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RESEARCH PAPER

The future incidence, prevalence and costs of stroke in the UK

DEREK KING¹, RAPHAEL WITTENBERG¹, ANITA PATEL^{2,3}, ZAHID QUAYYUM⁴, VLADISLAV BERDUNOV⁵, MARTIN KNAPP¹

¹Care Policy and Evaluation Centre, London School of Economics & Political Science, London, UK

²Anita Patel Health Economics Consulting Ltd., London, UK

³Queen Mary University of London, London, UK

⁴James P. Grant School of Public Health, BRAC University, Dhaka, Bangladesh

⁵Amaris, London, UK

Address correspondence to: Derek King, Care Policy and Evaluation Centre, London School of Economics & Political Science, Houghton Street, London WC2A 2AE, UK. Email: d.king@lse.ac.uk

Abstract

Background: we project incidence and prevalence of stroke in the UK and associated costs to society to 2035. We include future costs of health care, social care, unpaid care and lost productivity, drawing on recent estimates that there are almost 1 million people living with stroke and the current cost of their care is £26 billion.

Methods: we developed a model to produce projections, building on earlier work to estimate the costs of stroke care by age, gender and other characteristics. Our cell-based simulation model uses the 2014-based Office for National Statistics population projections; future trends in incidence and prevalence rates of stroke derived from an expert consultation exercise; and data from the Office for Budget Responsibility on expected future changes in productivity and average earnings.

Results: between 2015 and 2035, the number of strokes in the UK per year is projected to increase by 60% and the number of stroke survivors is projected to more than double. Under current patterns of care, the societal cost is projected to almost treble in constant prices over the period. The greatest increase is projected to be in social care costs—both public and private—which we anticipate will rise by as much as 250% between 2015 and 2035.

Conclusion: the costs of stroke care in the UK are expected to rise rapidly over the next two decades unless measures to prevent strokes and to reduce the disabling effects of strokes can be successfully developed and implemented.

Keywords: costs, incidence, older people, stroke, prevalence, projections

Key points

- We project that stroke incidence in the UK will increase by 60% per year between 2015 and 2035.
- Stroke prevalence is projected to increase by 120% between 2015 and 2035.
- Between 2015 and 2035, societal costs associated with increases in incidence and prevalence will almost treble in constant prices.
- Social care costs will increase at a greater rate, 270%, than will health care costs, unpaid care costs or lost productivity, after adjusting for inflation.

Introduction

Over 113,000 individuals suffer a stroke each year in the UK, and there are around 1 million stroke survivors currently [1,2]. These numbers are increasing due to population ageing and because treatment improvements lead to better survival rates. The number of strokes each year in Europe is projected to increase by 34% between 2015 and 2035 [3].

In addition to the significant impacts on individuals who suffer a stroke and their families, there can be substantial health and social care service implications. The current UK annual societal cost of stroke is £25.6 billion [4].

Projecting future epidemiological and economic impacts of stroke provides a platform for planning prevention, treatment and support services. Projected expenditure associated with these activities can inform decision-making on service funding.

We present projections of future incidence and prevalence of stroke among people aged 45 and over in the UK, and associated costs of treatment and support. Our estimate of future costs includes healthcare (prevention and treatment), social care, costs of contributions from family and friends supporting stroke survivors, and productivity losses due to stroke survivors leaving or interrupting employment. Our projections use official Office for National Statistics (ONS) population projections and incorporate results from expert consultation on future incidence and prevalence of stroke. Sensitivity analyses around the ONS principal population projection and expert consultation results are also presented.

Methods

Future incidence, prevalence and cost of stroke are estimated using a cell-based simulation model in Excel. The model structure has been used previously to project demand and associated expenditure for long-term care [5].

Data

Current stroke costs in the UK are estimated elsewhere, and detailed description of methods is provided there [4]. Projecting costs into the future uses ONS 2014-based population projections [6], future trends in incidence and prevalence rates from a consultation exercise with 11 stroke experts, the balance between public and private social care from the Personal Social Services Research Unit (PSSRU) projections model [5], and expected future changes in productivity and average earnings from the 2018 Office for Budget Responsibility (OBR) Fiscal Sustainability Report [7].

Overview of the model

Our model has 2015 as its base year. Projections of future societal costs of stroke are estimated for 2025 and 2035. Further details of the model design and data sources appear in [supplementary material](#), Appendix 1.

