Current, future & avoidable costs of stroke in the UK

Summary report

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Rebuilding lives after stroke

Stroke Association

Summary report

Produced by the Centre for Primary Care & Public Health, Queen Mary University of London and the Personal Social Services Research Unit, London School of Economics and Political Science for the Stroke Association

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This research and the methodology has been published in full in the following: **https://doi.org/10.1093/ageing/afz162/5679684** and **https://doi.org/10.1093/ageing/afz163**

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Introduction

Stroke is the second largest cause of death worldwide and fourth in the United Kingdom (UK).

There are over 113,000 strokes every year in the UK (Rothwell et al., 2004)* and over 950,000 stroke survivors among people aged 45 years and over (Geddes et al., 1996).* Many of these stroke survivors experience significant and long-term physical and psychological impacts, repeat strokes, transient ischaemic attacks (TIAs) and/or death within a year of stroke (Stroke Association, 2017).

Preventing, treating and managing the resulting illness or death from stroke all carry economic consequences, not just for health care services but also more widely across society (Saka et al.,2009; National Audit Office, 2010). For example, given that a quarter of all strokes in the UK happen among people of working age (Stroke Association, 2017), stroke can reduce employment prospects and productivity for society. It can also affect family and friends who are often involved with a stroke survivor's care and are unpaid in this caring role. This is even more concerning given current and likely ongoing financial pressures on health and social care services, families and other unpaid carers.

Despite significant progress in prevention, treatment and rehabilitation, there is still great capacity for further improvements, which in turn could reduce these large economic burdens. Achieving this requires more research, but stroke has received considerably less research investment compared to conditions with similar burdens. For example, the UK annual medical research-spend per stroke patient is £48, compared with £241 per cancer patient and £118 per dementia patient (Luengo-Fernandez et al., 2015).

* Estimates of the number of strokes and stroke survivors can vary across different studies depending on many factors, including the population sample and data sources that are used. While we have used alternative estimates in our other publications (e.g. Stroke Association, 2017), we use averages from a range of estimates for the purpose of this work.

We carried out a large body of work that has been split into three distinct parts for reporting:

1. **Burden of stroke in the next 20 years and potential returns from increased spending on research**

   Understanding the scale and range of impacts for a condition as prevalent as stroke can be of enormous value to help prioritise scarce resources. We therefore updated estimates of the current burden of stroke to ensure future research priorities, service and policy responses are based on timely and relevant data.

   Furthermore, we forecasted the burden of stroke in the future based on our current estimates. We took into account likely changes in demography and expert views on potential future trends in the numbers of first-time strokes (stroke incidence) and survivors after stroke (stroke prevalence) each year.

   However, estimates of the current and future burden of stroke won't in themselves offer solutions. We next gathered expert views on what research areas should be prioritised to reduce the burden of stroke in the UK. We also investigated whether investing in these research areas will help to reduce the burden of stroke in future years.

2. **Societal costs of stroke in the next 20 years and potential returns from increased spending on research**

   Further to the burden of stroke, we updated the current societal costs of stroke and examined potential future costs of stroke over the next 10 and 20 years. We forecasted these costs based on our current estimates and accounting for demographic changes, future service costs and future stroke burden estimates. We also examined whether investing in the top research priorities suggested by experts could alleviate some of these longer term costs.

3. **Societal costs of stroke and potential returns from implementing what we know works**

   Finally, there is already evidence of interventions that could bring benefits to the care sector and the wider population, but these are not yet fully implemented. We therefore estimated the potential future economic gains from implementing these interventions more widely.

1. Burden of stroke in the next 20 years and potential returns from increased spending on research

Methods

We gathered up-to-date estimates from published literature on the number of first-time strokes (stroke incidence) and number of survivors after stroke (stroke prevalence) each year for the UK population. To estimate what this burden could look like in the future, we looked at official estimates (ONS, 2015) of future demographic changes (e.g. growth in population size or spread of ages) to the UK population.

In addition, we needed to account for context-specific changes e.g. trends in risk factors and available treatments. We also needed to explore whether more research could alleviate these future burdens by thinking about what areas of research would make the most difference and how. To achieve this, we asked for the views of academic experts with knowledge, expertise or an interest in stroke, stroke care and/or stroke research as appropriate.

We placed the academic experts into two overlapping groups. One group was asked about future trends in incidence and prevalence rates for different age bands of people. The other was asked to name their top three research priorities and to rate the likelihood and timing of potential benefits if that research was funded immediately. Both groups received two rounds of questionnaires. The research priorities group was also asked to rank priorities generated from the first round so that we could generate a top-five list.

We used these expert views to estimate:

- **the number of strokes and stroke survivors in the future (to 2035)**
- **the size of future costs of stroke (to 2035)**
- **the benefits per person that might accrue, and how future returns might change as a result of more investment in just the top five research priorities, leading to the development of new or improved treatments or preventative measures.**

We had to make various necessary assumptions, for example, on what the costs of that research might be – we assumed £10 million for each of the top five research priorities over the next few years, assuming that around five clinical trials costing £2 million each would be needed to produce a cost-effective and implementable intervention. We also made assumptions around what kind of new or improved treatments the research might result in and what returns, including quality of life benefits, could be generated by these treatments.

Results

Current burden of stroke: number of strokes and stroke survivors now

Incidence: the estimated annual number of first-time stroke cases (stroke incidence) ranges from 113,400 to 119,100. Using ranges of incidence rate reported by various individual studies, the number could conceivably range from 85,800 to 147,600. We focused on the mid-point estimate of 117,600 (Stewart et al., 1999) for our various calculations.

Prevalence: The estimated number of stroke survivors (stroke prevalence) aged 45 and over in the UK ranged from 950,000 to 1.3 million in 2015. When the low and high estimates from various individual studies are considered, the number could range from 797,000 to 1.4 million. We focused on the estimate of 950,200 (Geddes et al., 1996) for our various calculations.

