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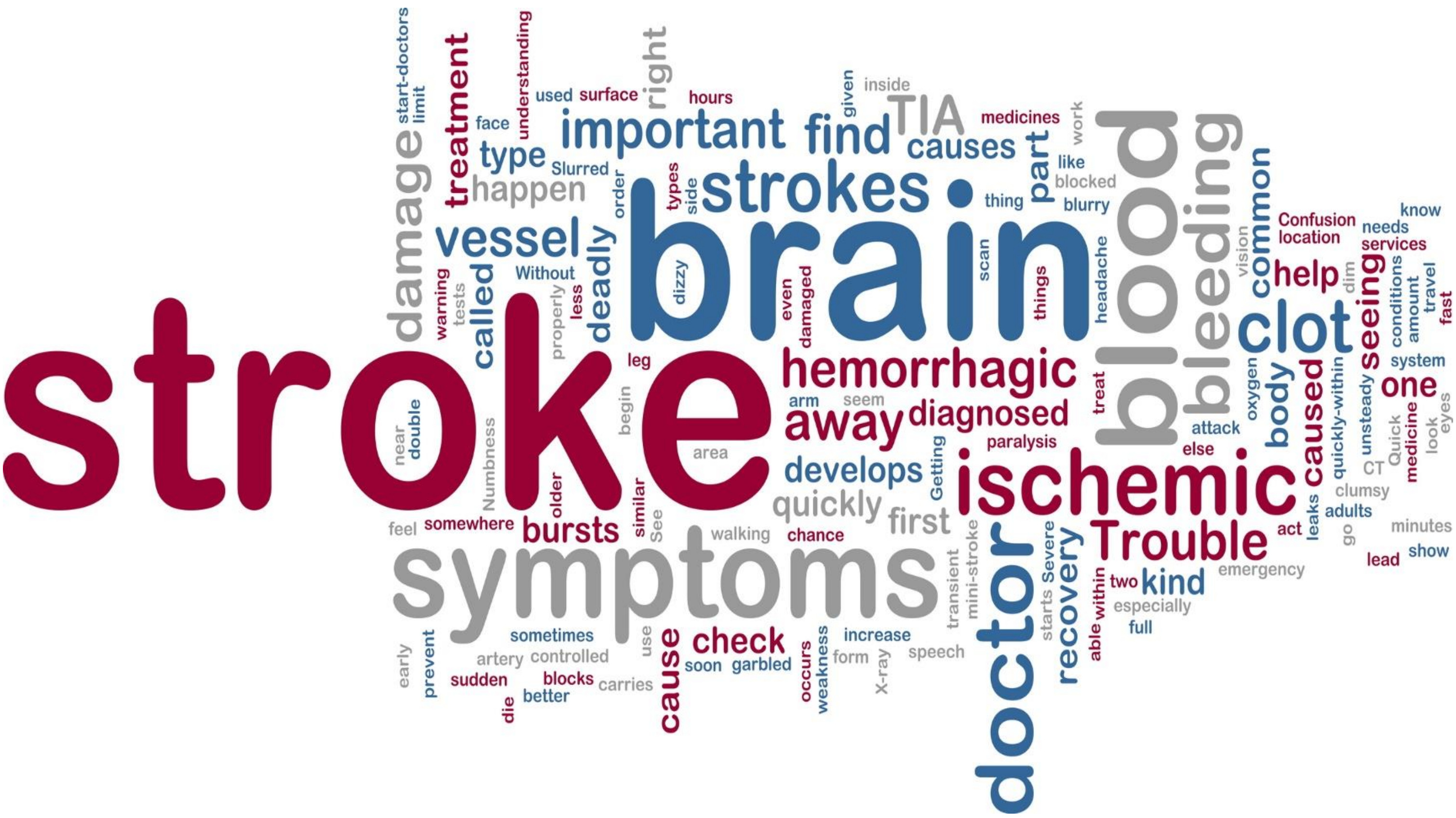

The social and economic costs of stroke in New Zealand – 2020 update

NZIER report to the Stroke Foundation

March 2020

About NZIER

NZIER is a specialist consulting firm that uses applied economic research and analysis to provide a wide range of strategic advice to clients in the public and private sectors, throughout New Zealand and Australia, and further afield.

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Each year NZIER devotes resources to undertake and make freely available economic research and thinking aimed at promoting a better understanding of New Zealand's important economic challenges.

