Economic burden of stroke in England

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Project Team

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Introduction

1. After coronary heart disease[1], stroke is the second most common cause[i] of death and the leading cause of disability in the UK[2]. Previous estimates suggest that stroke consumes 7.4% of spending on community health care, 5.5% of spending on hospital care[3] and between 4-6% of the total expenditure on the NHS[4]. Studies looking at the economic consequences of stroke are few and somewhat dated. The most up to date analyses of the economic burden of stroke in the United Kingdom estimated an average per patient cost of £15,000 to £30,000 over the first five years after stroke[5] but does not provide the total aggregate cost of stroke in the UK. A second study does calculate the overall cost of stroke care in England to be £2.3 billion in 1995-96 with lifetime per patient costs ranging from £2,000 to £62,000[6] however it fails to present details on the methodology and data sources used. Apart from these studies there is no up to date published material available estimating the current annual cost of stroke in England.

2. It is also important to estimate the effects of different care provision scenarios and their possible impact on stroke mortality, stroke recurrence and therefore costs because the standards of care are changing rapidly in this area. Although there have been various studies which have considered the clinical and cost effectiveness of individual treatment strategies[7], there have been no studies combining a number of essential service provision factors (i.e. more frequent use of stroke unit services, increased use of secondary prevention strategies) to assess their potential impact on the outcome and cost of stroke care.

3. The present study is designed to meet the need for up to date information on the burden of stroke in England and to determine the cost of treating new stroke cases in accordance with certain changes in service provision. Therefore the aims are twofold: (1) to estimate the economic burden of

[i] All cancers together account for a higher figure than coronary heart diseases and stroke in England and Wales in 2002 (26%, 19.3%, 11.1% respectively) (*Office Health Economics: Compendium of Health Statistics* 16th Edition, Peter Yuen).

stroke on the economy in 2003, and (2) to model the provision of care for incident stroke cases and investigate the impact of service improvements on costs, mortality and recurrence.

Cost of Illness (COI) analyses

4. Cost of Illness (COI) analysis is the main method of providing an overall view on the economic impact of a disease[8,9]. Such studies have been used to set priorities for health care policy and describe resource allocations for various diseases.

5. A number of analytical issues have to be considered when designing a COI[10]. Establishing the perspective of the study is an essential component of COI study design. Perspective will determine from whose point of view the analysis is conducted and will determine the types of costs to be included. It is important and preferable to take a societal perspective and include all the costs associated with the disease in question, both direct and indirect. In some cases this might not be necessary if the research is only considering the costs accrued by a specific stakeholder such as the patient or the payer of health care services[8]. In this context direct costs are defined as costs directly related to the provision of healthcare to the patient, such as hospital inpatient stay, outpatient care, secondary prevention and community care. Indirect costs are cost items, which arise as a result of the disease but not directly bourne for example the time off work due to illness, and the time family carers spend looking after the patient. Including both direct and indirect costs will enable a true understanding of the economic consequences of different disease groups.

6. Another aspect of COI studies is the time frame adopted for analysing the costs. The main methodologies used are prevalence based or incidence based analyses. In the prevalence-based approach to the COI analysis, the costs attributable to all individuals with a specific condition are accumulated over a particular year of analysis. In contrast, the incidence

approach focuses on those people with newly diagnosed illness during a specific year and it considers the present value of the expected lifetime costs of illness for those individuals. Consequently the prevalence approach examines the costs of a disease to the society in a given year associated with all those who have a particular disease, whereas the incidence approach considers the lifetime costs of a disease of the new cases.

7. The type of data used is also important in the performance of a COI. Two main methodologies are employed when COI studies are conducted; the “top down” or the “bottom up” approaches. The top down approach uses aggregate data on mortality, morbidity, inpatient, outpatient, long-term resource use and other directly or indirectly disease related items to calculate the economic burden of a disease. In this method data available from national resources are used to generate countrywide estimates of costs for a disease. Bottom up approaches, on the other hand, use information on disease and treatment probabilities from follow-up studies to derive annual incidence estimates and associated costs. The main advantage of the latter approach is that it makes fuller use of the available epidemiological data.

8. This study calculates the cost of stroke using two different methods. Both methods calculate the costs of stroke from a societal perspective including direct health care costs together with informal care costs and productivity losses. The first part of the study is the prevalence based, bottom up analysis, calculating the total annual cost of stroke to the economy for all the members of the society affected with stroke (prevalence). The second part of the study is a predictive one-year model calculating the costs of only the new stroke cases within a year and the effects of certain service changes (eg more frequent utilisation of stroke units for inpatient care and improvements in secondary prevention) on the costs and on the outcomes (mortality and morbidity, as well as recurrent stroke). The results of these two sections of the analysis are not directly comparable, mainly because of the differently defined populations. The

predictive one-year model allows the immediate cost and outcome consequences of some components of service change to be calculated.