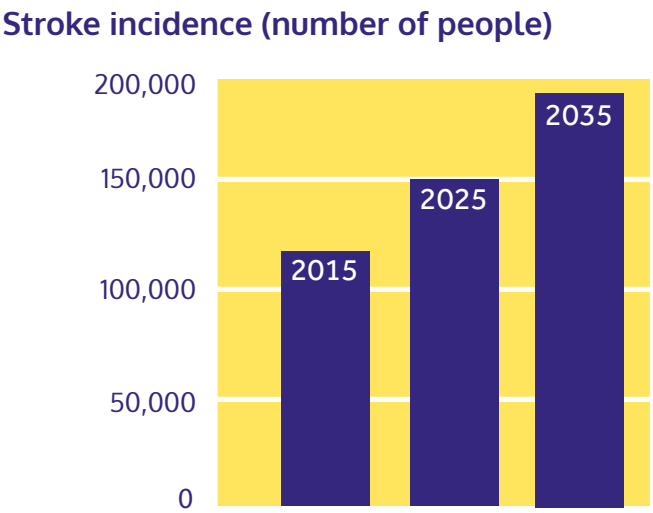
Future burden of stroke: potential number of strokes and stroke survivors in the future

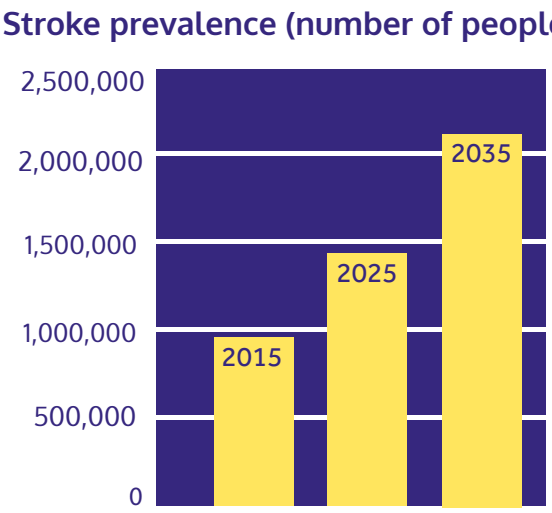
Experts had differing views on whether stroke incidence would decrease or increase in the future. Their views on prevalence were more similar, pointing towards no change or modest increases in prevalence among people aged 40-74 years and a modest or high increase among people aged 75-100 years. Alongside estimates of demographic trends, applying these views to current rates of incidence and prevalence points to a substantial future burden of stroke.

Incidence: first-time strokes among people aged 45 and over in the UK will rise from 117,600 in 2015 to 148,700 in 2025 and 187,000 in 2035, **an increase of 59% over 20 years.** This is based on the assumption from expert views that incidence rates will stay the same up to 2035 for those aged 45 to 84, and rise by 0.5% per year for those aged 85 and over. If incidence rates change by 1% per year more or 1% less than under this assumption, incidence would be 228,000 or 153,000 respectively in 2035.

Prevalence: the number of stroke survivors among people aged 45 and over in the UK will rise from 950,000 in 2015 to 1,425,000 in 2025 and 2,120,000 in 2035, **an increase of 123% over 20 years.** This is based on the assumption from the expert views that prevalence rates will rise by 1% per year for those aged 45 to 64, 1.5% per year for those aged 65 to 74, 2.0% per year (2.5% after 2025) for those aged 75 to 84 and 2.5% per year (3.0% after 2025) for those aged 85 and over. If prevalence rates change by 1% per year more or 1% less than under this central set of assumptions, prevalence would be 2,575,000 or 1,740,000 respectively in 2035.

Figure 1: Stroke incidence and prevalence, now and in the future





Returns from more spending on stroke research

Experts initially suggested 56 different research topics. After the ranking process, the top five were as follows (in rank order):

- Improved rehabilitation strategies
- Rehabilitation for cognitive difficulties
- Vascular dementia
- Thrombectomy
- Evidence-based practice

We estimate that annual NHS costs of stroke are set to treble from £3.4 billion in 2015 to £10.2 billion in 2035. Based on expert views and our own further assumptions, we estimate that investing £10 million into each of these priority research areas in the next few years could generate benefits that substantially reduce the burden of stroke by 2035 as follows:

- Improved physical rehabilitation: assuming a new rehabilitation intervention is offered to 10% of people experiencing a stroke from 2025 to 2029, and to 20% from 2030 onward, we estimate 230,000 stroke survivors in 2035 (11% of all stroke survivors in 2035) will have received it. We assume benefits would accrue over the first five years after the stroke and rehabilitation; that stroke survivors and their unpaid carers would experience improved quality of life; they would have lower disability and care needs so they would need less health care, social care and unpaid care; and they would be more likely to remain in employment.

- Rehabilitation for cognitive difficulties: as for improved physical rehabilitation, we again assume that a new rehabilitation intervention is offered to 10% of people experiencing a stroke from 2025 to 2029, and to 20% from 2030 onward, leading to 230,000 stroke survivors in 2035 (11% of all stroke survivors in 2035) receiving it. We assume stroke survivors would receive the same benefit as those receiving rehabilitation of physical function, plus an additional year's survival due to a reduced mortality rate.

- Vascular dementia: we assume that the incidence rate of stroke would be reduced by 5% from 2025 onward due to better detection and management of small vessel disease. The number of people living with stroke in 2035 would on this basis be some 70,000 lower than if the research was not conducted and the resulting improved treatment of small vessel disease was not developed.

- Thrombectomy: we assume that a further 5% of people experiencing a stroke between 2025 and 2029 and a further 10% of those experiencing a stroke from 2030 onward would receive thrombectomy. We estimate that on this basis 115,000 stroke survivors in 2035, (5.5% of stroke survivors in 2035), will have received this intervention. We assume that the benefits would be the same as for those receiving cognitive rehabilitation.

- Evidence-based practice: many effective clinical interventions are not implemented as well or as widely as they could be. Some need funding, service or policy changes to enable improved implementation (as will be highlighted in the third part of this work), others require further research to better understand, for example, the barriers and facilitators to good implementation so that relevant education or other support can be provided. Taking stroke prevention as an example, if we assume that better implementation of successful evidence-based measures, such as blood pressure control, could reduce the incidence of stroke by 5% from 2025 to 2029 and by 10% from 2030 onward, there would be around 114,000 fewer people living with stroke in 2035 than if these measures were not put in place.

