

The future cost of stroke in Ireland: an analysis of the potential impact of demographic change and implementation of evidence-based therapies

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Abstract

Background and purpose: this paper examines the impact of demographic change from 2007 to 2021 on the total cost of stroke in Ireland and analyses potential impacts of expanded access to stroke unit care and thrombolytic therapy on stroke outcomes and costs.

Methods: total costs of stroke are estimated for the projected number of stroke cases in 2021 in Ireland. Analysis also estimates the potential number of deaths or institutionalised cases averted among incident stroke cases in Ireland in 2007 at different rates of access to stroke unit care and thrombolytic therapy. Drawing on these results, total stroke costs in Ireland in 2007 are recalculated on the basis of the revised numbers of incident stroke patients estimated to survive stroke, and of the numbers estimated to reside at home rather than in a nursing home in the context of expanded access to stroke units or thrombolytic therapy.

Results: future costs of stroke in Ireland are estimated to increase by 52–57% between 2007 and 2021 on the basis of demographic change. The projected increase in aggregate stroke costs for all incident cases in 1 year in Ireland due to the delivery of stroke unit care and thrombolytic therapy can be offset to some extent by reductions in nursing home and other post-acute costs.

Keywords: stroke, cost of illness, demographic change, Ireland, stroke unit, older people

Introduction

Stroke is a leading cause of death and disability in the world [1–4]. The disease poses an important economic burden both in terms of direct costs, estimated to account for 2–5% of total health care costs in western countries [3, 5] and indirect costs of productivity foregone (e.g. informal care-giving) [6]. Drawing on Irish data, this paper examines the implications for aggregate stroke costs of demographic and epidemiological change, and of increased provision of evidence-based therapies for stroke which are known to reduce disability and mortality (e.g. endorsed by

the American Heart Association, the European Stroke Organisation and other international bodies).

Stroke incidence increases with age and there are concerns that population ageing in many countries in coming decades will lead to an increase in numbers at risk for stroke with consequent strain on stroke health care services and resources [7]. In Ireland, the proportion of the population aged over 65 years (accounting for 70% of stroke cases) is expected to increase from 11 to 15% by 2021 [8]. Stroke epidemiology is also changing with implications for incidence and survival patterns of stroke.

A high proportion of the total annual cost of stroke is due to the chronic phase of the illness (long-term nursing home care costs and indirect costs). Increasing access to evidence-based therapies such as stroke units and thrombolytic therapy can lead to improvements in stroke outcomes with implications for costs in the chronic phase (e.g. reduced need for long-term care). While the cost-effectiveness of these interventions has been examined [9, 10], there has been less focus on their overall budgetary implications. Given the constraints in health-care funding worldwide, budget impact analysis [11] is increasingly relevant in order to plan future services and allocate resources appropriately. In Ireland, the annual cost of stroke is estimated to be €489–€805 million, with direct costs accounting for 2–4% of total health expenditure [6].

This paper examines the impact of projected demographic and epidemiological change from 2007 to 2021 on the total cost of stroke in Ireland as well as the potential impact on total stroke costs of expanded access to stroke unit care and thrombolytic therapy. The analysis focuses on the outcomes and aggregate costs for stroke patients in their first year of stroke (i.e. incident stroke cases).

Methods and data

Baseline cost of stroke in 2007

The economic burden of stroke in Ireland was estimated for the year 2007 and the methods used have been previously reported [6]. Briefly, a prevalence-based study estimated the direct and indirect costs of stroke in Ireland from a societal perspective. The number of incident stroke cases were estimated using data from the North Dublin Population Stroke Study (a prospective cohort study of stroke and transient ischaemic attack in North Dublin city, population 294, 592, following internationally recommended methods for measuring incidence). Total stroke prevalence was estimated using data from the 2001 Health Module of the Quarterly National Household Survey in Ireland [12] and the World Health Organization Global Burden of Disease project [13]. Upper and lower estimates of total stroke prevalence were used for sensitivity analysis. Direct costs included acute hospital, in-patient rehabilitation, nursing home, specialist out-patient and general practitioner (GP) care, medication, community rehabilitation, aids, appliances and home modifications and voluntary stroke services. Indirect costs associated with informal care-giving for stroke patients and the costs of productivity foregone due to stroke illness or death were also estimated. Where possible, a bottom-up approach was adopted, whereby unit costs for specific services were combined with estimates of treatment utilisation rates.