9. Transient Ischaemic Attacks (TIAs) were included in the diagnosis, inpatient, outpatient and outpatient drug cost calculations but not in the community care and informal care calculations given the short-term nature of the symptomatology.

Prevalence Based Annual Cost of Stroke for All Stroke Cases

Calculation of the prevalence and incidence of stroke in England

10. Stroke is defined in this study as International Classification for Diseases ICD10 codes I60-66 and Transient Ischaemic Attack (TIA) is defined as ICD10 code G45. The population of England was obtained from the Office for National Statistics (ONS) 2003-2004 and grouped according to age and gender in different age bands[11]. Using this as the base population different sources were used to calculate the annual incidence of stroke in this study [12-14]. These sources all included sub-arachnoid haemorrhage under the umbrella of stroke, but publish different stroke incidence rates because of differences in their study populations. Thus crude stroke incidence per 1000 population in these studies ranged from 1.33 in South London to 1.58 in East Lancashire (1.45 in Oxford). An incidence rate of 1.33 based on the South London Stroke Register was used for the primary calculations in this study[12]. In addition data from these two other studies were used in sensitivity analysis[13-14]. Finally the number of recurrent strokes was estimated to be one third of the incident stroke cases[15] and this was added to the number of stroke incidence cases to estimate the total number of annual incident stroke cases.

11. Published studies on the prevalence of stroke provided a wide range of estimates in the range 1.5% to 2.1% of the total population[16-18]. Estimates from the most up to date study carried out in North Yorkshire calculated stroke prevalence rate to be 1.75%. Estimates from that study are used

for the primary prevalence calculations[16]. However the two previous studies are also used to estimate the effects of different prevalence rates on the annual stroke costs[17,18].

12. Estimates of the annual number of TIAs are taken from MacDonald et al[19].

Costing methodology

13. In a COI study the measurement of the costs of different cost items depends on the perspective taken in the analyses[20]. A societal perspective will allow comparisons to be made between different components of costs and will help detect the transfer of costs between different cost groups[21]. In this analysis a societal perspective is taken and direct healthcare costs as well as community care costs, informal care and indirect care costs are included. Income loss due to mortality and/or morbidity and social benefit payments to stroke patients are accounted for in the indirect cost calculations.

14. In this study, due to the availability of data, the premium costs of services to the purchasers of healthcare is taken as a basis of direct cost measurement and as a proxy for opportunity costs[22].

<u>Direct Care Costs</u>

Diagnostic costs

15. Diagnostic costs, inpatient-stay costs, surgery costs, outpatient visit costs, outpatient drug costs and community care costs were separately calculated to give total direct health care costs.

16. Costs of diagnostic care and inpatient care are calculated by multiplying the incidence of stroke by the related unit costs. The assumption is that incident stroke cases and recurrent strokes seen within the year of the analyses will require hospital care, whereas those who had their stroke in

the previous years would have already received hospital care in the year they had their stroke and do not require further hospital care.

17. The diagnostic costs were calculated in two separate components. The first is the cost of diagnosis at a general practitioner's (GP) practice or at a hospital, and the second is the cost of diagnostic tests. The costs of GP practice and hospital diagnosis were taken from the calculations of Grieve et al[23,24]. The percentage of patients undergoing various diagnostic tests was obtained from the National Sentinel Audit of Stroke, 2004 (NSAS)[25]. The calculation of the other tests includes routine blood tests (haematology and biochemistry) and the assumption that 100% of the patients go through these tests during diagnostic procedures.

Inpatient care costs

18. The cost of the inpatient stay was calculated using the average length of stay for stroke (as reported in the NSAS[25]) and the average length of stay for TIA (obtained from the Hospital Episode Statistics[26]) multiplied by the per diem cost of hospital stay. The per diem cost of hospital stay included cost of hospital bed (including nursing services, overheads etc.), physicians and therapists. The hourly costs of specialists were calculated using the salary schedules of specialists obtained from the accountancy department at Guy's & St. Thomas' Foundation Trust (for stroke unit and general medical ward) as well as the per day cost of hospital stay (including nursing services)[27]. The per diem cost of a hospital bed (£125) is the average cost of an inpatient bed in a stroke unit (£150) and in a general medicine ward (£100). This is because the NSAS estimated that approximately half of hospital stay is in a stroke unit and the other half in a general ward[25]. The amount of time spent by physicians, physiotherapists, occupational therapists and speech and language therapists per patient per diem is taken from De Wit et al[28].