  Similarly, in terms of treatments that could improve outcomes after stroke, national stroke audit data have shown that despite evidence and guidance for intermittent pneumatic compression (IPC), an intervention for reducing deep vein thrombosis after stroke which can improve survival, only a minority of hospitals in England were using this well (Royal College of Physicians, 2016). If we assume that research to support the wider implementation of IPC led to an additional 15% of those who have a stroke during 2020 to 2024, and 25% of those who have a stroke from 2025 onward receiving IPC, then 140,000 stroke survivors in 2025 will have received it. The additional patients offered it would also gain one additional year of life.

Conclusions

The number of stroke survivors in the UK is expected to more than double in the next 20 years. Increased funding to invest in priority research areas, such as cutting edge emergency treatments, developing and rolling out new rehabilitation approaches, and understanding the cognitive difficulties that can be associated with stroke could alleviate this burden.

There are of course some caveats related to this work, the main one being that these are projections related to an unknown future. There is uncertainty in current estimates of new strokes that occur each year and the number of people living with stroke. So, considering future trends in these numbers is challenging, as illustrated here by the differing views of experts. Similarly, the potential returns from further research spending are based on a mixture of expert views on potential benefits of the priorities they suggested; estimates from current evidence; and a range of necessary assumptions related to future intervention costs, other care costs and benefits. While we have based our estimates on plausible assumptions, alternative assumptions and methods could of course generate different specific estimates of those returns. Our estimates nevertheless point toward potential scope for substantial future savings from increased research investment.

2. Societal costs of stroke in the next 20 years and potential returns from increased spending on research

Methods

Range of costs considered

We aimed to estimate the annual societal cost of stroke in the UK now, in 2025 and in 2035. We report all costs at 2015 prices and have accounted for costs falling upon:

- the National Health Service (NHS)
- personal social services (PSS) e.g. care homes (public and private payers)
- informal (unpaid) carers such as family and friends
- broader society in terms of productivity losses associated with lost/reduced employment among stroke survivors.

Broad approach to estimating current and future costs

1. We first estimated **average annual costs per person with either a new or previous stroke in 2015,** broken down into various categories of stroke survivors (by stroke severity, stroke type, age and sex). Our estimates of health and social care costs build upon recent high quality modelling work completed by others (NGC & SSNAP, 2016), which simulated average one- and five-year care costs for new-onset stroke using national data from the Sentinel Stroke National Audit Programme (SSNAP) and the South London Stroke Register (SLSR). We broke these numbers down further to differentiate between care costs in the first year following a stroke (stroke incidence) and costs in subsequent years (stroke prevalence). We also added estimates of the costs of informal care using appropriately adjusted data from two large stroke trials recently completed in the UK (Forster et al., 2013; Forster et al., 2015). One of these trials (Forster et al., 2015) also provided data on stroke survivors' changing employment status over the year following their stroke and we used this to estimate lost productivity. We applied national wage rates to these losses as a proxy for lost productivity to society.

2. To extend these costs beyond the individual level and gauge the magnitude of costs for the **UK population in 2015,** we combined these individual-level costs with up-to-date estimates from the literature on stroke incidence and prevalence for the UK population (see Results, p. 5)

3. Next, we projected these 2015 **UK cost estimates to future years.** We used a cell-based simulation model in Excel that accounted for likely changes in the following:

   - The demography of the UK population: 2014-based population projections suggest that between 2015 and 2035 the total UK population aged 45 and over will rise by 22.5% (Office of National Statistics, 2015).
   - Stroke incidence and prevalence rates (based on expert views; see Results, p. 5).
   - Wages in health and social care services, since these services are highly labour-intensive (+2% per year in real terms; Office for Budget Responsibility, 2017).

4. Finally, since estimates based on multiple data sources, extrapolations and assumptions necessarily carry risks of estimation errors, we explored how the results would be affected by **alternative estimates and assumptions.** In relation to current costs, we firstly used statistical approaches to create more stable estimates of costs. We then in turn examined the impact of changing values related to incidence/prevalence rates, length of stay in a stroke unit/acute stroke unit following stroke, probability of thrombolysis in ischaemic stroke, probability of post-stroke unit community rehabilitation and care home admission, probability of death in stroke units and stroke recurrence. We also examined the impact of using alternative estimates for the value of informal care and lost productivity. In relation to the projections, we examined the impact of Office of National Statistics variant population projections, variant trends in stroke incidence and prevalence rates (based on expert views; see Results, p. 5), variant trends in real average earnings in the care sector and in annual costs of care per person.

Returns from further investment in research

Our process for eliciting expert views on research priorities and for estimating the potential savings associated with their top five priorities is outlined in the first section of this report (see Methods, p. 4).

A note on our methods

Further caveats and assumptions made in our methods can be found in Appendix 1.

Results

Stroke costs in 2015

Average costs per person

The **average societal cost of stroke per person is £45,409** in the first 12 months after stroke (cost of incident stroke), **plus £24,778** in subsequent years (cost of prevalent stroke). The average cost of NHS and Personal Social Services (PSS) care in the first year after a severe stroke is almost double that for a minor stroke (£24,003 compared to £12,869). More generally, average NHS and PSS costs varied little between males and females, and between those with ischaemic versus haemorrhagic stroke, but were significantly higher for those aged 85 years and older compared to younger adults. However, lower informal care costs among older adults led to a balance in total average costs across age groups.

Aggregate costs for the UK

In order to estimate the aggregate cost of stroke in the UK, we combined incidence and prevalence figures from literature (Rothwell et al., 2004; Wolfe et al,. 2002; Stewart et al., 1999; Jagger et al., 2006; Geddes et al., 1996; O'Mahony et al., 1999) with current age-specific population figures (Office of National Statistics, 2015). Average estimated numbers of first time strokes and stroke survivors were 117,600 and 950,200, respectively (see Results, p. 5). In aggregate terms this translates into a substantial **£25.6 billion attributed to stroke in the UK per year.**

Of note, we estimate that **£15.8 billion of this is the value of care contributed by informal/ unpaid carers, which is almost double the NHS and PSS care costs of £8.6 billion.** Of the NHS and PSS costs, the cost attributed to NHS-funded care (including secondary care, early supported discharge and community rehabilitation) is £3.4 billion (13% of cost to society). Formal social care contributes more at £5.2 billion (20%). Although the majority of stroke survivors are of older age, lost productivity amounts to £1.6 billion per year.

