are candidates for hyperacute treatment immediately and scan all of the remaining patients within 48 hours.
S 8	Scan patients on anticoagulants, in life a threatening condition or are candidates for hyperacute treatment immediately and scan all of the remaining patients within 7 days.
S 9	Scan patients on anticoagulants, in life a threatening condition or are candidates for hyperacute treatment immediately and scan all of the remaining patients within 14 days.
S 10	Scan only patients with atrial fibrillation within 7 days of admission to hospital.
S 11	Scan only patients on anticoagulation within 7 days of admission to hospital.
S 12	Scan only patients on antiplatelet drugs within 7 days of admission to hospital.
S 13	Scan only patients in atrial fibrillation, on anticoagulants or antiplatelet drugs within 7 days of admission to hospital.
S 14	Scan only patients with life threatening stroke within 7 days of admission to hospital.
S 15	Scan only patients without a life-threatening stroke within 7 days of admission to hospital.
S 16	Scan only patients with a life-threatening stroke on anticoagulants within 7 days of admission to hospital.
S 17	Scan only patients with a non-life threatening stroke and anticoagulants within 7 days of admission to hospital.
S18	Do not scan anyone.

Note: A life threatening stroke is defined in terms of the severity of the stroke (TACs) with an impaired level of consciousness.

Model structure

A decision tree was constructed to model the expected costs and outcomes associated with the strategy to CT scan all patients suspected of having suffered a stroke within 48 hours. This tree will then be modified to assess each of scanning strategies listed in Table 1. Given that some CT scanning strategies are similar in nature, a detailed tree was required to ensure that even small differences in the costs and outcomes could be potentially identified in the decision analysis. The tree incorporates key decisions and events such as CT scanning, the sensitivity and specificity of scans, diagnosis, treatment options and the effect on costs and patient outcomes.

The decision tree was constructed in accordance with a number of conventions used in decision analysis (Weinstein and Fineberg, 1980). The tree depicts patients admitted to hospital with first ever stroke. The main tree is displayed in figure 1 and the treatment and outcome sub-trees in figures 2 and 3. A brief description of the tree is given below.

In figure 1, chance nodes 1 and 2 represent the patient's true clinical status. Of the patients admitted to hospital suspected of having suffered a first stroke, a proportion of them would have actually had a stroke and a proportion would have not had a stroke (chance node 1). At chance node 2, of the patients who actually had a stroke, a proportion would have had a PICH and a proportion would have suffered a cerebral infarction.

Stroke severity is incorporated in the model by categorising patients in terms of clinically identifiable sub-types at chance nodes 3 and 4. The Bamford classification system (Bamford et al, 1991) consists of four clinical sub-types and are classified as, partial anterior circulation syndrome (PACs), lacunar syndrome (LACs), total anterior circulation syndrome (TACs) and posterior intracerebral haemorrhage (POCs). In terms of severity, TACs are considered to be the most severe and these patients have the highest mortality rate (Bamford et al, 1991). Given the small percentage of haemorrhages, patients were categorised into two groups, TACs and non-TACs.

All patients in the model are given a CT scan within 48 hours of admission to hospital. A diagnosis is then made on the basis of information provided by the scan and a clinical examination. The sensitivity and specificity of the CT scans is incorporated at nodes 5-11. For example, at node 5 patients who actually suffered a haemorrhage could be given one of three possible diagnoses. Firstly, a proportion of patients will be correctly diagnosed as having suffered a haemorrhage. There will also be a proportion of patients who will be incorrectly diagnosed as either an infarct or non-stroke. Similarly, patients are diagnosed on the basis of the information provided by the CT at nodes 6 – 11.

A sub-tree was constructed to incorporate decisions regarding primary treatment (see figure 2). At node 12, patients diagnosed as having suffered a haemorrhage, will either be taken off anticoagulation or aspirin or receive no active treatment. Patients diagnosed as having had an infarct (node 13) will either be administered aspirin, anticoagulation, thrombolysis or receive no active treatment.