Incidence and prevalence

The model first estimates the numbers of new strokes (incidence) and stroke survivors (prevalence) for each age band and gender. Three key studies reporting stroke incidence were found after a focused review of UK studies [1,8,9]. For our central case estimates, we used as estimated stroke incidence in 2015 the mid-point estimate of 117,600. A further three-key studies reported stroke prevalence [2,10,11]. Our modelling used the prevalence estimate, 950,200, from the largest of these studies [2].

Health and social care costs

We produced separate cost estimates for people in the first year following stroke and for subsequent years after stroke, following the approach by the National Guideline Centre (NGC) and the Sentinel Stroke National Audit Programme (SSNAP) [12]. We separately estimate health care, social care (publicly and privately funded), unpaid care and lost productivity costs.

Unpaid care costs and lost productivity

Data from the Training Caregivers after Stroke (TRACS) trial [13] and the Longer-Term Stroke (LoTS) Care study [14] on self-reported carer inputs to personal care and other supports were used to estimate costs associated with unpaid care (sometimes called 'informal care'). TRACS data were used to generate unpaid care estimates in the first year and LoTS Care data to estimate unpaid care costs in subsequent years.

Estimates for 2025 and 2035

Incidence and prevalence

Future increments in incidence and prevalence of stroke were derived from a consultation with stroke experts. We used a Delphi-style approach to obtain their views on the level of annual change in stroke incidence and prevalence rates in the next 10 years and 11–20 years. Experts approached had previously worked on epidemiological studies related to stroke and were aware of relevant evidence and trends related to both stroke epidemiology and clinical care.

Of the 19 experts contacted, 11 participated. Results of each round of the consultation appear in [supplementary materials](#), Appendices 2 and 3. We chose as our central case the most frequently chosen options after the second (final) round of the consultation. These are presented in [Table 1](#).

Unit costs of health and social care

Also necessary was an assumption about the rate of increase in unit costs of health and social care. These services are highly labour intensive. As such, they are likely to rise broadly in line with average earnings of professionals working in these sectors. The OBR assume that average earnings and productivity will rise by 2% per year in real terms (i.e. over and above general inflation) [7]. Our central

Table 1. Assumed annual increments in stroke incidence and prevalence rates between 2015–2025 and 2025–2035

	2015–2025		2026–2035	
	Incidence	Prevalence	Incidence	Prevalence
Age 45–64	0.0%	1.0%	0.0%	1.0%
Age 65–74	0.0%	1.5%	0.0%	1.5%
Age 75–84	0.0%	2.0%	0.0%	2.5%
Age 85 and over	0.5%	2.5%	0.5%	3.0%

Source: Expert consultation exercise.

case, therefore, is that health and social care unit costs will rise by 2% per year in real terms.

Sensitivity analysis

Sensitivity analysis around increases in health and social care unit costs, trends in population mortality rates and trends in stroke incidence and prevalence were performed. A detailed description of these analyses can be found in [supplementary material](#), Appendix 4.

Results

Primary projection of future cost of stroke

We project stroke incidence will rise from 117,600 in 2015 to 148,700 in 2025 and 186,900 in 2035, an increase of 59% over the total 20-year period 2015 to 2035. We also project that stroke prevalence will rise from 950,200 in 2015 to 1,424,100 in 2025 and 2,119,400 in 2035, an increase of 123% over the 20-year period. Our central projections are set out in more detail in [Table 2](#).

Our model projects societal costs of stroke in the UK will rise from £26 billion in 2015 to £43 billion in 2025 and then to £75 billion in 2035, an increase of 194% over 20 years, in constant 2015 prices. Given projections of UK GDP, at 2015 prices, of £1873 billion, £2144 billion and £2641 billion in 2015, 2025 and 2035, respectively [7,15], our projections are that societal cost of stroke will rise from 1.4% of GDP in 2015 to 2.0% in 2025 and 2.9% in 2035.

Health care costs are projected to rise by 201%, social care costs by 273%, unpaid care costs by 171% and lost productivity costs by 136%. It is estimated that private social care costs will rise at a slightly greater rate than public costs: 278% versus 268%, respectively. These projections are set out in more detail in [Table 3](#).