Incidence versus prevalence

Figure 1 highlights how the economic burden falls upon different sectors of society and how this composition changes over the course of stroke. **The aggregate annual cost to society of new cases of stroke is £5.3 billion, of which £1.6 billion** (30%) is NHS care. As the majority of NHS care is received in the acute phase while the person is in hospital, NHS costs level off in subsequent years to 9%.

In contrast, the contribution of formal social care increases from 11% in the first year after stroke to 22% (£4.6 billion) in subsequent years. Furthermore, the **informal care sector contributes a vast £12.8 billion per year in subsequent years, leading to an aggregate annual cost of £20.6 billion for prevalent stroke.**

The main driver for the difference in incident and prevalent stroke costs is the much larger number of stroke survivors (950,200) compared to new stroke cases each year (117,600).

Stroke costs in 2015 by country

A breakdown of estimated, aggregate costs of stroke in England, Wales, Scotland and Northern Ireland can be found in (Appendix 2).

Figure 1: Breakdown of costs for incident and prevalent stroke

Stroke costs in 2025 and 2035

We project that the overall costs of stroke in the UK for those aged 45 years and over will rise from £26 billion in 2015 to £43 billion in 2025 and £75 billion in 2035, an increase of 194% over 20 years, based on constant 2015 prices (Figure 2). There are several key drivers for such a substantial increase: first, predictions that the number of older people (especially those aged 85 years and over) in the population will increase substantially due partly to rising life expectancy and partly to the 'baby boom' cohorts reaching old age; second, our assumption that because care is highly labour intensive, the cost per hour of care will rise in line with average earnings, which in turn are expected to rise by 2% per year after accounting for inflation (Office for Budget Responsibility, 2017); and finally, the experts we consulted expect stroke survival rates to improve.

The cost increase comprises projected increases in health care costs by 201%, social care costs by 273%**, informal care costs by 171% and lost productivity costs by 136%. The projected increase is highest for social care because of high use of social care in late old age by survivors of severe strokes. It is estimated that private social care costs will rise to a slightly greater rate than public costs: 278% versus 268% respectively.

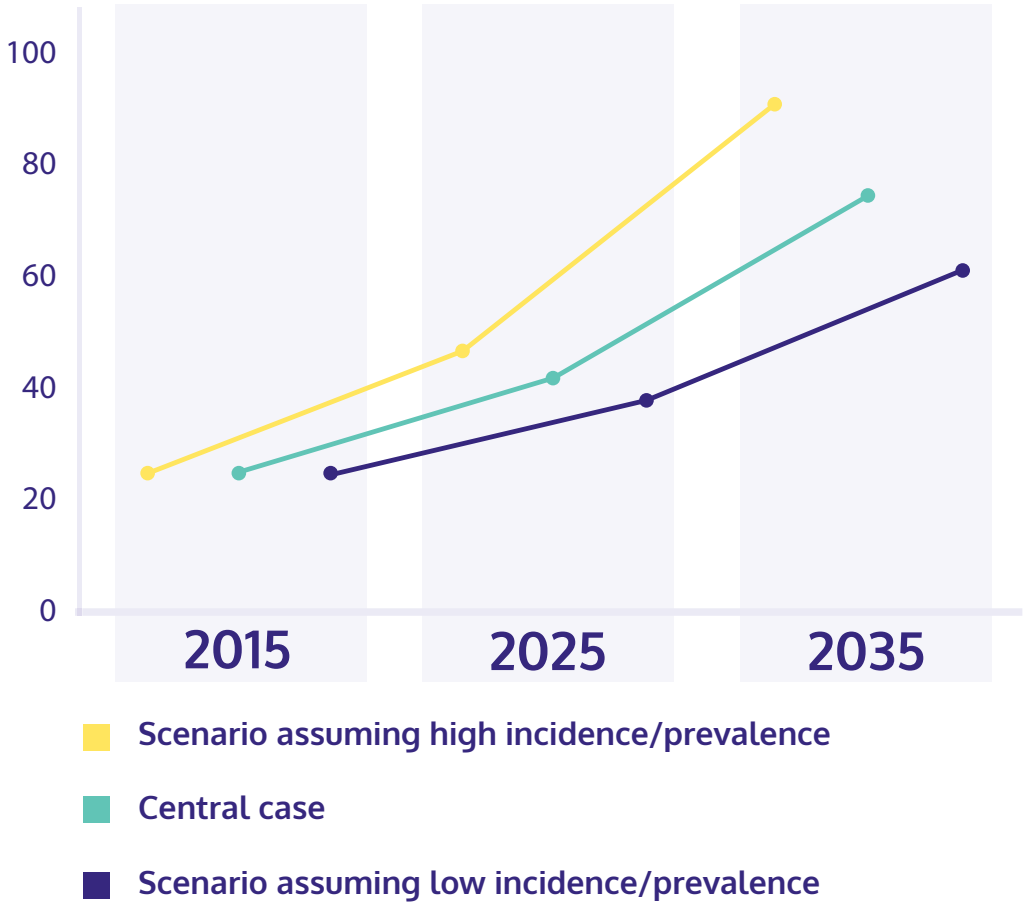
***** Social care costs include the costs of both publicly and privately funded care. As we do not have a source for the breakdown between public and private social care expenditure specific to stroke survivors, we draw from other projections for all older adults (Wittenberg and Hu, 2015). Publicly funded social care includes Personal Social Services net expenditure and expenditure funded by Attendance Allowance, but excludes NHS expenditure. Private expenditure includes user charges and privately purchased social care expenditure.***

Stroke costs in 2025 and 2035 by country

A breakdown of estimated, aggregate costs of stroke in England, Wales, Scotland and Northern Ireland can be found in (Appendix 2).

Figure 2: Change in aggregate costs over time

(£ billions)



Cost estimates under alternative assumptions

Varying the estimated annual incidence and prevalence of stroke over a range of literature-sourced estimates led to the aggregate societal cost of incident stroke in 2015 ranging between £3.9 billion and £6.7 billion and the cost of prevalent stroke ranging between £17.6 billion and £30 billion.