At node 14 patients diagnosed as non-stroke are categorised into three main groups, tumours (primary or secondary), infections such as meningitis, encephalitis or abscesses and 'other', which includes 'funny turns', epilepsy and seizures. Treatment decisions for these patients are incorporated at nodes 15, 16 and 17. Patients with a tumour may have surgery, radiotherapy, steroids or no active treatment. Those suffering from infections will be treated with antibiotics or no active treatment. Finally, patients who are in the 'other' group are likely to receive further investigations to identify the cause of the event and the appropriate treatment to be administered. Possible treatments include stopping or starting drugs, mechanical measures to improve blood pressure or procedures such as inserting a pacemaker.

Figure 1

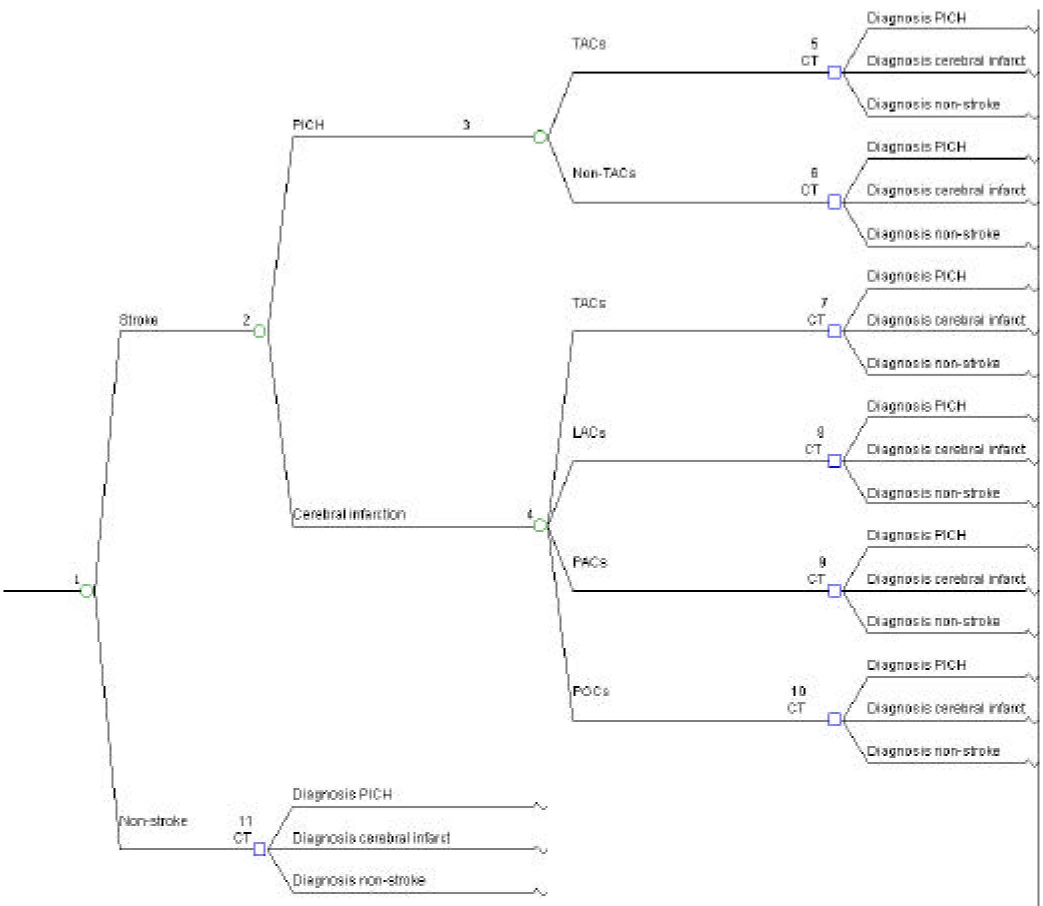
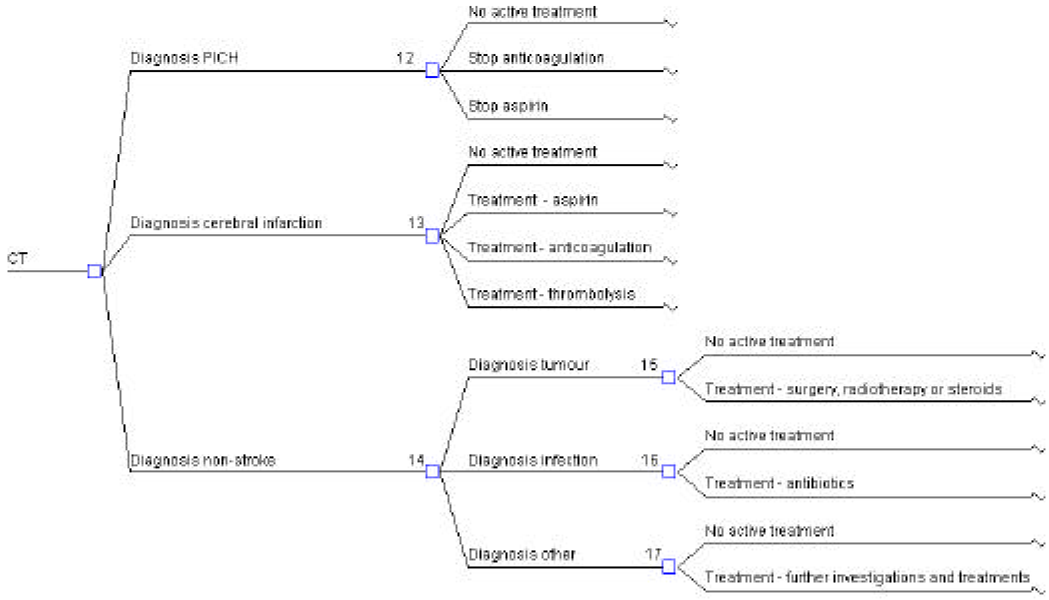