Social care costs are projected to rise much more rapidly in the next 20 years than the health care, unpaid care or lost productivity costs. This is because the size of the population aged 75 and over is projected to rise more rapidly than the population aged 45–75 and social care use is more prevalent at older ages. That is, social care cost per person rises much more sharply with age than health, unpaid care or lost productivity costs. Among people who have survived ischaemic stroke, annual average social care costs per person

at age 75 and over is more than twice the costs at ages 45–74. Average annual health costs, however, vary far less by age. As we would expect, unpaid care costs are significantly higher for the older age group, while lost productivity costs are not.

Sensitivity analysis

The ONS 2014-based life expectancy variant population projections are used to show the impact of variant population projections on projected incidence, prevalence and costs. We project stroke incidence will rise between 2015 and 2035 by 66% under the high-life-expectancy variant and 52% under the low-life expectancy variant in comparison with 59% under the principal projection (our central case). Stroke prevalence will rise by 132% under the high-life expectancy variant and 114% under the low-life expectancy variant in comparison with 123% under the principal projection. We further project overall stroke costs in the UK will rise by 205% under the high-life expectancy variant and 183% under the low-life expectancy variant in comparison with 194% under the principal projection ([supplementary material](#), Appendix 5).

If incidence and prevalence rates in each age band rise by 1 percentage point per year more than under our central case described above, stroke incidence will rise by 94%, the number of stroke survivors aged 45 and over will rise by 171% and overall stroke costs will rise by 257% between 2015 and 2035 ([supplementary material](#), Appendix 5). If the incidence rate falls by 1 percentage point per year for those aged 45–84 and by 0.5 percentage point per year for those aged 85 and over and prevalence rates in each age band rise by 1 percentage point per year more than under our central case described above, we estimate stroke incidence will rise by 30%, stroke prevalence among people aged 45 and over will rise by 83% and overall costs of stroke will rise by 141% between 2015 and 2035 ([supplementary material](#), Appendix 6). The variation in projected future costs is greater under our variant assumptions on future incidence and prevalence rates than under the ONS variant population projections ([supplementary material](#), Appendix 7).

Finally, we consider the impact of alternative assumptions on real annual rise in costs. If costs per person rose by 2.5% per year in real terms, overall stroke costs would rise from £26 billion in 2015 to £83 billion in 2035, an increase of 224%, in constant 2015 prices. If costs per person rose by only 1.5% per year in real terms, overall stroke costs would rise from £26 billion in 2015 to £68 billion in 2035, an increase of 166%. These projections should be compared with our central case projection of a rise of 194% in overall costs between 2015 and 2035. Projections of aggregate costs over a 20-year period are inevitably highly sensitive to assumed real annual rise in costs per person.

Discussion

Our projection modelling suggests that, on the basis of ONS population projections and expert opinion on trends

Table 2. Projections of future number of incident and prevalent cases of stroke, age 45 and over, by gender and stroke type, 2015–2035, UK

Gender, type of stroke	Incidence			Prevalence		
	2015	2025	2035	2015	2025	2035
Females						
Ischaemic	53,700	66,400	84,300	397,300	594,800	912,500
Haemorrhagic	6400	7900	10,000	41,800	62,700	96,200
Males						
Ischaemic	51,700	66,600	82,900	462,500	693,300	1,004,300
Haemorrhagic	5900	7700	9800	48,600	73,300	106,300
Total						
Ischaemic	105,300	133,000	167,200	859,800	1,288,100	1,916,900
Haemorrhagic	12,300	15,700	19,700	90,400	136,100	202,600
Total all strokes	117,600	148,700	186,900	950,200	1,424,100	2,119,400

Note: Numbers may not add exactly due to rounding. Source: Expert consultation exercise and authors' calculations.

Table 3. Projections of future costs of stroke by type of cost (in £million), 2015–2035, age 45 and over, UK

Costs (£m)	2015	2025	2035	% change
Health care	3400	6900	10,200	200%
Social care—Public	2400	4700	9000	275%
Social care—Private	2700	5400	10,300	280%
Social care—Total	5200	10,100	19,300	270%
Unpaid care	15,600	24,400	42,200	170%
Lost productivity	1500	2300	3500	135%
Total	25,600	42,600	75,200	195%

Note: Numbers may not add exactly due to rounding. Source for 2015 costs: Patel *et al.* [4], authors' calculations.

in incidence and prevalence rates, the number of strokes in the UK per year will increase by 60% between 2015 and 2035 and the number of stroke survivors in the population will more than double over those 20 years. We project that over this period societal costs associated with these increases in incidence and prevalence will almost treble in constant prices. The greatest increase is projected to be in social care costs—both public and private—which may be over two and a half times higher in 2035 than in 2015, after adjusting for inflation.