Altering healthcare-related values generated less variation, with the aggregate cost of NHS and PSS ranging between £8.1 billion and £9.1 billion. In contrast, changing estimates related to the value of informal care led to the aggregate cost of informal care ranging between £12.8 and £18.8 billion.

While our methodological approaches preclude estimating a formal confidence interval for aggregate cost, it is possible to gauge uncertainty surrounding this estimate by considering credible low/high ranges for mean cost together with the low/high ranges for incidence and prevalence rates mentioned above. On this basis, our lower bound estimate for the aggregate societal cost of stroke is £18 billion per annum and the higher bound is £43 billion. Following the same approach, the credible range for NHS and PSS costs only is £6.6 billion to 12.8 billion.

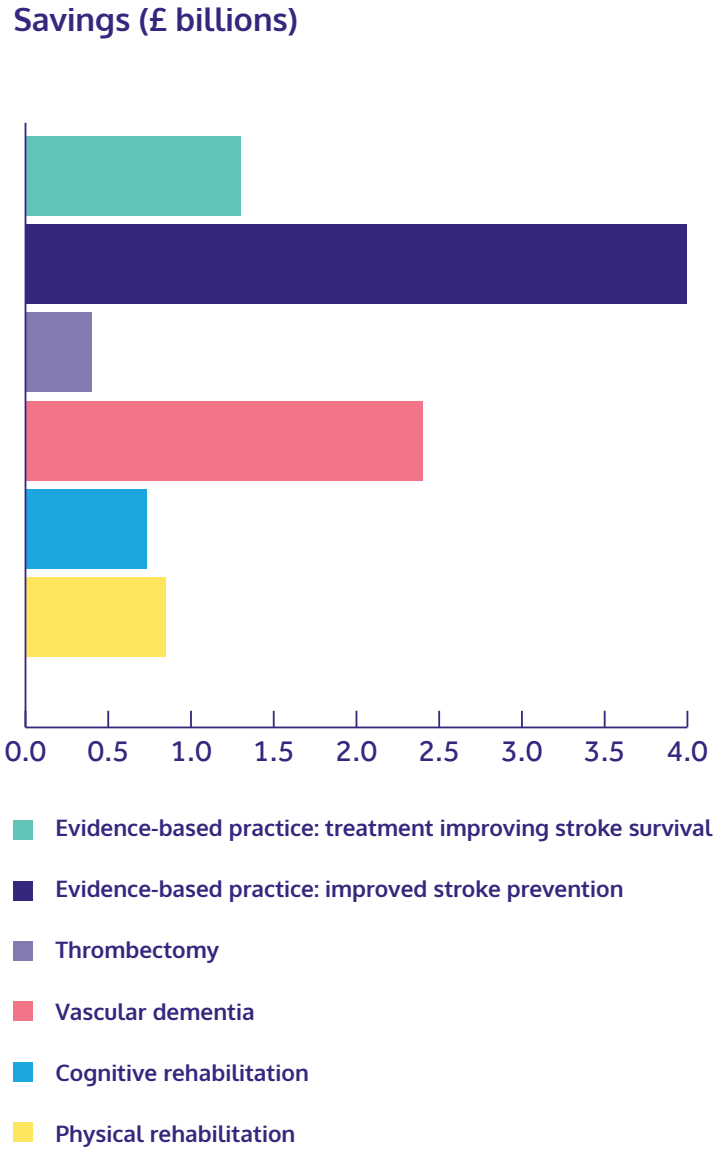
In summary, **the largest source of uncertainty for our estimates of current aggregate costs is the annual rate of stroke prevalence that we apply,** followed by the value we use for the average cost of informal care and the rate we use for annual incidence of stroke.

Changing our rates for trends in incidence, prevalence and costs of care per person show a wide range of cost projections. For example, higher or lower rates of future incidence and prevalence result in estimates of aggregate annual costs of stroke in the UK in 2035 rising to £91.5 billion or only to £61.8 billion respectively (Figure 2). Therefore, the total burden remains high even under more conservative assumptions.

Returns from further investment in research

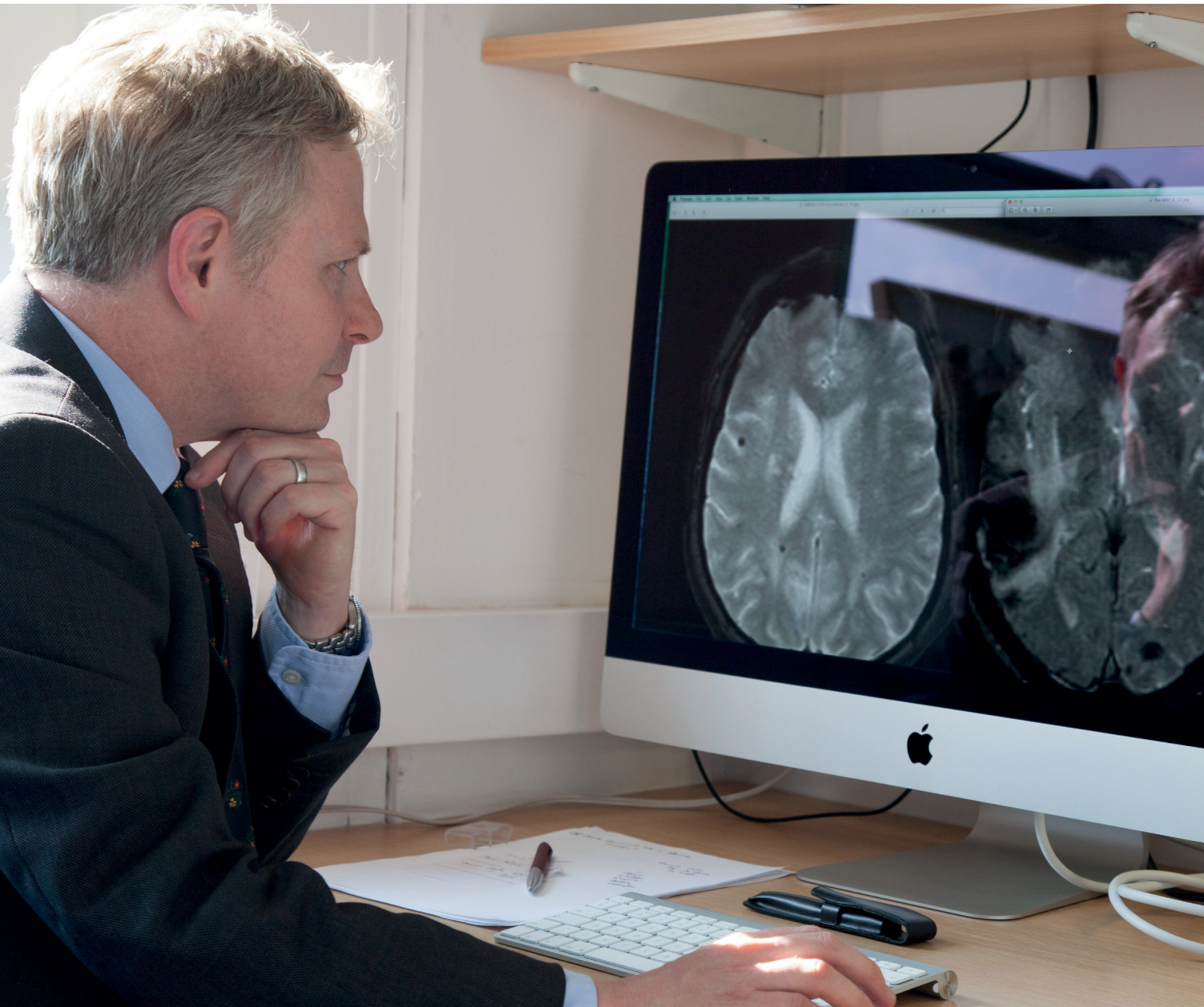
We estimate that investing in each of the top five priority research areas identified by stroke experts (see Results, p. 6) could generate benefits that substantially reduce these costs by 2035 (Figure 3). Savings are greatest – approximately £4 billion – for research related stroke prevention.