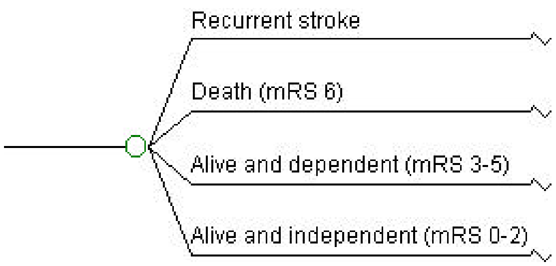
Figure 2



The main tree and the treatment subtree was developed primarily on the basis of expert clinical opinion. A key challenge involved persuading the clinicians that it was necessary to incorporate varying degrees of sensitivity and specificity of CT scans in the tree.

Clinical outcomes are incorporated into the model in figure 3. The main clinical outcomes are measured using the modified Rankin Scale (mRS) (Bamford et al, 1989). The mRS is an instrument used to measure functional ability of stroke patients on a scale from 0 to 6. The scores of the mRS are collapsed to give three main outcomes, alive and independent (mRS 0-2), alive and dependent (mRS 3-5) and dead (mRS 6). Recurrent stroke is included as a fourth outcome. Clinical outcomes are assessed at 6 months, 12 months and 24 months, post stroke.

Figure 3



The mRS has been used in a number of studies to assess stroke outcomes (Hallan et al, 1999; Counsell et al, 1995; Dorman et al, 2000; Dennis, Wellwood, Warlow, 1997). One concern with using this instrument is whether it will be sufficiently sensitive to detect changes in outcomes in this analysis.

Data

The parameter estimates for the main tree were obtained from a number of sources. These included a series of systematic reviews of CT scanning and the treatment for stroke (undertaken as part of the HTA project). This was supplemented with additional information from secondary data sources, in particular the Lothian Stroke Register (LSR, 2000). Tables 2 and 3 list the base values for each of the parameters in the model.

One of the main challenges which lie ahead with this study is to consider how to adjust the probabilities for different imaging strategies. It is envisaged that this process will rely heavily on expert clinical opinion.