Cost of stroke in 2021

Demographic change

Stroke prevalence in 2021 is first estimated based on projected changes in the composition and size of the Irish

population (i.e. estimated trends in fertility, mortality and migration) [8] with stroke incidence rates and stroke prevalence kept constant at 2007 levels [14]. Applying the same methodologies that were used to estimate stroke costs in 2007, direct and indirect costs of stroke are re-estimated based on the projected number of stroke cases in 2021.

Epidemiological change

Sensitivity analysis relaxes the assumption that there is no change in stroke epidemiology in Ireland between 2007 and 2021. International evidence on temporal trends in stroke incidence is mixed [15–18] although a recent systematic review of 56 population-based studies observed a decline in stroke incidence in high-income countries over the period 1970–2008 [16]. Data on temporal trends in stroke epidemiology are not available for Ireland [19]. International evidence suggests that implementation of preventive treatments and reductions in stroke risk factors have contributed to declining stroke incidence [15, 16]. Limited available Irish data indicate mixed progress on stroke risk factors with some improvements in smoking and alcohol consumption but deterioration in obesity, physical activity and diabetes levels in recent decades [20] and poor levels of hypertension management [21].

The projected population growth together with an increase in the proportion of older people between 2007 and 2021 are expected to increase total stroke prevalence in Ireland. However, the potential impacts on prevalence of changing patterns in stroke incidence, case fatality and survival duration are not known. One recent UK study observed a decline in stroke incidence and a concurrent increase in stroke prevalence over the period 1999–2008 [15]. We consider one conservative scenario whereby stroke incidence declines in line with international trends of 1% per annum. We assume that prevalence remains otherwise unchanged over and above any changes brought about by demographic change (e.g. changes in the duration of survival are not estimated). Sensitivity analysis of the full range of alternative scenarios for stroke incidence and prevalence is beyond the scope of this article.

Changes to stroke services: stroke outcomes

Stroke unit care

Drawing on available evidence, the number needed to treat (NNT) for stroke unit care to avert death/institutionalisation ranges from 8 to 30 [22]. To test for sensitivity, this paper estimates the number of deaths/institutionalised cases avoided where the NNT for stroke unit care is 30, 19 (the midpoint in the range) and 8. Only one stroke unit was identified in the Irish hospital sector in 2005 [23]. As changes to stroke service provision in Irish public acute hospitals are being phased in over time, this analysis estimates the potential number of deaths/institutionalised cases averted among incident stroke cases in Ireland in

2007 at different rates of stroke unit coverage (25–95%). The upper boundary of 95% coverage is consistent with other studies that have modelled changes in stroke service provision [24]. At each rate of stroke unit cover, the potential number of incident deaths/institutionalised cases averted is estimated at varying rates of NNT (30, 19, 8).

Thrombolytic therapy

The estimated NNT for thrombolytic therapy to achieve a positive functional outcome ranges from 20, to 15, to 7.4, where treatment is administered during the 181–270 min window after symptom onset [25–27]. At shorter intervals from symptom onset, the NNT range is lower. In 2005, thrombolytic therapy was administered to ~1% of acute stroke cases in Ireland [23], which is lower than observed in other countries [28]. This study estimates the potential number of additional positive functional outcomes among incident stroke cases in Ireland in 2007 with thrombolytic therapy rates varying from 5 to 20%. At each rate of cover, the potential number of incident deaths/dependent cases averted is estimated at varying rates of NNT (20, 15, 7.4).