Figure 3: Potential savings to societal costs of stroke in 2035 through £10 million investment in each priority research topic



Conclusions

- We estimated aggregate annual costs of stroke, now and over the next two decades.
- Our results point towards a substantial economic burden on society associated with stroke (£25.6 billion each year).
- Even accounting for the caveats related to our estimates, it is clear that informal carers are significant contributors to stroke care and that social care costs will increase substantially by 2035. Therefore, the burden of stroke extends well beyond that obviously shouldered by people with stroke and health care services.
- The economic burden of stroke will almost treble within 20 years, due to predicted rises in the number of older people in the population, the number of stroke survivors and costs of formal care. This will present real societal challenges in future. There is great potential to alleviate some of these costs through increased investment in research.
- It is clear that a condition that generates such a sizeable economic burden in the UK requires greater priority in care funding and policy support.



3. Societal costs of stroke and potential returns from implementing what we know works

This section of the Summary report links to the report: Current, Future and avoidable costs of stroke. Economic case for wider implementation of interventions that work (Patel et al., 2018).

Methods

We conducted a series of focused literature reviews related to interventions spanning three overarching areas of the stroke care pathway: prevention, acute care and rehabilitation/ long-term care.

As the purpose here was to highlight potential economic gains from implementing effective interventions more widely, these reviews were pragmatically focused on identifying relevant interventions and evidence. Wherever available, we prioritised evidence from systematic reviews over that from individual studies, and drawing out information that would enable us to highlight the potential benefits and savings from implementing those interventions. For some interventions, we generated new estimates of likely benefits, in terms of cost savings, mortality reductions or quality of life gains as relevant. Our methodological approaches for these calculations varied across each intervention, led by the nature and strength of evidence, but it generally entailed extrapolating findings from specific studies to national level, using appropriate estimates of incidence, prevalence and numbers of patients eligible for the intervention concerned.

Results

[Key findings are highlighted below in bold]

Prevention

Detecting and managing atrial fibrillation

Stroke is a preventable condition. Those with known risk factors or conditions could be better identified and managed using existing interventions. Atrial fibrillation is one such risk factor, associated with a 5-fold increase in the risk of stroke (Wolf et al., 1991). Using anticoagulant medication in people with atrial fibrillation and no previous history of stroke or transient ischaemic attack has been shown to reduce the risk of stroke by 61% compared to no treatment (Aguilar & Hart, 2005) and 32% compared to antiplatelets alone (Aguilar et al., 2007).

We estimate that an atrial fibrillation **screening programme could avoid 500 new strokes each year.** This corresponds to approximately £11 million of savings to NHS and social care or £28 million of savings in broader societal costs. Accounting for longer-term post-stroke survival rates, **potential cost savings to society (excluding costs of implementing the intervention) over a 5 year period amount to approximately £230 million,** £147 million of which relates to the opportunity cost of unpaid care and lost employment opportunities.

Appropriate anticoagulant management of atrial fibrillation in all eligible patients could avert approximately 4,500 strokes each year. This translates to approximately £97 million savings in NHS and social care costs, or £259 million savings in societal costs in the first year. Over 5 years, corresponding savings would be approximately 23,000 fewer new strokes, 8,800 fewer people living with health consequences of stroke and societal savings of £2 billion, including £690 million savings to NHS and social care.