Tables 2: Data - Main decision tree

Variable	Baseline	Source
Stroke		
Proportion of actual stroke	0.81	Libman, 1995
Proportion of actual PICH	0.163	Systematic review
Proportion of actual cerebral infarctions	0.837	Systematic review
Non-stroke		
Proportion of primary brain tumours	0.029	Libman, 1995
Proportion post-seizures	0.032	Libman, 1995
Proportion of systemic infections	0.032	Libman, 1995
Proportion of other diagnoses	0.097	Libman, 1995
Severity		
PICH		
- TACs	0.29	LSR, 2000
- Non TACs	0.71	LSR, 2000
Cerebral infarctions		
- TACs	0.13	LSR, 2000
- LACs	0.28	LSR, 2000
- PACs	0.42	LSR, 2000
- POCs	0.17	LSR, 2000
CT scan		
Sensitivity		
a) Stroke vs non-stroke	0.90	Sotaniemi, 1990;
b) PICH vs cerebral infarction		Ebrahim, 1999[a];
Expert	1.0	Clinical consensus
Non-expert	0.77	
Specificity		
a) Stroke vs non-stroke	0.98	Sotaniemi, 1990;
b) PICH vs cerebral infarction		Ebrahim, 1999[a];
Expert	1.0	Clinical consensus
Non-expert	0.77	

Tables 3: Data - treatment

Variable	Baseline	Source
Treatment		
PICH		
- No change of antihaemostatic treatment	0.661	LSR, 2000
- Stop anticoagulation	0.074	LSR, 2000
- Stop aspirin	0.265	LSR, 2000
Cerebral infarction		
- No change of antihaemostatic treatment	0	
- Commence aspirin	0.91	Ebrahim, 1999[b]
- Continue aspirin		
- Commence anticoagulation	0.35	Ebrahim, 1999[b]
- Thrombolysis	0	
Non-stroke		
Tumour		
- Surgery, radiotherapy, steroids	1	Clinical consensus
- No active treatment	0	
Infections		
- Antibiotics	1	Clinical consensus
- No active treatment	0	
Other diagnoses		
- Further investigations and treatment	1	Clinical consensus
- No active treatment	0	

Methods

Outcomes

The number of life years was estimated by modelling survival using 5-year survival data from the LSR (LSR, 2000). Survival was modelled based on age and severity of the stroke using 6 monthly intervals over a 5-year period for 1854 first ever stroke patients using Cox's proportional hazards regression analysis. The number of years of survival was calculated, taking into consideration the age distribution, for stroke patients aged 45 to 89, in terms of five year age bands and severity (TACs, LACs, PACs and POCs) for a five year period (table 4). Five-year survival was initially calculated on the basis of individual years. However, it was considered to contribute very little additional information and therefore survival was aggregated in terms age bands. The number of life years was also calculated for a cohort of 10,000 stroke patients based on the age distribution of patients in the LSR (table 5).

While modelling 5-year survival based on data from the LSR has the advantage of providing a greater degree of accuracy, there are limitations associated with using this dataset. For example, information regarding treatments administered to stroke patients was not routinely collected in the LSR. Therefore patients in this dataset are likely to have received different treatments, which could not be controlled for in the survival analysis.

Table 4: Five year survival by age and stroke severity (life years)

	Severity			
Age	TACs	PACs	LACs	POCs
45 – 49	3.997	4.613	4.764	4.648
50 – 54	3.704	4.487	4.685	4.533
55 – 59	3.347	4.323	4.581	4.382
60 – 64	2.929	4.114	4.445	4.190
65 – 69	2.457	3.850	4.269	3.944
70 – 74	1.955	3.135	4.045	3.640
75 – 79	1.457	3.135	3.764	3.271
80 – 84	1.003	2.686	3.420	2.841
85 – 89	0.629	2.195	3.013	2.362

Table 5: Five year survival for a cohort of 10,000 by age and stroke severity

	Severity			
Age	TACs	PACs	LACs	POCs
45 – 49	171.5	678.9	496.5	427.5
50 – 54	249.8	852.9	919.2	528.1
55 – 59	184.7	1563.9	1741.2	886.7
60 – 64	466.9	1866.6	1689.7	1001.8
65 – 69	406.8	3115.7	1963.1	1426.8
70 – 74	359.6	2571.3	2033.5	1115.8
75 – 79	294.7	2325.5	1130.7	842.4
80 – 84	215.2	1531.7	712.9	435.5
85 – 89	138.9	538.3	350.9	144.8