Changes to stroke services: stroke costs

Stroke units

Drawing on the results from the above analysis on the potential positive outcomes from greater access to stroke units, adjustments are made to the discharge profile (i.e. home or nursing home) of incident stroke cases in 2007. For example, where access to stroke unit care is increased to 50%, and at an NNT of 19, the baseline numbers of incident stroke cases living at home and in a nursing home in 2007 are adjusted according to the projected number of deaths/institutionalised cases averted in this scenario. Where deaths are averted, the total number of stroke survivors increases and these are assumed in this analysis to reside at home on discharge (this can be re-examined in further analysis). Where institutionalised cases are averted, the number of cases estimated to be discharged to long-term care in 2007 is reduced and the number residing at home increases. To identify cost implications, it is important to separate out the estimated number of deaths averted (which could increase aggregate costs) from the number of institutionalised cases averted (which could reduce aggregate costs). In the absence of further evidence, the total number of adverse outcomes averted with the rollout of stroke units is split evenly between deaths averted and institutionalised cases, although this proportional split could be varied in further analysis. Total costs of stroke for incident cases in Ireland in 2007 are recalculated on the basis of the revised numbers of incident stroke patients who survive stroke and reside at home in the context of expanded access to stroke unit care. Acute hospital in-patient costs are adjusted to take into account the estimated costs of stroke

unit therapy relative to conventional care. Unfortunately, detailed Irish data are not available and international estimates vary widely, influenced by differences in stroke unit types and other factors. Drawing on recent Australian analysis, we estimate that the costs of stroke unit care are 31% higher than for conventional care [10]. For sensitivity, we also adopt a lower estimate (2%) of the cost of stroke unit care relative to conventional care obtained from international literature [29].

Thrombolytic therapy

Drawing on the results from the above analysis on the potential positive outcomes from greater access to thrombolytic therapy, adjustments are made to the discharge profile (i.e. at home or at nursing home) of incident stroke cases in 2007. For the purposes of analysis, positive outcomes are interpreted as the number of nursing home cases avoided. The focus here is on the number needed to treat with thrombolysis to avert dependent cases, given uncertainty in the literature about the potential for reducing deaths [25]. Total costs of stroke for incident cases in Ireland in 2007 are recalculated on the basis of the revised numbers of incident stroke patients who survive stroke and reside at home in the context of expanded access to thrombolytic therapy. Acute hospital in-patient costs are adjusted to take into account estimated costs of administering thrombolytic therapy. As with stroke unit care, consistent estimates of these costs are not available in Ireland. Drawing on available international literature, we estimate the cost of thrombolytic therapy increases average acute in-patient costs by 14% [30, 31].

Results

Cost of stroke in 2021

The Irish population is projected to increase by ~18% between 2007 and 2021 [8]. The total number of stroke cases in 2021, based on demographic change alone, is estimated to increase by 58% from 2007. Based on the projected increase in prevalence due to demographic change only, the future cost of stroke is estimated to be between €743 and €1,266 million in 2021 (in 2007 prices), an increase of 52–57% relative to the baseline in 2007 (€489–€805 million). In the scenario, where stroke incidence declines over the period, alongside demographic change, the future cost of stroke is estimated to be between €723 and €1,247 in 2021 (in 2007 prices).

Changes to stroke services: stroke outcomes

Stroke units

Table 1 presents the estimated number of incident stroke deaths/institutionalised cases that could have been avoided in Ireland in 2007 were stroke patients treated in a stroke unit. Estimates are presented for varying rates of the

effectiveness of stroke unit care (i.e. NNTs of 30, 19, 8), and at varying rates of stroke unit cover (25–95%). Where access to stroke unit cover is extended to 25% of cases, >1,300 cases would have been treated in a stroke unit and an estimated 46–172 deaths or institutionalised cases avoided in Ireland in 2007. Where stroke unit coverage reaches 95%, an estimated 175–652 deaths/institutionalised cases could have been averted.

Table 1. Potential annual number of incident stroke deaths/institutionalised/dependent cases averted with stroke unit care and thrombolytic therapy based on hospitalised cases of stroke in Ireland in 2007

	Number of deaths and institutionalised cases averted		
	NNT = 30	NNT = 19	NNT = 8
.....			
Levels of stroke unit cover			
Stroke unit cover at 25%	46	73	172
Stroke unit cover at 50%	92	145	345
Stroke unit cover at 95%	175	276	655
.....			
	Number of deaths and dependent cases averted		
	NNT = 20	NNT = 15	NNT = 7.4
.....			
Levels of thrombolysis cover			
Thrombolysis cover at 5%	9	13	25
Thrombolysis cover at 10%	19	25	51
Thrombolysis cover at 15%	28	38	76
Thrombolysis cover at 20%	38	50	102