The survey of experts tended towards a small or no change in stroke incidence rates rather than a continuing decrease. This can be interpreted as an expectation that the falling incidence rate has now levelled out or that contributors to falling incidence will in future be counterbalanced by other trends (e.g. rising obesity rates) that increase the likelihood of stroke. It is helpful to compare our projections, based on these assumptions, with those made in other studies, although methodologies differ.

Kingston *et al.* [16] estimated that stroke prevalence in England will increase by 84% between 2015 and 2035 from 726,000 to 1,338,000 among those aged 65 and over (as opposed to 45 and over used in our study). The authors used a discrete time dynamic microsimulation model (PACSim) to simulate characteristics of individuals and their probability of transitioning into a state of chronic illness over the period 2014–2035.

A projection of future stroke prevalence in Australia, using demographic trends only, estimated a 75% increase between 2011 and 2032 [17]. Thus, while their projection covers a very similar length of time, it is lower than our estimate of a 123% increase. One would, however, expect their estimate to be lower given they assumed no change in incidence and prevalence rates over time, which seems unlikely.

Ovbiagele *et al.* [18] projected that between 2012 and 2030 health care costs associated with stroke in the US would increase by 160%. Their model used official population projections but did not make assumptions on future changes in incidence or prevalence rates or real increases in unit costs of care. We made these further assumptions in our analyses, for the reasons set out earlier, with the consequence that our model projects health care costs associated with strokes in the UK for a similar period will increase by 200%.

We assume in our central projections that mortality rates by age and gender will fall in line with ONS assumptions and incidence and prevalence rates of stroke will change in line with the views of experts. We have shown in sensitivity analyses that our projections are sensitive to these assumptions. We hold constant over time the intensity of service receipt by age, gender, type of stroke and stroke severity. We do not assume any increase in coverage or quality of services, since we want to inform future policy by investigating future

costs under *current* policy and practice rather than speculate about future policy or practice developments. It is likely that in practice intensity of service receipt by stroke patients will change due to changes in treatments, such as wider use of thrombectomy, changes in risk factor profiles within the population and changes in expectations of treatment and support of stroke survivors and their families. We have not made assumptions about such changes here.

We assume that the supply of unpaid care by family and friends will rise in line with demand as the number of stroke survivors rises. This is clearly uncertain [19]. If the supply of unpaid care does not rise in line with demand, formal services and their associated costs may need to rise more rapidly than under our projections.

The model estimates costs attributable to stroke. We are aware, however, that individuals who have a stroke and survive may have considerable comorbidities. As such, it is very difficult to distinguish between costs attributable to stroke and those attributable to concurrent comorbidities though we have attempted to do so [4].

Particularly concerning are the expected future consequences of strokes for the social care sector, especially given that funding for social care in parts of the UK is currently so severely constrained. The scale of projected future costs highlights the urgency of addressing future funding arrangements for social care. Our projections may be helpful, for example, in informing current debate in England about how to pay for adult social care.

Effective measures to prevent strokes and treatments to reduce the disabling effects of stroke have the potential to reduce future health, well-being and cost impacts of stroke. These would include thrombectomy for a larger proportion of people experiencing a stroke. Development and implementation of measures to prevent strokes and to reduce disabling effects of strokes will be crucial. This may likely require increased investment in research to develop interventions and approaches to implementing them successfully.

Supplementary data: Supplementary data mentioned in the text are available to subscribers in Age and Ageing online.

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Informed consent: We obtained informed consent for the consultation with experts. This was not required for the remainder of the work because it used only secondary data in aggregated form.

Ethical approval: We obtained necessary approvals from the relevant Research Ethics Committee (Proportionate Review Sub-committee of the East of England—Cambridge South Research Ethics Committee; Reference: 16/EE/0451) for the consultation with experts. Ethical approval was not required for the remainder of the work because it used only secondary data in aggregated form.

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