Clinical outcomes were assessed at 6 months, 12 months and 24 months using data from the LSR. While the LSR provides data on clinical outcomes at these points in time, there is no information beyond two years post stroke. This model examines the effect of scanning on survival over a five year period and therefore it is assumed that clinical outcomes remain constant from two to five years post stroke.

A set of utility weights were derived to reflect the quality of life associated with each of the three stroke health states using a number of secondary data sources. The utility weights were calculated using data from the International Stroke Trial (Dorman et al, 2000) and the LSR (LSR, 2000) . Patients in the IST were administered the EuroQol questionnaire, EQ5D (EuroQol Group, 1990; EuroQol Group, 1996) to assess quality of life 72 weeks following their stroke. Utility weights were assigned to each of the EuroQol health state profiles using the time trade off (TTO) tariff derived for the UK population. Given that a significant proportion of stroke patients are aged 60 years and over, it was considered appropriate to use the TTO values modified for older people in this study (MVH Group, 1995).

Data on clinical outcomes (mRS) for the same group of patients was available from the LSR at 12 months and 24 months post stroke. The LSR data contained data on the mRS assessed at 12 months and 24 months after stroke (see table 6). In terms of the mRS, 83% of patients remained in the same state, 5.2% of patients improved, 8.6% of patients deteriorated and 3.3% of patients had missing data between 12 months and 24 months post stroke. This enabled the utility weights to be mapped to the mRS health states. The weights are presented in table 7 for all patients and those who remained constant between the two time periods to remove any effect of the differential timing.

This enables the expected number of quality adjusted life years (QALYs) to be calculated by multiplying utility weights which reflect the quality of life associated with each of the stroke health states (alive and independent, alive and dependent and dead) by the number of life years.

One of the key challenges in this evaluation will be determining if, and how, clinical outcomes (mRS health states) and, or survival will alter with the different CT imaging strategies. For example, if patients suspected of having suffered a stroke were not routinely given a CT scan (S18), how will this affect decisions regarding diagnosis and treatment and also will this result in changes in clinical outcomes and, or survival? Given the lack of published information in this area, it is expected that many of the decisions concerning modifying these parameters will be based largely on expert clinical opinion.

Table 6: Modified Rankin Scale (mRS) health states for IST patients at 12 months and 24 months post stroke

Modified Rankin Scale	12 months	24 months
N	149	145
Independent (mRS 0– 2)	98 (65.8%)	92 (63.4%)
Dependent (mRS 3 – 5)	51 (33.3%)	49 (33.8%)
Dead (mSR 6)	0	4 (2.8%)

Table 7: Modified Rankin Scale health states and TTO weights

	TTO weights	TTO weights - constant mRS at 12 months and 24 months
Modified Rankin Scale		
N	146	124
Alive and independent		
N	95	84
Mean	0.76	0.78
95% CI	0.72 – 0.81	0.73 – 0.82
Median	0.80	0.80
Minimum	0.06	0.06
Maximum	1	1
Alive and dependent		
N	51	40
Mean	0.37	0.34
95% CI	0.28 – 0.47	0.23 – 0.45
Median	0.51	0.33
Minimum	-0.57	-0.57
Maximum	1	1

Costs

The costs in this model are estimated from the perspective of the health service. Key areas of resource use include CT scans, primary treatment (which consists of primary intervention and length of stay), additional hospital admissions and GP visits. A number of different sources of data are currently being explored to identify length of stay (LOS) data. At this stage it is hoped that LOS data for the sample of 1854 stroke patients from the LSR will be obtained from Information and Statistics Division (ISD), Scotland. This will enable LOS data to be identified over the five year period, across different hospital settings, taking into account age, sex and severity of the stroke. Information on resource use for primary treatment and GP visits will be obtained from the literature. Once the main set of resources has been identified for the initial scanning strategy, these will be modified for the alternative scanning strategies.