Thrombolytic therapy

Table 1 also presents the estimated number of incident stroke deaths/dependent cases that could have been averted in Ireland in 2007 if thrombolysis was administered (where clinically appropriate) within 4.5 h of stroke symptom onset. Results are presented for varying rates of thrombolysis cover (5–20%) and at varying estimates of the effectiveness of thrombolysis (i.e. NNTs of 20, 15, 7.4). More than 3,700 cases of ischaemic stroke (ICD-10 code I63) were recorded in acute hospitals in 2007. With a thrombolysis rate of 5%, a potential 188 stroke patients could have been treated with thrombolytic therapy. At this rate of cover, the potential number of incident deaths/dependent cases that could have been averted was 9–25, where the NNT ranges from 20 to 7.4. At a thrombolysis rate of 20%, an estimated 38–102 deaths/dependent cases could have been averted. These are likely to be underestimates, because the potential number of deaths/dependent cases averted increases the earlier thrombolytic therapy is administered following the onset of stroke symptoms.

Changes to stroke services: stroke costs

Stroke units

The baseline aggregate cost of stroke for all incident cases in their first year of stroke in Ireland was estimated to be €174 million in 2007. Table 2 shows the impact on this aggregate cost in Ireland in 2007 where stroke units are rolled out to cover 25–95% of stroke patients, at varying rates of stroke unit effectiveness (i.e. NNTs of 30–8), and with acute in-patient costs projected to increase by 31% for those treated in a stroke unit. Where stroke units cover

Table 2. Estimated impact of stroke unit rollout on aggregate stroke incidence costs (2007, €000 and %)

	Baseline	NNT = 30		NNT = 19		NNT = 8	
		Increased stroke unit service	Change from baseline	Increased stroke unit service	Change from baseline	Increased stroke unit service	Change from baseline
	€000	€000	%	€000	%	€000	%
.....							
25% stroke unit cover							
Direct costs for incident cases	146,519	151,187	3.2	150,742	2.9	149,073	1.7
Indirect costs for incident cases	27,590	27,639	0.2	27,667	0.3	27,773	0.7
Total incident costs	174,108	178,826	2.7	178,409	2.5	176,846	1.6
50% stroke unit cover							
Direct costs for incident cases	146,519	155,856	6.4	154,966	5.8	151,628	3.5
Indirect costs for incident cases	27,590	27,688	0.4	27,744	0.6	27,956	1.3
Total incident costs	174,108	183,543	5.4	182,710	4.9	179,584	3.1
95% stroke unit cover							
Direct costs for incident cases	146,519	164,259	12.1	162,568	11.0	156,226	6.6
Indirect costs for incident cases	27,590	27,775	0.7	27,883	1.1	28,286	2.5
Total incident costs	174,108	192,035	10.3	190,451	9.4	184,512	6.0

50% of stroke patients and at an NNT of 19, the aggregate cost for all incident cases in 2007 is estimated to increase to €183 million (4.9% higher than the baseline). For each rate of stroke unit cover, lower NNTs are associated with smaller increases in total incident costs above the baseline. Over all scenarios, aggregate incidence costs are estimated to increase by no more than 10% above the baseline.

A more detailed breakdown of costs is presented in Supplementary data available in *Age and Ageing* online, Appendix 1 for the scenario with 50% stroke unit cover and an NNT of 19. The projected increases in acute care costs that are due to the delivery of stroke unit care, and in other costs (e.g. aggregate GP costs increase because of a higher number of stroke survivors), are offset to some extent by reductions in nursing home costs (i.e. fewer cases discharged to nursing homes). These costs are fully offset in the case where the cost of delivering stroke unit care is just 2% above that of conventional care, and aggregate incident costs decline by >1%.

Thrombolytic therapy

Table 3 shows the impact on aggregate incident costs in Ireland in 2007 if access to thrombolytic therapy for eligible patients was increased, at varying rates of effectiveness (i.e. NNTs of 20–7.4) and with acute in-patient costs projected to increase by 14% for those treated with thrombolysis. With

a thrombolysis rate of 5%, and at an NNT of 20, the aggregate cost for all incident cases in 2007 is estimated to stay almost unchanged (<0.1% increase). Increases in total acute in-patient costs are offset by reductions in aggregate nursing home and other costs. At lower NNTs, aggregate incident costs could fall below the baseline. Where the thrombolysis rate is 20%, and at an NNT of 7.4, aggregate incidence costs are estimated to fall by 1% below the baseline.