Detecting and managing hypertension

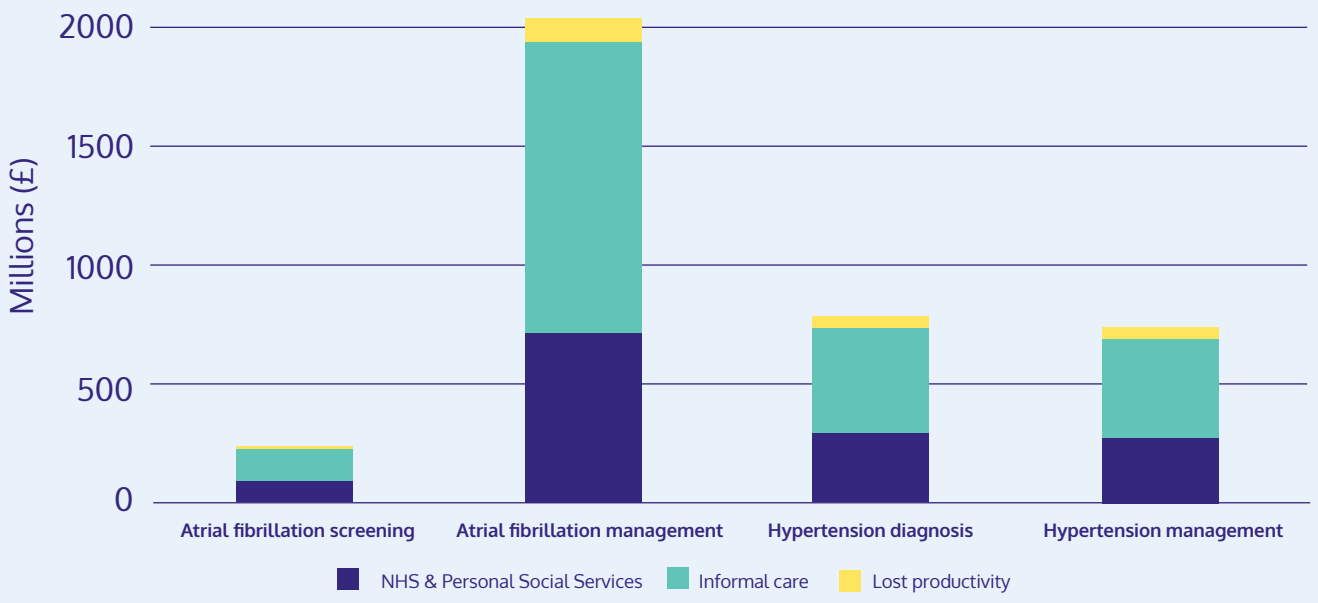
Hypertension is another major modifiable risk factor for stroke. Stroke sufferers are 2.79 times more likely to have pre-existing hypertension compared to non-stroke controls in high-income countries (INTERSTROKE study; O'Donnell et al., 2010). More broadly, it is estimated that 13.8% of people in England have a diagnosis of high blood pressure (NHS Digital, 2016). However, it is also estimated that a further 5.6 million people in England (9.8% of the population) live with undiagnosed hypertension (Public Health England, 2016).

Over 5 years, this translates into avoiding 9,995 new cases and 3,800 prevalent cases of stroke, yielding potential cost savings of £715 million to society, £260 million of which is attributed to NHS and social care.

We estimate that a **successful strategy to increase the proportion of diagnosed hypertension cases by 15% could potentially avoid 10,790 new cases and 4,100 prevalent cases of stroke over 5 years,** yielding potential cost savings of approximately £770 million to society, £284 million of which is attributed to NHS and social care.

A **strategy to increase the proportion of patients on treatment for hypertension who achieve a 'standard' blood pressure reading** (<140/90 mm Hg) from 63% to 78% would allow **an additional 1.3 million patients to benefit from a reduced risk of stroke.** Improved blood pressure control can avoid an estimated 2,000 new stroke cases each year. This could potentially save approximately £36 million in NHS and social care costs, £52 million in informal care costs and £3 million in lost productivity costs for first-time stroke each year.

Breakdown of a 5-year cost savings associated with wider implementation of stroke prevention interventions



Acute care

Service reconfiguration

Major acute system reconfiguration to increase delivery of effective urgent care has been successful in London and Greater Manchester (Morris et al., 2015). In London, a significantly higher proportion of patients received care compliant with care processes and the new model delivered a **5% relative reduction in mortality at 90 days.** Both areas saw reductions in length of hospital stay. There is scope to replicate such outcomes elsewhere. For example, the West Midlands is another major urban region with a population size broadly equivalent to Greater Manchester's so could potentially achieve similar gains to the Greater Manchester reconfiguration i.e. **~18,000 hospital days/£5 million saving over 2 years.**

Thrombolysis

Delivering thombolysis within three hours of stroke is effective in reducing death or dependency (Wardlaw et al., 2014). It has been estimated that after 5 years each extra patient thrombolysed saves £4,100 in NHS costs, £6,900 in social care costs, and generates an extra 0.26 quality-adjusted life years (QALYs) (NCGC/SSNAP, 2016). Thus, we estimate that the **2,000 eligible patients who do not receive the drug each year incur £8.2 million in avoidable costs to the NHS over 5 years.**

Mechanical thrombectomy

The benefits of thrombectomy are substantial: for every 100 patients treated, 38 have a less disabled outcome than with best medical management, and 20 more achieve functional independence (Goyal et al., 2016). Such long-term benefits offset the short-term increased costs associated with the treatment (Lobotesis et al., 2016) making it a highly cost-effective treatment. The additional cost per quality-adjusted life year (QALY) gained has been estimated at approximately £7,000 (over 20 years) – significantly lower than many other NHS interventions (Ganesalingam et al., 2015). Over 8,000 people a year in England could be eligible for thrombectomy but currently only 10% of eligible patients receive it. There is also huge geographic variation in access, with 37% of sites in England having no access to the procedure locally or by referral (Royal College of Physicians, 2016). **On average, one extra patient receiving thrombectomy would save the NHS £47,000 over 5 years, thus representing potential annual savings of millions** (Guijarro et al., 2017). With estimated quality-adjusted life year gains of 0.12 at one year (Achit et al., 2017), **aiming to treat just 1,750 patients within a year could generate 210 quality-adjusted life years.**

Rehabilitation/long-term care

Physical rehabilitation and occupational therapy

A significant body of evidence related to various types of physical rehabilitation indicates its effectiveness for recovery of function and mobility after stroke (Pollock et al., 2014). In comparison, the evidence base for occupational therapy interventions is smaller, but suggests improved outcomes from interventions focussing on activities of daily living (Legg et al., 2007). However, **evidence for rehabilitation therapy in the longer-term is limited** (Aziz et al., 2009). This research gap was confirmed by findings from our own survey of experts (see Results, p. 6)