Unit costs will be derived using a combination of both a detailed costing approach and estimates available in the published literature. A detailed costing of CT scans will be conducted to calculate the cost of CT scans across a range of hospitals and during normal operating hours as well as 'out of hours'. The cost of CT scanning will be estimated for each of main types of hospitals identified in the access to imaging facilities survey.

Discussion

This paper describes the model currently being developed to assess the cost effectiveness of routine CT scanning of patients who are suspected of having suffered a stroke. A comprehensive list of CT scanning strategies has been identified. A main decision tree has been developed to model the expected costs and outcomes associated with the base strategy to scan all suspected stroke patients within 48 hours of admission to hospital. It is planned that this model will be adapted to reflect changes in costs and patient outcomes which directly occur as a result of the different screening strategies. It is envisaged that this will enable the CT scanning strategies to be ranked in terms of cost effectiveness.

This paper highlights that the model is the result of a series of compromises. In particular, the model is weak in terms of health outcomes. It is acknowledged that a simple model was used in this study and that patient outcomes may have been able to be incorporated more accurately by using a Markov model. In addition, survival is examined over a five year period rather than over the life of the patient. This assumes that there are no differences in survival between CT scanning strategies after five years. It is necessary to examine this assumption more closely and to review its acceptability. A related issue is that data on clinical outcomes is available from the LSR until 24 months post stroke. Given that patient outcomes are however assessed over a five year period it is necessary to assume that clinical outcomes (and quality of life) remain constant for the final three years in the analysis. The impact of this assumption will be explored further in the sensitivity analysis.

The greatest weakness of the model is with respect to modelling changes in health outcomes given different imaging strategies. This is a challenge which is yet to be faced in the study, however given the lack of data available, this process will rely heavily on expert clinical opinion. Again, it is important that the uncertainty associated with various aspects of the model are thoroughly explored in the sensitivity analysis.

These are not the only issues which remain to be addressed. Data are currently being sought to model length of stay and to estimate the cost of CT scans in a range of settings. An additional issue which needs to be addressed is the identification of longer term resource implications of altering the mix of patients who survive and who are dependent, compared to those who are independent.

The primary challenge faced in this study is to develop a model which is sufficiently complex to investigate the wide range of potential imaging strategies while not making undue demands on the limited available data.

Summary and conclusion

This paper provides an overview of the work currently being undertaken in the HTA project. It describes the main question and the approach we are using to assess the cost effectiveness of a range of CT imaging strategies for stroke. At this point, work in the project has focussed on developing a decision tree to model the effect of CT for stroke in terms of the costs and outcomes. This has presented a number of challenges, some of which have been addressed, while others have yet to be overcome. Particular priorities now include identifying resource use data, undertake costings, modifying the model to reflect the different imaging strategies and undertaking sensitivity analysis.

This analysis will enable the incremental cost effectiveness of each of the CT scanning strategies to be assessed and allowing a ranking of the strategies to be made. Importantly, information from the survey examining access to stroke services will able us to identify an optimal strategy in different clinical settings, taking into account access to imaging facilities.

References

Antiplatelet Trialists' Collaboration: Collaborative overview of randomised trials of antiplatelet treatment. Part 1: Prevention of death, myocardial infarction, and stroke by prolonged antiplatelet therapy in various categories of patients. BMJ 1994;308 :81-106.

EQ5D user guide: A measure of health related quality of life developed by the EuroQol Group. Rotterdam, EuroQol Group, 1996.

OHE Compendium of Health Statistics. London: Office of Health Economics, 2000.

Alberts, MJ. Diagnosis and treatment of ischaemic stroke. American Journal of Medicine 1999;106: 211-221.

Bamford, D, et al. A prospective study of acute cerebrovascular disease in the community: the Oxfordshire Community Stroke Project 1981 - 86. Journal of Neurology, Neurosurgery and Psychiatry 1988;51:1373-1380.