19. Utilisation of carotid endarterectomy in the UK is around 5/100,000[29], accordingly we calculated the percentage of stroke and TIA patients undergoing carotid endarterectomy in England (2% of all stroke and TIA

cases). Unit costs of surgery are taken from Grieve et al's previous calculations[23,24]. It is also assumed that only stroke patients would undergo other neurosurgical procedures. It is assumed that 2% of the stroke patients undergo carotid endarterectomy and 2% of the patients undergo other surgical procedures.

20. The cost of thrombolysis was calculated separately. Unit cost of rt-PA was taken from Sandercock et al[30]. The rate of thrombolysis in the UK was taken from the National Audit Office estimations (1%).

Outpatient costs

21. The percentage of patients being seen by different specialists (GPs, geriatrics, rehabilitation specialists, neurologists) was obtained from the SLSR data from the outpatient visits within the first year after stroke. Unit costs of seeing different specialists were taken from the Personal Social Services Research Unit (PSSRU) Unit Costs of Health and Social Care 2004[31].

22. An assumption was made that the specialists saw the patients only once in a year. This might lead to an under estimation of costs, which is likely to be offset by the fact that patients do not see specialists as frequently after the first year of stroke. By using the prevalence figures, it is assumed that the patients who visit a specialist, regardless of the time of their stroke, were seeing the specialist once within the first year and also once in each of the following years of therapy.

Outpatient drug costs

23. Unit costs of drugs were obtained from the British National Formulary 2004 to calculate the outpatient drug costs (BNF)[32]. Since different hypertension drugs clusters (Beta Blockers, ACE inhibitors etc.) include various drugs (generics and brands) with different costs, SLSR data were used to identify the most commonly used drug in each drug cluster (eg Ramipril for ACE inhibitors). The same methodology is employed to obtain a unit cost for cholesterol lowering drugs (eg Simvastatin).

Dosages of drugs used were obtained from the SLSR as well as the number of times they were used in a day. The SLSR includes data on patients using and not using specific drugs. It is assumed all TIA cases are treated in this manner. Data from the SLSR were used to calculate the rate of different drugs used by patients.

24. The SLSR collects drug use cross-sectional data at four different time points; at discharge, 3, 6 and 12 months after stroke. It was assumed that the third month follow up data can be applied to the second and third months after having stroke (or the first and second month after being discharged), sixth month follow up data to the fourth, fifth and sixth months after having stroke and 1 year follow up data to the rest of the year.

25. Calculations of the annual outpatient drug costs were based on eleven months of drug use, not twelve, for the incident strokes and recurrent strokes, which occur in the year of the analyses. That is because the average length of hospital stay is approximately a month (28 days according to the NSAS[25]) and the inpatient drug costs were already included in the inpatient costs calculations. Outpatient drug costs were calculated to be 12 months for the rest of the prevalent cases.

Community care costs

26. Only the stroke patients were included in the community care service costs calculations based on an assumption that TIA patients will not need community care services (that is unless they have a stroke after having a TIA, in which case they will be included as stroke patients in the prevalence of stroke estimates).

27. The community care costs were calculated first by using the unit cost and service use data gathered by Grieve et al, using an average length of stay in a residential home, sheltered home or a nursing home. Secondly, SLSR data is used to identify the number of patients residing in different locations post discharge from the hospital and the total cost of community

care is calculated based on that. SLSR collects place of residence data cross-sectionally at three different time points; immediately after the patient is discharged, followed by six month and 1 year follow-ups. It was assumed that initial data can be applied to the second and third months after having stroke (or the first and second month after being discharged), sixth month follow up data to the 4th 5th and 6th months after having stroke and 1 year follow up data to the rest of the year.

Informal Care Costs

28. Time spent by the carers of disabled stroke patients who have to stay at home was calculated. Carer costs were defined for two groups: patients who are attended by family members/friends and patients attended by professional carers (home help). The average hourly wage was used to cost home help[33]. Unit cost for the care provided by family members was obtained from Liu et. al[34] as the hourly wage for over 65 years of age, unemployed or economically inactive carers. These unit costs were multiplied by the service use data from SLSR. SLSR collects cross-sectional data on the assistance needs of patients use data at two different time points: 3 and 12 months. If patients answered yes to the question “Did you need assistance in the past 2 weeks?” then they were assumed to be in need of assistance for daily activities for the whole period. Thus it was assumed that 3 month follow up data can be applied to the second and third months after having stroke (or the first and second month after being discharged), and 1 year follow up data to the rest of the year.