NZIER was established in 1958.

Authorship

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2020 update – Key points

This report is an update of an original 2018 report finalised in February 2019. Specifically, for this update, NZIER was asked to:

- Estimate the annual social and economic costs of stroke in New Zealand with projected stroke costs to 2023 and 5 yearly to 2038.
- Include a section on equity to make clearer the disproportionate impact of stroke on Māori and Pacific.
- Include a section on acute stroke services with a focus on thrombectomy volumes and costs, projected through to 2038, and estimates of possible cost impact for increased thrombectomy rates.

The 2020 update did not include a new literature search or assessment of new evidence. As such, the framework and assumptions used in the 2018 report largely remain. Updated estimates are based on:

- The most up-to-date Ministry of Health data on stroke hospitalisations.
- Expected future stroke hospitalisations which we projected consistently with the methods used in Ranta (2018).
- Published estimates of the cost of thrombectomy and effectiveness of thrombectomy in reducing post-stroke disability.

Key points that were highlighted in 2018 remain true, most notably that Māori and Pacific people experience stroke at a significantly younger age and have not seen the outcome improvements that the overall New Zealand population has had.

The updated analysis also indicated that:

- An annual cohort of strokes in New Zealand based on the 2020 projected cohort is expected to incur over $1.3 billion in social and economic costs (including the value of lost quality of life and life years lost prematurely) over next five years (discounted to 2020).
- The discounted expected cost of a stroke over five years is approximately $105,000.
- The cost of stroke to New Zealand in 2020 is approximately $1.1 billion, projected to increase to $1.7 billion by 2038.

Our 2018 recommendations are still relevant, but the 2020 update highlights the urgency of investment to increase access to thrombectomy, initially by increasing thrombolysis rates to 20 percent. Catch-up investment in DHBs with particularly low rates and high proportion of Māori and Pacific populations is needed to ensure that the existing equity gap is narrowed and not widened as major centres increasingly perform thrombectomy, leaving provincial hospitals behind. Thrombectomy is a cost-effective intervention which could deliver disproportionate benefits to Māori and Pacific due to the earlier age of stroke onset in these populations.

Our projections suggest the stroke survivor population will increase by 55 to 60 percent by 2038, increasing the prevalence of disability in the general population (and in the Māori and Pacific populations disproportionately). This trend underscores the importance of investments that cost-effectively optimise quality of life and functional outcomes for survivors, delivered in a way that ensures equity of access.

Executive summary

What we found

Based on our most conservative assumptions and lowest cost results across all cost components, we estimate that a very conservative value for the 2020 cost of stroke to New Zealand is approximately $1.1 billion. With a growing and ageing population, the annual cost of stroke is projected to increase to $1.7 billion by 2038.

The total discounted five-year cost associated with the 12,410 hospitalised strokes projected for 2020, is over $1.3 billion. Each stroke costs New Zealand approximately $105,000 over five years. This estimate is consistent with other published estimates.

If the cost of premature death and quality of life are omitted, the total discounted five-year cost of an annual cohort of hospitalised strokes is still over $800 million.

We also present an indicative cost-benefit analysis of thrombectomy which, despite being a costly intervention, offers dramatic improvements in functional outcomes and reduced mortality.

Our analysis indicates that thrombectomy has the potential to be cost-saving from a societal perspective, due mainly to reduced aged residential care costs and improvements in quality of life, even with a low QALY threshold value. Extending access to thrombectomy, however, must be based on improved access to thrombolysis for Maori and Pacific people or existing ethnic disparities in stroke outcomes will be exacerbated.

The size of the burden

Stroke represents a significant disease burden for New Zealand. It is the third highest cause of death, accounting for 8.2 percent of all deaths in New Zealand and 4.2 percent of all premature deaths.

There has been a significant decrease in mortality from stroke over recent decades in developed countries. OECD data, however, places New Zealand above the OECD average for cerebrovascular disease mortality and suggests that the reduction in mortality achieved since 1990 has also been below the OECD average. New Zealand may be able to reduce the burden of stroke further, but the motivation to work to achieve this relies on decision-makers being aware of the costs of stroke as well as opportunities to improve.