Bamford J, Sandercock P, Warlow C, Slattery J. Interobserver agreement for the assessment of handicap in stroke patients. Stroke 1989;20:828.

Bamford J, Sandercock P, Dennis M, Burn J, Warlow C. Classification and natural history of clinically identifiable subtypes of cerebral infarction. Lancet 1991;337:1521-6.

CAST (Chinese Acute Stroke Trial) Collorative Group. CAST: randomised placebo controlled trial of early aspirin use in 20000 patients with acute ischaemic stroke. The Lancet 1997;347:1641-1649.

Counsell C, Boonyakarnkul S, Dennis M, Sandercock P, Bamford J, Burn JP et al. Primary intracerebral haemorrhage in the Oxfordshire Community Stroke Project. Cerebrovascular Diseases 1995;5:26-34.

Dennis MS, Bamford JM, Molyneux AJ, Warlow CP. Rapid resolution of signs of primary intracerebral haemorrhage in computed tomograms of the brain. BMJ (Clinical Research Ed) 1987;295:379-81.

Dennis M, Wellwood I, Warlow C. Are simple questions a valid measure of outcome after stroke? Cerebrovascular Diseases 1997;7:22-7.34.

Dorman P, Dennis M, Sandercock P, on behalf of the United Kingdom Collaborators in the International Stroke Trial (IST). Are the modified "simple questions" a valid and reliable measure of health related quality of life after stroke? Journal of Neurology, Neurosurgery & Psychiatry 2000;69:487-93.

Ebrahim S, Harwood R. Investigation. Stroke. Epidemiology, evidence and clinical practice. Oxford, Oxford University Press, 1999[a] pp 95-114.

Ebrahim, S. and Redfern, J. Stroke care - A matter of chance. A national survey of stroke services. London, The Stroke Association, 1999[b].

EuroQol Group. EuroQol - a new facility for the measurement of health-related quality of life. Health Policy 1990;16:199-208.

Hallan S, Asberg A, Indredavik B, Wideroe TE. Quality of life after cerebrovascular stroke: a systematic study of patients' preferences for different functional outcomes. Journal of Internal Medicine 1999;246:309-16.

IST (International Stroke Trial) Collaborative Group. The International Stroke Trial (IST): A randomised trial of aspirin, subcutaneous heparin, both, or neither among 19 435 patients with acute ischaemic stroke. Lancet 1997;349;9065:1569.-1581.

Libman RB, Wirkowski E, Alvir J, Rao TH. Conditions that mimic stroke in the emergency department. Implications for acute stroke trials. Archives of Neurology 1995;52:1119-22.

Lothian Stroke Register. 2000.

MVH Group. The measurement and valuation of health. Final report on the modelling of valuation tariffs. Centre for Health Economics, University of York, 1995.

Norris JW,Hachinski VC. Misdiagnosis of stroke. Lancet 1982;1:328-31.

Royal College of Physicians (RCP). National Clinical Guidelines for Stroke. http://www.rcplondon.ac.uk/pubs/ceeu_stroke_contents.htm 2000.

Sandercock PAG, Warlow CP, Jones LN, Starkey IR. Predisposing factors for cerebral infarction: The Oxfordshire community stroke project. BMJ 1989 298;6666:75.-80.

Scottish Intercollegiate Guidelines Network (SIGN). Management of patients with stroke: A national clinical guideline recommended for use in Scotland. (24) Edinburgh, SIGN Publications, 1997.

Sotaniemi KA, Phytinen J, Myllyla VV. Correlation of clinical and computed tomographic findings in stroke patients. Stroke 1990;21:1562-6.

Wade DT. Stroke (acute cerebrovascular disease). In Stevens A, Raftery J, eds. Health care needs assessment. The epidemiologically based needs assessment reviews. Oxford, Radcliff Medical Press, 1994, 111-255.

Weinstein MC, Fineberg HV. Clinical decision analysis. Philadelphia, W.B Saunders Company, 1980.

Wolfe C, Rudd T, Beech R. Stroke services and research. An overview, with recommendations for future research. London, The Stroke Association, 1996.