Indirect Costs

Social benefit payments

29. Data on the Payments for Disability Living Allowance, Attendance Allowance and Incapacity Benefit payments made to sufferers of stroke were received from the Department of Work and Pensions.

Income lost

30. Income lost due to the mortality and morbidity related to stroke and TIA are calculated separately. The productivity loss from mortality attributable to stroke was estimated by using the following:
    - median and mean total earned income split down by gender and age 2002-03[35]
    - average economic activity and unemployment rate in 2003[36]
    - number of remaining working years until the age of 65
    - number of stroke related deaths[36].

31. For mortality calculations the data obtained from the Office for National Statistics on mortality as a result of stroke in England in different age bands were used. That was multiplied by the mean earnings of UK workers in different age bands for 2003[35]. For both the mortality and morbidity calculations stroke population up to the age 65 is included and it is assumed that the above 65-age group is retired. Rate of economic productivity and the current unemployment figures as published in the Annual Abstract of Statistics were also factored in[37]. The income loss of stroke related morbidity was then estimated by multiplying the number of certified days off work from stroke and TIA[38] with the income per day[36].

Sensitivity analysis

32. Due to the wide range of sources and assumptions used in the present study, there is room for uncertainty in the estimated costs of stroke. Sensitivity analysis was conducted to examine the robustness of the total cost estimates. First different incidence and prevalence rates, as defined above, were used and the changes in total annual costs were observed. In addition to this the effects of a 10-20% increase or decrease in the baseline resource quantities and unit costs were investigated. The sensitivity analysis was undertaken simultaneously on all the unit cost items, separately for the resource use items.

Results

33. The calculations undertaken on this basis suggest that stroke results in total costs of £7 billion a year. Total annual direct care accounts for approximately 40% of this total; informal care for 35%; and the indirect costs for approximately 25%. The figure for total annual direct care costs, £2.8 billion, is about 25% higher than the previously published figure of £2.3 billion[6] which is approximately accounted for by inflation over the period1995-1996 and 2003-2004 figures (table 1).

Table 1. Total cost of stroke in England

Cost items	Cost
Diagnostic costs	9,600,000
Inpatient care costs	530,000,000
Outpatient care costs	46,200,000
Outpatient drug costs	507,200,000
Community care costs	1,741,100,000
Total annual direct care cost	**2,834,100,000**
Informal care costs	**2,406,400,000**
Income Lost due to mortality	483,700,000
Income lost due to morbidity	604,100,000
Benefit payments	686,600,000
Total annual indirect costs	**1,774,400,000**
Total	**7,014,900,000**

34. Using the alternative incidence estimates from the Oxford[13] or East Lancashire[14] studies did not have a significant impact on the inpatient care costs (table 2).

Table 2. Costs when different incidence rates were used

Cost items	SLSR[12]	OXVASK[13]	East Lancashire[14]
Diagnosis costs	59,600,000	60,200,000	61,800,000
Inpatient care costs	530,000.000	534,600,000	549,900,000

35. On the other hand changing the prevalence estimates did have a significant impact on the total costs. Total annual direct care costs ranged between £2.5 billion to £3.3 billion and informal care costs ranged

between £1.9 billion to 2.8 billion when different prevalence figures are used (table 3).

Table 3. Costs when different prevalence rates were used

Cost items	Newcastle	North Yorkshire	Health Survey From England 1998
Total annual direct care cost	2,452,800,000	2,834,100,000	3,269,600,000
Informal care costs	1,933,000,000	2,406,400,000	2,831,600,000

36. In addition a sensitivity analysis was conducted of increasing and decreasing unit costs of health care (eg hospital stay, therapists cost, physicians cost, cost of stay in a nursing home etc) by 10% from their current value. This resulted in the same relative effect, causing an oscillation in the total costs of the order of magnitude of £0.5 billion (table 4).

Table 4. Sensitivity analyses: unit costs

Cost items	10% decrease in unit costs	no change	10% increase in unit costs
Total Annual Direct Care Costs	2,615,500,000	2,883,100,000	3,148,800,000

37. A sensitivity analysis was also carried out separately for individual resource use items (eg therapist time per patient, physicians time per patient etc.) Its effect was similar to that found through increasing/decreasing unit costs. Total annual direct care costs were between £2.5 and £3.3 billion when the resource use items were allowed to increase and decrease by 20% (table 5a).