Although stroke is associated with older age groups, 25 to 30 percent of strokes occur in people aged under 65. At any age, stroke can result in death, or for survivors, short-term or long-term impairment. Older stroke survivors face a higher risk of admission to residential care. Younger stroke survivors face a risk of impairment that has been shown to have a significant and long-lasting effect on employment and income. Māori and Pacific people are significantly more likely to experience stroke during their working lives – up to 15 years younger than New Zealand Europeans, resulting in a disproportionate social and economic burden from premature mortality and disability. When impairment is severe, informal caregiver burden increases or institutional care may be needed. These costs are as important to estimate as well as the direct medical costs of stroke.

The loss of quality of life (due to both impairment and the change of residence that often occurs post-stroke) and premature loss of life years are equally important costs of stroke. Anxiety and depression in stroke survivors are common and many struggle with the known risk of recurrent stroke and fear of the worst outcomes. These dimensions are rarely monetised, but because they matter to those at risk, as well as to stroke survivors and their families, it is important to at least attempt to capture some of the value. Our estimates suggest that to neglect these components is to ignore the major non-system costs of stroke.

Our approach

For this project, we were reliant on national level data and published evidence from stroke studies in New Zealand and, where necessary, from other jurisdictions. In 2018 we constructed a simplified model based on the number of hospitalised strokes in New Zealand in 2014 and published estimates of mortality, recurrent stroke, service use, and quality of life. For the 2020 update, we projected 2020 stroke hospitalisations and beyond – to 2038 – based on the most recently available stroke hospitalisation data.

Costs were derived from New Zealand sources (the Treasury CBAx model, Pharmac's cost manual, and New Zealand-based published cost studies) except for the cost of secondary stroke prevention which was derived from data from the North-East Melbourne Stroke Incidence Study (Gloede et al., 2014).

A high reliance on assumption, both implicit and explicit, is the necessary result of an approach that relies on averages and a simplified underlying epidemiological model to overcome a lack of data on specific populations. Because of this shortcoming, we made conservative assumptions about service use at every step. We included costs up to a maximum of five years from a stroke, even though many dimensions we captured, including quality of life and employment income, may continue to be affected for much longer. We discounted all future costs at the Treasury CBAx model default rate of six percent per annum.

The most controversial aspect of our analysis will be the inclusion and monetisation of the value of life years lost prematurely and quality of life lost due to stroke. These were quantified using high quality published evidence and monetised using the value of quality-adjusted life years in the Treasury CBAx model.

Based on our review of cost-effectiveness literature, improvements in stroke care can be associated with significant improvements in outcomes at low cost, and even with cost-savings when long term and indirect costs are considered. In line with these findings, NZIER recommends increased investment to:

- Improve stroke prevention for Māori and Pacific people to reduce the growing ethnic disparities in stroke incidence and mortality.
- Increase rates of thrombectomy for eligible patients by improving overall access and equity of access initially through increasing the thrombolysis rate to 20 percent, with catch-up investment in DHBs with particularly low rates and a high proportion of Māori and Pacific populations.
- Increase investment in in-hospital and community rehabilitation for all eligible stroke patients to reduce the associated social and economic burden of stroke.
- Develop guidelines for optimal use of early home-supported discharge.

- Investigate the potential for increased intensity of rehabilitation at different stages.
- Explore the potential for further ICT investments to improve access to specialist care.[1]

Overall, it will be important to consider that, with more people surviving stroke – our projections suggest the survivor population will increase by 55 to 60 percent by 2038 – the prevalence of disability in the general population (and in the Māori and Pacific populations disproportionately) is expected to increase. This is expected to increase demand for rehabilitation and residential care as well as income support and caregiver burden. This trend underscores the importance of balancing life-saving interventions with interventions that optimise quality of life and functional outcomes for survivors. Without focussed attention on outcomes for Māori and Pacific stroke survivors, there is significant risk (based on current trends) that improved treatment of stroke may exacerbate existing disparities.

An indicative cost-benefit analysis of thrombectomy conducted for this 2020 update indicates that thrombectomy has the potential to save lives and improve functional outcomes cost-effectively although the level of investment needed to meet demand is substantial. Cost-savings are demonstrated for this intervention with the inclusion of aged residential care costs and quality of life gains for those who achieve functional independence instead of severe disability. Although insufficient evidence was available to quantify benefits for different groups, the benefits for Māori and Pacific people are likely to be greater due to their younger age and higher mortality rates.

Our caveats

We sought to capture the full cost impact of stroke in a way that is consistent with the Treasury CBAx approach, which encourages monetisation of non-market values and provides a value for quality-adjusted life years. We recognise, however, that our valuation of life years lost prematurely and of lost quality of life may be controversial. For this reason, we present results with and without these dimensions.