Discussion

Future costs of stroke

The growth in the number of stroke cases by 2021 due to demographic change alone could increase the future economic burden of stroke in Ireland by >50% relative to 2007. The scenario examined under sensitivity analysis demonstrates that declines in stroke incidence over time will have a downward impact on future stroke costs relative to the baseline scenario of no change in stroke epidemiology between 2007 and 2021. However, relative to the total economic burden of stroke, the impact is not large. This highlights the fact that it is the chronic phase of stroke that accounts for a large proportion of the costs associated with stroke. Measures to improve outcomes following stroke will lessen these longer-term costs. Further sensitivity analysis

Table 3. Estimated impact of thrombolysis rollout for ischaemic strokes on aggregate stroke incidence costs (2007, €000 and %)

	Baseline	NNT 20		NNT 15		NNT 7.4	
		Increased thrombolysis service €000	Change from baseline %	Increased thrombolysis service €000	Change from baseline %	Increased thrombolysis service €000	Change from baseline %
5% Thrombolysis cover							
Direct costs for incident cases	146,519	146,525	0.0	146,415	-0.1	145,964	-0.4
Indirect costs for incident cases	27,590	27,616	0.1	27,624	0.1	27,660	0.3
Total incident costs	174,108	174,141	0.0	174,040	0.0	173,624	-0.3
10% Thrombolysis cover							
Direct costs for incident cases	146,519	146,531	0.0	146,312	-0.1	145,410	-0.8
Indirect costs for incident cases	27,590	27,642	0.2	27,659	0.3	27,730	0.5
Total incident costs	174,108	174,173	0.0	173,971	-0.1	173,140	-0.6
15% Thrombolysis cover							
Direct costs for incident cases	146,519	146,537	0.0	146,208	-0.2	144,856	-1.1
Indirect costs for incident cases	27,590	27,668	0.3	27,693	0.4	27,800	0.8
Total incident costs	174,108	174,205	0.1	173,902	-0.1	172,656	-0.8
20% Thrombolysis cover							
Direct costs for incident cases	146,519	146,544	0.0	146,105	-0.3	144,302	-1.5
Indirect costs for incident cases	27,590	27,693	0.4	27,728	0.5	27,870	1.0
Total incident costs	174,108	174,237	0.1	173,833	-0.2	172,172	-1.1

in this area is therefore needed to examine alternative projections for stroke prevalence, underlining the importance of generating reliable Irish data on the factors driving stroke incidence and prevalence. Nevertheless, the findings presented here on the estimated future economic burden of stroke that is due to demographic change alone emphasise the importance of taking measures to prevent stroke, and to lower the cost burden associated with those strokes that do occur.

As discussed, measures to reduce the costs associated with the chronic phase of the illness are expected to have an important impact on the total cost burden of stroke. Apart from the costs of delivery, changes to stroke services have a number of implications for the economic burden of stroke. By increasing the number of stroke survivors and reducing the need for long-term care, the changes can have conflicting impacts on the overall costs of stroke. An increase in the number of patients living with the consequences of stroke (e.g. requiring rehabilitation, out-patient visits, medication etc.) will have an upward influence on aggregate direct costs. The impact on indirect costs is uncertain: fewer deaths reduce the total amount of productivity foregone due to mortality, but this could be counterbalanced by a greater number of people living with the consequences of stroke increasing productivity foregone due to illness. A reduction in the number of stroke patients requiring long-term nursing home care puts downward pressure on the total cost of stroke.

Analysis in this paper has shown that in the Irish context, there are potential savings that accrue from supporting a greater number of stroke patients to live at home rather than in a nursing home following stroke. These are achieved by increasing access to stroke unit care and thrombolytic therapy. These savings are shown to offset at least some of the aggregate costs of delivering those services to patients in the first year following a stroke. This is consistent with international evidence which finds that over a longer time horizon, there are net cost savings from expanded access to thrombolytic therapy [32], although similar analyses for the budget impact of stroke units are not available in the literature.