Table 5a. Sensitivity analyses: resource use

cost items	20% decrease in resource use	10% decrease in resource use	no change	10% increase in resource use	20% increase in resource use
Total annual direct care costs	2,481,100,000	2,681,600,000	2,883,100,000	3,082,600,000	3,283,000,000

38. Most of this change was due to the change in the cost of community care. Inpatient and outpatient care were not unduly affected by the 20% sensitivity analyses (table 5b).

Table 5b. Sensitivity analyses: resource use

Cost items	20% decrease in resource use	no change	20% increase in resource use
Inpatient	492,000,000	528,000,000	564,000,000
Outpatient	555,400,000	565,200,000	575,000,000
Community care costs	1,392,900,000	1,741,100,000	2,089,300,000

39. However, the increase in the use of nursing homes, which is a component of community care services, would lead to a decrease in home care needs, causing a relatively large decrease in informal care costs (table 5b and 5c). When the indirect relationship between community care costs and informal care costs were observed it was seen that they almost offset one another.

Table 5c. Sensitivity analyses: resource use

	10% decrease in resource use	no change	10% increase in resource use
Informal Care Costs	1,922,204,000	2,373,100,000	3,095,400,000

Predictive one year model of annual cost of stroke for new stroke cases

40. A second model estimates the immediate (first year costs following stroke) cost and outcome consequences of increased use of treatment guidelines. Stroke incidence is calculated as outlined above except that number of recurrent cases was not added into the model because the model generated the number of strokes.

41. This predictive one-year model has three sections. Firstly it considers the effect of inpatient care on mortality after the initial stroke attack. A second section models stroke recurrence based on the impact of secondary prevention on the risk of having a recurrent stroke and the final section looks at the outcome of hospital care as a result of this recurrence. The model integrates the combined effect of the following factors during acute care and in secondary prevention (Figure 1).