Without analysis of individual-level, linked data, accuracy and a high degree of granularity are not possible. Our cost model is based on a number of simple assumptions to make a complex picture manageable enough to generate broad estimates. These estimates should not be taken as conclusive, but rather indicative of rough magnitudes in costs and of areas where more in-depth research is warranted.

[1] Evidence from overseas suggests that high-volume hospitals produce better outcomes. If this is true in New Zealand, ICT investment to enable skill-sharing may be one way to address disparities.

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1. The burden of stroke in New Zealand

The burden of stroke is an important concept to understand because it has a direct bearing on the level of investment warranted to address the problem.

Research, funding for which is often motivated by a sense of 'the size of the prize', may identify opportunities and interventions to reduce the burden of stroke. Evidence suggests that optimal management of stroke can significantly improve both short-term and long-term outcomes.

Strokes are largely preventable (Lancet 2016), and some progress has been made in reducing key risk factors (such as smoking). Some reduction in the impact of stroke has been achieved in New Zealand in recent years (see section 1.3.1) due mainly to a reduction in mortality from stroke and only in small part to a reduction in the incidence of stroke.

With more and more people surviving strokes however, the prevalence of stroke-related disability is expected to increase (Tobias et al. 2007). In turn, this will increase the demand for stroke rehabilitation services as well as the potential total savings associated with optimising stroke rehabilitation as well as secondary stroke prevention. This trend is likely to be reinforced by population ageing.

1.1. Background

Stroke is a cerebrovascular condition which increases in incidence as people age. It can cause significant disability and premature death. It occurs when the blood supply to the brain is cut off, often as a result of a blood clot or a bleed. Mortality rates are high, particularly in haemorrhagic stroke, which is more likely in younger people. Rehabilitation after stroke can be short-term or long-term, and disability can gradually improve or be permanent.

Risk factors associated with cerebrovascular disease include:

- High blood cholesterol level
- High blood pressure
- Smoking
- Diabetes
- A family history of atherosclerotic disease
- Ageing, which increases risk of atherosclerosis.

There are three major types of stroke according to the Centres for Disease Control. These are:

- Transient ischaemic attack (TIA)
- Ischaemic stroke
- Haemorrhage stoke which in turn can be Intracerebral or Subarachnoid.

Transient ischaemic attacks (warning or mini-strokes) often go unrecognised and do not necessarily develop into a further stroke. As a result, these are less likely to result in treatment or hospitalisation, or ongoing effects. However, the increased risk of another more significant stroke, has led to calls for increased public awareness and better education for the primary health sector and care workers to improve recognition of and response to TIAs.

The other two types are more likely to result in hospitalisation, treatment and ongoing impairment or death. As a result, there is also better data available to describe these types of stroke.

In practice, the heterogeneity of stroke patients means that some patients will experience little health loss while others experience long term reduction in quality of life and others' lives are ended prematurely.

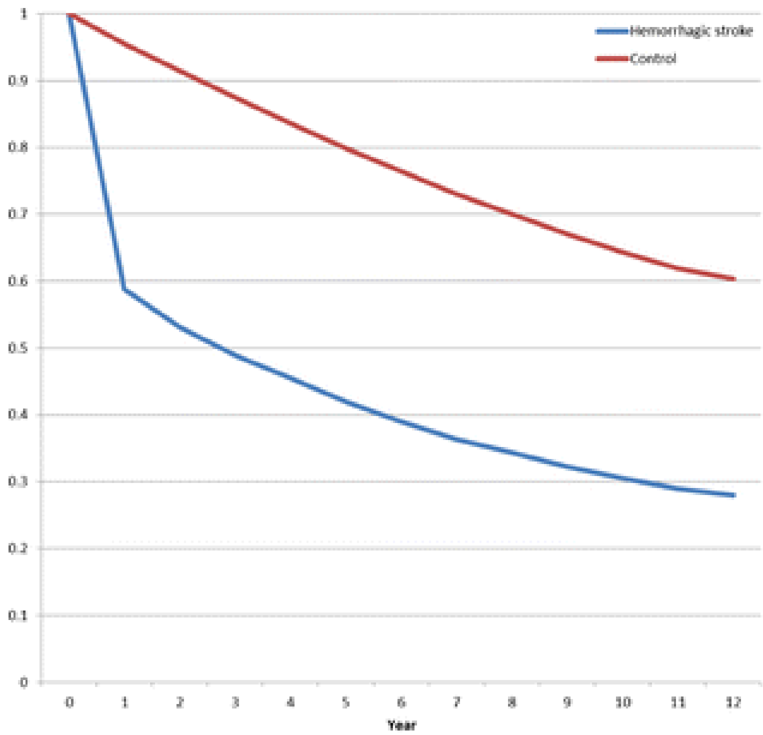
According to the UK Stroke Association, 1 in 8 strokes are fatal within the first 30 days and 1 in 4 strokes are fatal within a year.