Data and methodological issues

In contrast to previous analysis in this area [33], this paper has examined the cost implications of expanded access to stroke units and thrombolytic therapy within a cost of illness framework. The cost savings can be directly compared with the overall economic burden of stroke allowing the findings to be set in context.

The outcome and cost implications of improving access to stroke units and thrombolytic therapy have been analysed separately. This partial approach does not allow for the assessment of the total impacts if the interventions were to be implemented concurrently. However, the sensitivity analysis around the estimates, allowing for varying rates of coverage and effectiveness, ensures conservative interpretation of the findings.

Costs of expanding access to stroke units and thrombolytic therapy have been estimated. This article

has demonstrated the scope for these delivery costs to be offset to some degree by savings in the numbers requiring long-term care. Further analysis is required to establish Irish-based estimates of the costs of delivering stroke unit and thrombolytic care over and above conventional care. The new national Cardiovascular Health Policy recommends that stroke services in Ireland are organised into stroke networks, each providing a range of services required for optimal stroke care [34]. Identifying the costs associated with these networks requires a detailed analysis of the potential for reconfiguration of existing staff and services, additional staffing requirements and skill mix. The estimated capital costs of establishing new stroke units have not been included in this analysis. The capital requirements for new stroke units vary across the system and in some cases can be accommodated within existing structures.

This article has focused on the potential savings in aggregate incident stroke costs that are associated with improved acute care within 1 year. By assuming a greater proportion of incident cases continue to live at home in the years following their stroke, there are potential savings in the long-term total prevalence stroke costs and these can be examined using appropriate decision-analytic modelling techniques.

In this analysis, the major savings occur in nursing home costs. The State contributes a high proportion of funding for long-term care, giving scope for public stroke resources that are saved in one area of the system to offset or partially offset increased public stroke costs at another point in the system.

Conclusions

The future economic burden of stroke is projected to increase in Ireland due to population ageing although declining stroke incidence may dampen the increase to some extent. Improved access to evidence-based treatments would support positive outcomes of fewer deaths and better quality of life for stroke survivors, with a greater number of stroke patients able to live at home rather than in a nursing home following stroke. These improved outcomes can be considered alongside the evidence provided in this article that there is potential for cost savings to offset to some degree the costs associated with improving the stroke services.

Key points

- Demographic change is estimated to increase the future cost of stroke in Ireland by 52–57% between 2007 and 2021.
 - Greater access to stroke unit care and thrombolytic therapy can improve outcomes and yield potential savings.
 - The projected increase in aggregate stroke costs for all incident cases in 1 year in Ireland due to the delivery of stroke unit care and thrombolytic therapy can be offset to some extent by reductions in nursing home and other post-acute costs.
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Conflicts of interest

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Supplementary data

Supplementary data mentioned in the text is available to subscribers in *Age and Ageing* online.

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Smoking, hypercholesterolaemia and hypertension as risk factors for cognitive impairment in older adults

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Abstract

Background: the prevalence of all types of cognitive impairment, including dementia, is increasing but knowledge of aetiological factors is still evolving.

Objective: this study aimed to evaluate the association between cardiovascular risk factors and cognitive function in older persons.

Design, setting and subjects: a population-based cohort design involving 2,312 men and women (aged 50–75) enrolled in the University of Edinburgh Aspirin for Asymptomatic Atherosclerosis trial.

Methods: cognitive tests included the Mill Hill Vocabulary Scale, auditory verbal learning test (AVLT), digit symbol test, verbal fluency test (VFT), Raven's Progressive Matrices and the trail making test. A 'g' score (measure of general intelligence) was computed for each subject. Regression analysis was used to evaluate the association between relevant variables.

Results: higher diastolic BP was negatively associated with AVLT ($\beta = -0.153$, $P < 0.01$), and with an estimated decline on AVLT ($\beta = -0.125$, $P < 0.01$). Smoking was negatively associated with all the cognitive variables except VFT. The total cholesterol level was not associated with cognitive function or estimated decline.

Conclusions: smoking and elevated blood pressure may be risk factors for cognitive decline, and thus potential targets for preventive and therapeutic interventions.

Keywords: hypertension, smoking, cholesterol, cognition, older people