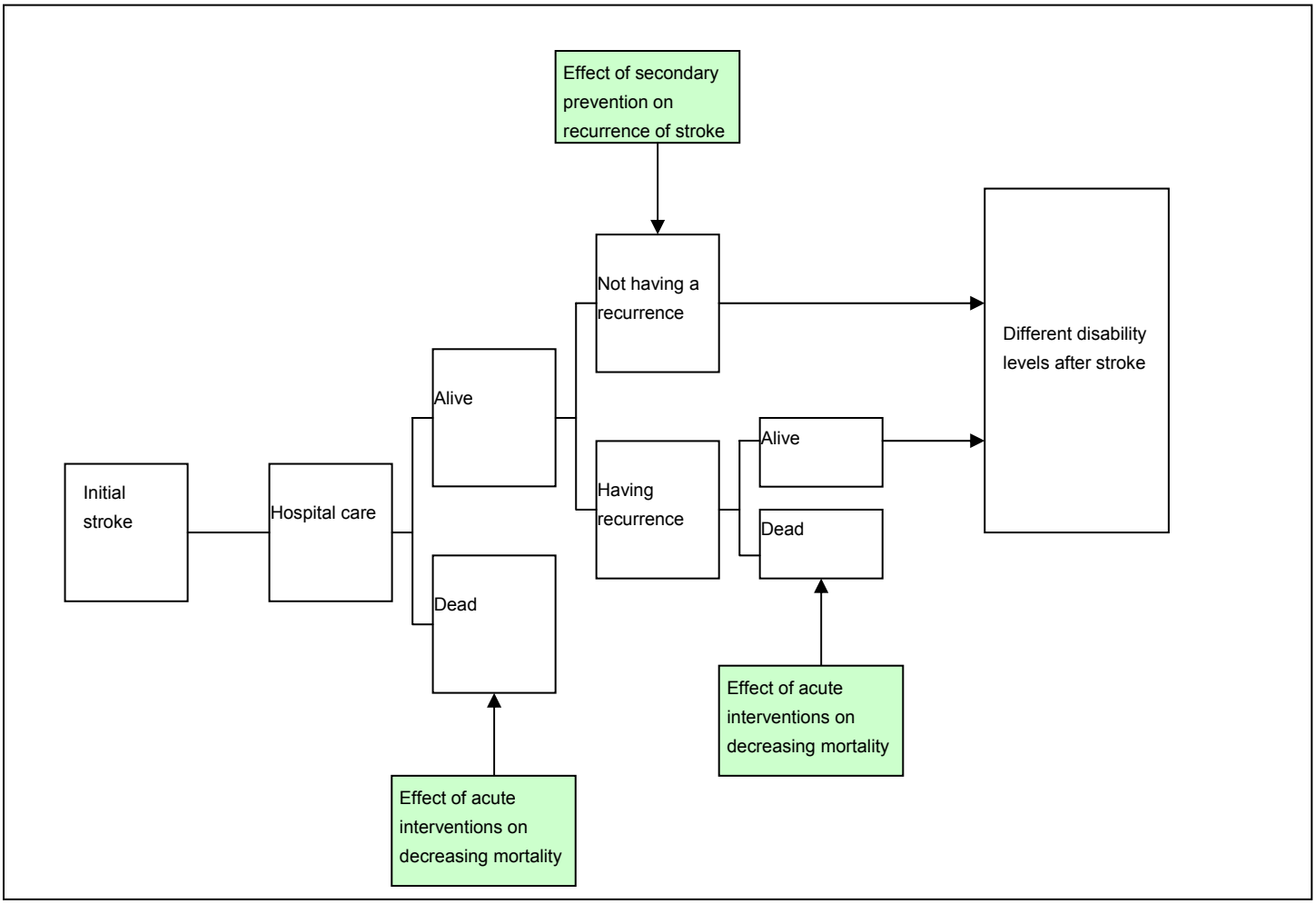
    Acute stroke care

    a. utilising stroke units for
    b. thrombolising eligible patients
    c. using antiplatelets

    Secondary prevention

    d. using antiplatelets
    e. using blood pressure reducing drugs
    f. using cholesterol reducing drugs
    g. carotid endarterectomy for symptomatic carotid stenosis

Figure 1. Predictive one-year model



42. Data on Relative Risk Reductions (RRR) as a result of those interventions was obtained from Hankey and Warlow[15]. The mortality rates after initial stroke and the recurrent stroke were taken from a number of resources[39,40]. Different disability levels of stroke after the first year were taken from the NSAS[25].

43. A societal perspective was adapted for costing the incidence of stroke where the health care costs of hospital stay, drugs, outpatient services, surgical procedures, rehabilitation were included as well cost of carers, community care services and income lost as a result of mortality or morbidity. The unit costs used for these items were defined as above in the prevalence-based analyses.

44. A number of assumptions were made to construct the model. The model considers incident stroke treatment for new or recurrent strokes occurring at the beginning of a twelve-month period and models their treatment over this annual period. All the stroke cases have the same average risk of recurrent stroke or mortality within one-year after the first or recurrent stroke regardless of age, or the severity of stroke. Mortality risk in the first 30 days after the first stroke was 29%[40] and mortality risk after a recurrent stroke was 41%[39]. The model is structured to accommodate one recurrence within the timeline of measurement (1 year) assumed to occur at the sixth month.

45. The average length of inpatient hospital stay is 28 days for patients discharged from the hospital alive[25]. This is the average length of stay for both general ward and stroke unit patients. The per diem hospital cost is assumed to be the same for all cases in a stroke unit or a general ward and every case receives an average volume of medical care per day (physician, nurse and therapy time).

46. Disability status of the patients is determined according to the Barthel scores at discharge from hospital as taken from the NSAS[25] (Barthel score 20 independent, 15-19 mild, 10-14 moderate, 5-9 severe, 0-4 very severe). Disability status at discharge is assumed to be the same until the end of the year. Transition between different states of disability within the year is not allowed. It is assumed that every stroke patient visits the outpatient services once. Independent patients are assumed not to need further rehabilitation following their discharge from hospital. They are assumed not to have additional living costs due to stroke.

47. Mild stroke cases are assumed to require some care at home for daily activities but no rehabilitation. Moderate stroke cases are assumed to require rehabilitation. Rehabilitation costs are based on the PSSRU Unit Costs of Health and Social Care 2004[31]. They are also assumed to require some care at home for daily activities, which is calculated as informal care costs. Severe stroke cases are assumed to stay in a

residential home for disabled people and very severe cases are assumed to stay in a high dependency care home for disabled people and their costs are based on PSSRU Unit Costs of Social Care 2004[31]. Moderate, severe and very severe stroke cases are assumed not to be able to go back to work after stroke. Productivity losses due to mortality and morbidity are calculated for the year of stroke alone and not extended to include the following years.

48. Calculation of hospital costs is based on the assumption that the per diem cost per patient is the same regardless of the age of the patient or the different level of care needs. For that purpose an average per diem cost in an in-patient unit in addition to the cost of a health care specialist's time is used. Costs of interventions were only attached to specific cases going through those interventions. Average length of stay in hospital during acute care is taken from the NSAS (28 days)[25].