A fatal stroke results in a number of life years lost, based on the life expectancy that the stroke victim had at the age they were when the fatal stroke occurred. But non-fatal strokes are also known to shorten lives, reducing life expectancy for survivors.

Survival of stroke patients relative to matched controls was mapped out by Jennum et al. (2015) and the resulting survival curves are shown in Figure 1 and Figure 2 below.

Figure 1 Survival of haemorrhagic stroke patients compared with matched controls

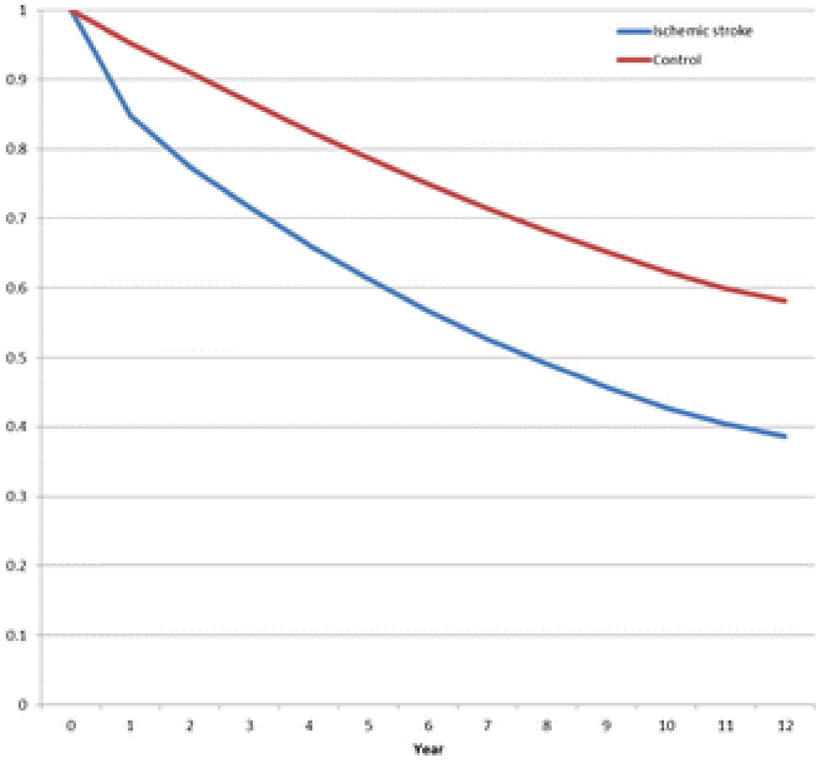
(probability of survival at 0-12 years post-stroke)



Source: Jennum et al., 2015

Figure 2 Survival of ischaemic stroke patients versus matched controls

(probability of survival at 0-12 years post-stroke)



Source: Jennum et al., 2015

In managing patients who survive the immediate effects of stroke, a rehabilitation service associated with the hospital will assess patients as belonging to one of several categories (McNaughton et al., 2005), typically including:

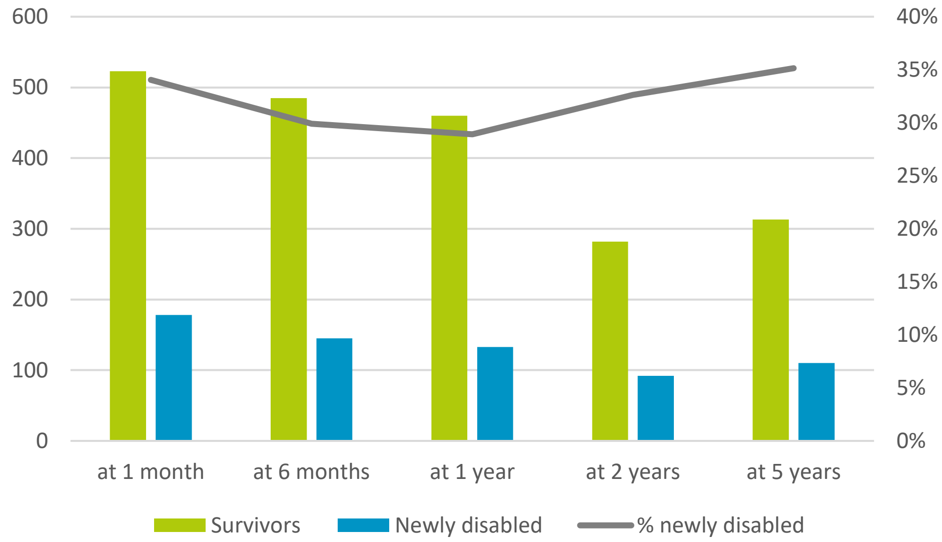
- Likely to die in hospital. These will be managed in a general medical ward.
- Needing long-term institutional care and unlikely to benefit from short-term inpatient rehabilitation. These are generally discharged to institutional care.
- May benefit from short-term inpatient rehabilitation. These are generally transferred to inpatient rehabilitation services.

Stroke prevention, treatment and rehabilitation achieves a number of objectives, as well as survival, including the ability to: maintain employment or to return to employment after rehabilitation, to continue living independently and avoid long term residential care, to avoid further strokes and maximising quality of life.

Disability post-stroke is an important dimension for both employment and quality of life.

Luengo-Fernandez et al. (2013) followed surviving stroke patients in the Oxford Vascular Study for 5 years post-event and identified the presence of new disability at 1 month, 6 months, 1 year, 2 years and 5 years. The study showed that there was a marked increase in the prevalence of disability in stroke patients at one month compared with their pre-stroke disability (43 percent disabled compared with 21 percent disabled, for a new disability impact on 32 percent of stroke patients). Changes in the prevalence of new disability shows that stroke survivors do improve in terms of functional impairment over the first-year post-stroke. However, disability that was not pre-existing remains common and even increases somewhat up to 5 years post-stroke.

Figure 3 New disability in stroke survivors



Source: Based on Luengo-Fernandez et al., 2013

Ganesh et al. (2017) examined outcomes in stroke trials based on a 3-month modified Rankin scale (mRS) as well as death and disability at 1- and 5-years post-stroke. The results suggest that, although later recovery does occur in some stroke survivors, extending follow-up to only 1 year is mostly sufficient to identify long term stroke-related disability. This result suggests that the increase in new disability shown in Figure 3 above after 1 year may not be directly stroke-related. Disability may be a direct consequence of falls, but falls are also more likely after a stroke (studies have found that up to 37 percent of stroke survivors experience a fall between 1 and 6 months post-stroke and up to 73 percent have fallen by one year, with many falls resulting in injury and fracture).

Overall, stroke is the third highest cause of death, accounting for 8.2 percent of all deaths in New Zealand and 4.2 percent of all premature deaths – defined as deaths before age 75. Based on life expectancy at the mid-point of each age group (averaged over males and females) published in the Statistics New Zealand Complete Period Life Tables 2012-14, premature deaths due to stroke result in an average of 22.37 years of life lost and a total of 10,736 years of life lost over all premature stroke deaths in New Zealand in 2014 (see Table 1 below).

Table 1 Stroke deaths versus deaths from all causes, by age group

New Zealand, 2014

Age	Total deaths from all causes	Total stroke deaths	Stroke deaths as % of total	Approximate average years of life lost per death	Approximate total years of life lost prematurely
0	331	0	0	81.33	0
1	27	0	0	80.70	0
2	8	0	0	79.73	0
3	10	0	0	78.75	0
4	10	0	0	77.76	0
5-9	37	0	0	73.80	0
10-14	27	0	0	69.84	0
15-19	126	0	0	64.92	0
20-24	162	1	0.6%	60.10	60.10
25-29	153	0	0.0%	55.26	0.00
30-34	170	1	0.6%	50.40	50.40
35-39	233	5	2.1%	45.58	227.89
40-44	393	20	5.1%	40.79	815.87
45-49	588	25	4.3%	36.08	901.94
50-54	987	50	5.1%	31.47	1573.42
55-59	1,265	56	4.4%	26.98	1511.00
60-64	1,688	63	3.7%	22.63	1425.61
65-69	,2321	101	4.4%	18.46	1864.51
70-74	2,860	158	5.5%	14.59	2305.61
Total Premature	**11,396**	**480**	**4.2%**	**22.37**	**10,736**
75-79	3,600	306	8.5%		
80-84	4,861	469	9.6%		
85+	11,307	1,314	11.6%		
TOTAL	**31,164**	**2,569**	**8.2%**		