Dysphagia

A fifth of people with ischaemic stroke are likely to suffer from dysphagia and a fifth of these are likely to develop pneumonia (Arnold et al., 2016). Recent evidence suggests that stroke associated pneumonia is a main cause of post-stroke mortality and could be prevented by early dysphagia assessment, an intervention that doesn't require supporting specialist stroke care or high-technology equipment (Bray et al., 2017). We estimated that Arnold et al.'s figures suggest over 4,500 people could develop pneumonia each year in the UK, carrying **potentially avoidable additional treatments costs of approximately £2.5 million as well as a preventable risk of mortality.**

Early supported discharge

Appropriately resourced early discharge services, with co-ordinated multidisciplinary team input provided for selected groups of stroke patients, can reduce length of hospital stay, increase the likelihood of remaining at home six months after stroke and increase the likelihood of being independent (Langhorne et al., 2017). However, there remain gaps and variations in the implementation of such services. NHS England estimates related to extending provision suggest that **170 lives could potentially be saved in England and a saving of £15,100 per 100,000 people (NHS England, 2014).**

Psychological assessment and treatment

Screening for psychological state after stroke remains hampered by clinician uncertainty about which screening tools to use (Burton and Tyson, 2014). Also, **evidence of psychological treatments relevant to the stroke population is limited in extent, quality and nature.** It is thus difficult to draw robust conclusions on effectiveness or cost-effectiveness of psychological support for stroke patients. This research gap was confirmed by findings from our own survey of experts (see Results, p. 6)

Conclusions

- We have examined evidence for various existing interventions related to prevention, acute care and stroke rehabilitation and long-term care: diagnosis and management of atrial fibrillation, diagnosis and management of hypertension, centralisation of acute care services, thrombolysis, thrombectomy, early supported discharge, early mobilisation, physiotherapy, occupational therapy, dysphagia screening and psychological assessment and support.

- Our results suggest a clear case for change across the care pathway. Many of the potential benefits can be realised by extending provision of services and treatments that are already available and recommended in clinical guidelines, but currently offered at variable or otherwise sub-optimal levels.

- Better stroke prevention, in the form of greater diagnosis and treatment of atrial fibrillation and hypertension, offers significant scope for cost savings, mortality reductions and improved health – and the benefits would extend to other cardiovascular conditions.

- In acute care, centralising services to increase the delivery of effective urgent care offers opportunities to save lives and reduce hospital stay. There is also much scope to reduce costs and improve outcomes by increasing the proportion of eligible people who receive thombolysis and thrombectomy.

- In the broad area of rehabilitation and long-term care, there is potential to save lives, improve outcomes and save money from extending early supported discharge provision and preventing post-stroke pneumonia through better management of dysphagia. However, further evidence is required about what rehabilitative interventions might be cost-effective beyond initial hospital care.

- Inevitably, current resources, system pressures and practical hurdles create challenges for achieving such measures. Increased investments and a more coordinated approach could alleviate the future clinical and financial burden of stroke, improve outcomes and reduce variations in stroke care.

Appendix 1

A note on our methods

There are of course some caveats related to this work, the main being that we include projections for an unknown future. A significant uncertainty is the number of new strokes that are expected to occur each year and the number of people that will live with stroke. Experts have divergent views on this, and this uncertainty impacts on the cost predictions.

More broadly, 'costs of illness' studies like this are necessarily context-specific and can vary in their approach. For example, the data that are used reflect the availability/quality/outcomes of care at that point in time. Data availability is generally improving over time and estimates of aggregate costs are naturally influenced by the range of costs considered relevant or measurable. For example, our estimates of health care costs cover those relating to Accident and Emergency (A&E) departments, acute and regular stroke units and early supported discharge. These do not include any primary care costs or costs associated with other illnesses occurring at the same time as stroke (co-morbidities).

These variations naturally create challenges for drawing comparisons with other estimates.

To illustrate, our estimate of the aggregate annual cost of stroke is substantially larger than previously estimated by Saka et al. (2009). They estimated direct medical care costs at £4.4 billion compared to our estimate of £8.6 billion. More strikingly, they calculated informal care costs to be £2.4 billion per year, compared to our estimate of £15.8 billion. Such a difference may be driven by several factors. For instance, our data sources differed greatly: we used two large trials of post-stroke care as the basis of our calculations which, although detailed and from a national sample, may have included a more selective sample of people with stroke compared to the more localised but routine data source used by Saka et al. (2009) (the South London Stroke Register). Also, we applied hourly wages of a professional carer to those informal care inputs that related to personal care activities, which generates higher costs than if we assumed that all informal care inputs involve only an opportunity cost of time to carers.

While we use plausible estimates throughout this work, our extensive sensitivity analyses (detailed in the full report) clearly show that alternative values and assumptions can generate different specific estimates. As is the case for all cost of illness studies, our figures thus represent an indicative, rather than definitive, estimate of the economic burden of stroke. Estimates of returns from investment in research are similarly indicative.

Appendix 2

Projections of future costs of stroke – age 45 and over, by country and type of cost (in £million)

ENGLAND			
Cost (£million)	2015	2025	2035
Health care	2,983	5,189	9,015
Social care - Public	2,148	4,163	7,936
Social care - Private	2,403	4,733	9,130
Social care - Total	13,675	21,453	37,300
Unpaid care	4,551	8,896	17,066
Lost productivity	1,305	2,012	3,106
Total	**22,514**	**37,550**	**66,487**

WALES			
Cost (£million)	2015	2025	2035
Health care	133	226	379
Social care - Public	96	183	338
Social care - Private	108	208	388
Social care - Total	204	392	726
Unpaid care	613	929	1,549
Lost productivity	58	85	123
Total	**1,008**	**1,631**	**2,776**

SCOTLAND			
Cost (£million)	2015	2025	2035
Health care	213	361	615
Social care - Public	152	285	542
Social care - Private	170	324	624
Social care - Total	323	610	1,166
Unpaid care	988	1,515	2,574
Lost productivity	97	149	218
Total	**1,620**	**2,634**	**4,572**

NORTHERN IRELAND			
Cost (£million)	2015	2025	2035
Health care	64	144	203
Social care - Public	45	89	178
Social care - Private	50	102	204
Social care - Total	96	191	382
Unpaid care	296	480	852
Lost productivity	29	48	74
Total	**484**	**832**	**1,510**

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