49. Recurrent stroke cases might have stayed in a stroke unit for their initial strokes but on a general ward for their recurrent stroke or vice versa. The cost and outcomes of such cases were calculated separately. The percentage of cases eligible to go through specific interventions were again taken from Hankey and Warlow[Error! Bookmark not defined.]. The model allows the proportion of those eligible cases that actually receive specific acute and secondary prevention interventions to be changed. For the base case scenario, the proportion of eligible patients,
    a. receiving care in a stroke unit
    b. undergoing thrombolysis
    c. using antiplatelets
    d. using blood pressure reducing drugs
    e. using cholesterol reducing drugs
    f. undergoing carotid endarterectomy for symptomatic carotid stenosis

were taken from the NSA[25]. The model also allows testing for possible changes in the unit costs of interventions in order to assess the sensitivity of results to different unit costs.

50. The predictive model analyses the changes in costs in two ways. First the effect of changes in every service item in acute care and in secondary prevention were analysed separately. This was followed by changing the items all together from the base case scenario to the best-case scenario.

Table 6. Different rates of service use in different case scenarios

		Base Case	Better Case	Best Case
acute care	percentage of eligible patients taking aspirin	0.68	0.75	0.95
	percentage of eligible patients going to stroke unit	0.5	0.75	0.95
	percentage of eligible patients being thrombolised	0.01	0.2	0.5
secondary prevention	percentage of eligible patients taking antiplatelets	0.85	0.9	0.95
	percentage of eligible patients taking antihypertensive drugs	0.85	0.9	0.95
	cholesterol lowering drugs	0.64	0.75	0.95
	carotid endarterectomy	0.2	0.75	0.95

51. The better and best-case scenarios were taken as a rule of thumb. Since there will always be cases that will not receive the optimum level of care the best-case scenario is set at 95% of utilisation for all the service items.

Results

52. The total cost estimate in the base case scenario is £1.2 billion per year including informal care costs and income lost. Health care costs make up over 75% of the total costs (£965 million).

Table 7. Results from the predictive one year model under the base case scenario

TOTAL	
Total cost	1,202,100,000
Health care costs including informal care	965,800,000
Stroke incidence	82,138
Total number of deaths	23,922
Total number of recurrent stroke	4,018.67

53. Increasing the utilisation of all the service items leads to a decrease in number of deaths and recurrences and to an increase in the number of independent cases. However the number of very severe cases also increased as a result of decreases in mortality.

54. Increased utilisation of stroke units for the care of stroke patients leads to better service outcomes. When the use of stroke units was increased to 75%, 550 deaths and 35 recurrences were prevented. This increased the total cost by £32 million. When utilisation of stroke units was further increased to 95% then 441 more deaths and 29 recurrences were prevented at an additional cost of £25 million. However if the average length of stay was 3 days shorter in the stroke units than in the general wards than there would not be an increase in costs with the same number of deaths prevented and the same number of increase in the independent cases.

55. Increasing the use of acute aspirin to 75% prevented 40 deaths and 10 recurrences, also leading to an increase of 15 independent cases at the

end of the first year. The additional annual cost of this is calculated to be £330,000. If the acute use of aspirin was further increased to 95 % then 114 more deaths were prevented and 42 more cases are independent at the end of the first year at an additional cost of £900,000.

56. If the use of thrombolysis on eligible cases was increased from the base case (1%) to 20% then 44 deaths were prevented. This would also lead to an increase of 16 independent cases at the end of the first year at an additional cost of £3.7 million. If the use of thrombolysis was further increased to 50% then 70 more deaths were prevented and 26 more cases are independent at the end of the first year at an additional cost of £2.5 million.

Changes to service provision in secondary prevention

57. The use of antiplatelets (aspirin) when increased to 95% prevented 17 deaths and 45 recurrent strokes in addition to saving £136,000. Similarly increased use of blood pressure lowering drugs (95%) and cholesterol lowering drugs (95%) prevented, respectively, 25 and 49 deaths, 64 and 124 recurrences, but leads to an increase in costs (£450,000 and £1,365,000 respectively). However the results were sensitive to the costs of blood pressure lowering drugs. When the monthly cost of blood pressure drugs were halved, then increasing their use prevented the same number of deaths and recurrent strokes, and did not lead to an increase in costs.

58. More frequent use of carotid endarterectomy on the eligible cases improved mortality and morbidity figures. If the ratio of the eligible cases undergoing carotid endarterectomy was increased from the 25% to 50% then 14 deaths and 36 recurrent strokes were prevented. This would also lead to an increase of 5 independent cases at the end of the first year at an additional cost of £800,000. If this ratio is further increased to 95% then 24 more deaths, 74 more recurrent strokes were prevented and 11 more cases were independent at the end of the first year at an additional cost of £1.4 million.

Base case to best case

59. When the percentage of the use of all service items were increased simultaneously (use of stroke units 75%, acute use of aspirin 75%, patients being thrombolysed 20%, use of antiplatelets (aspirin) for secondary prevention 90%, use of blood pressure lowering drugs 90%, use of cholesterol lowering drugs 75%, eligible patients undergoing carotid endarterectomy 75%) then 683 deaths and 94 recurrent strokes were prevented. This would also lead to an increase of 253 independent cases at the end of the year for an additional cost of £37 million. If the use of all interventions were further increased (use of stroke units 95%, acute use of aspirin 95%, patients being thrombolysed 50%, use of antiplatelets (aspirin) for secondary prevention 95%, use of blood pressure lowering drugs 95%, use of cholesterol lowering drugs 95%, eligible patients undergoing carotid endarterectomy 95%) 673 more deaths and 123 more recurrent strokes were prevented. These improvements would come at an additional cost of £30 million at the end of the first year.

Table 8. From base case to best case scenario

	Base case	better case	best case
Cost	1,202,100,000	1,238,200,000	1,270,900,000
Total death	23,922	23,239	22,553
Total stroke recurrence	4,019	3,924	3,765
Number of independent cases after stroke	21,540	21,793	22,046
Number of very severe cases after stroke	6,986	7,068	7,150
Change in costs		36,000,100	68,900,000
Change in the number of deaths		-683	-1,369
Change in the number of recurrence		-95	-253
Change in the number of independent cases		253	507
Change in the number of very severe cases		82	164

Discussion

60. The OECD reports that stroke is a significant burden to countries, accounting for 10% of all deaths worldwide in 1999 and amounting to health system costs ranging between 2 and 4% of total health system expenditures, in addition to similarly significant costs building up outside the healthcare system, because of different levels of morbidity associated with stroke[41]. This study analysed the situation in England. Health care expenditure in England amounts to £70 billion (Total NHS expenditure in England in 2004-2005 estimated outrun)[42] of which total annual direct cost of stroke (£2.8 billion) make up 4%. Including the costs of informal care and lost productivity stroke costs £7 billion a year to the economy in England. This is in line with the previous estimates on the cost of stroke in other countries. Evers et al. reported the percentage of health care expenditures stroke makes in 6 developed countries. On average 3% is spent on stroke from health care budgets, with a minimum of 1.6% in the USA and a maximum of 6.9% in Scotland[8].

61. The results from our study show that stroke costs £7.014 billion (as much as Coronary Heart Diseases (CHD) at £7.055 billion), to the economy every year[34] even though the magnitude of cost items are not equal. Productivity losses make up a much larger part of total costs in CHD (41%) in comparison to stroke (25%). This occurs mainly because of the age structure of these 2 diseases. When only one fourth of stroke cases are under the retirement age of 65, CHD affects a much younger population. On the contrary direct health care costs of stroke are higher than that of CHD (£2.8 billion 1.73 billion[34] respectively). This is mainly caused by the major community services costs (£1.7 billion for stroke and £74.8 million for CHD[34]), which go together with stroke disease due to the chronic nature of stroke.

62. The predictive one-year model gives us an idea of the immediate effect of changing the utilisation of service items on the stroke mortality, recurrence and costs. However one shortcoming of the study, as also

mentioned in Hankey and Warlow. is that the effects of the interventions considered is not additive which might have lead to an over-estimation of the absolute effects[15]. But what might offset this over estimation is that the interventions we factored into the analysis will also have a diminishing effect on the risk of coronary heart diseases.

63. This study did not calculate a cost per stroke patient, mainly because in the case of stroke there is also a wide difference between average costs of cases. However when we used the assumptions of Bosanquet and Franks and estimated the cost of a rapid recovery case, a case with disability but discharged into the community, and a case discharged with disability and into long term care we found the costs to be wide ranging (£2,800, £17,500, £135,500 respectively). From this perspective it would have been impossible to interpret a per patient cost obtained by dividing the total costs by the patient number to obtain an average cost per patient.

Conclusion

64. Stroke is a disease causing high mortality and long-term morbidity. It is a significant burden on the economy, costing £7 billion to the economy including informal care and productivity losses each year and making up approximately 4% of direct NHS health care expenditures in England. A little over one third of this cost is spent on providing health care to stroke sufferers (direct costs), and the rest is shared between informal care costs and productivity losses.

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