Source: Ministry of Health, 2014

In addition to the burden of mortality, many stroke survivors suffer from continuing physical, cognitive and emotional issues including motor deficit, vision problems, speech impediments, lack of confidence and depression.

Table 2 below shows how important cerebrovascular disease is in comparison to other causes of mortality.

Table 2 Cerebrovascular disease amongst other causes of mortality

Selected causes of mortality 2016

Condition	Total deaths	Percentage of deaths		Māori rate		Non-Māori rate	
		Male	Female	Male	Female	Male	Female
All cancers	9,516	52.8	47.2	206.9	175.5	126.2	97.4
Lung cancer*	1,758	53.4	46.6	58.6	61.7	22.1	16.1
Colon, rectum and rectosigmoid junction cancer	1,268	50.4	49.6	19.6	9.8	16.6	13.3
Breast cancer	673	0.9	99.1	0.8	21.8	0.1	16.8
Prostate cancer	590	100.0	-	22.1	-	13.6	-
Melanoma of the skin	363	66.9	33.1	1.8	1.9	6.7	2.9
Cervical cancer	55	-	100.0	-	3.0	-	1.4
Ischaemic heart disease	4,662	57.1	42.9	135.5	63.6	61.6	31.0
Cerebrovascular disease	2,321	39.3	60.7	32.0	30.8	21.0	22.7
Diabetes mellitus	843	53.0	47.0	43.6	26.0	9.1	6.9

* Includes cancer of the trachea, bronchus and lung

Rates per 100,000 population, age standardised to WHO World Standard Population

- = Not applicable

Source: Ministry of Health, 2019

1.2. Trends

There are several important trends that inform our expectations of the future burden of stroke on New Zealand, including trends in:

- Health loss
- Risk factors
- Stroke recognition
- Incidence and prevalence
- Types of stroke
- Survival.

1.2.1. Trends in health loss

Despite mixed progress on stroke risk factors, there has been a significant reduction in age-adjusted health loss rates attributed to stroke over time. The improvement in 28-day case fatality rates overall (shown in Figure 4 below) is equivalent to a 43.2 percent reduction in fatalities between 1981-82 and 2011-12 and a 9.2 percent reduction in fatalities between 2002-03 and 2011-12.

Between 1990 and 2013, stroke fell from 7th to 8th most important cause of health loss for men, from 3.5 percent to 2.7 percent of disability-adjusted life years (DALYs) lost; and, from 3rd most important to 8th most important cause of health loss for women, from 4.7 to 3.4 percent of DALYs lost (see Figure 4 below).

Figure 4 Contribution of 'top 20' leading major specific conditions to health loss (% total DALYs), whole of population, by gender, 1990 and 2013

Males

1990		
Rank	**Condition**	**%**
1	CHD	14.9
2	Transport injury	7.0
3	Back disorders	6.6
4	Lung cancer	3.7
5	COPD	3.6
6	Self harm	3.5
7	Stroke	3.5
8	Addictive disorders	2.4
9	Bowel cancer	2.3
10	Asthma	2.3

2013		
Rank	**Condition**	**%**
1	CHD	10.1
2	Back disorders	8.2
3	COPD	3.7
4	Lung cancer	3.4
5	Transport injury	3.4
6	Self harm	3.2
7	Diabetes	2.9
8	Stroke	2.7
9	Addictive disorders	2.7
10	Bowel cancer	2.6

Females

1990		
Rank	**Condition**	**%**
1	CHD	9.2
2	Back disorders	7.9
3	Stroke	4.7
4	Depressive disorders	4.2
5	Breast cancer	3.7
6	COPD	3.4
7	Anxiety disorders	3.3
8	Transport injury	3.2
9	Asthma	2.8
10	Skin diseases	2.6

2013		
Rank	**Condition**	**%**
1	Back disorders	9.7
2	CHD	5.8
3	Depressive disorders	4.7
4	COPD	4.1
5	Dementia	4.0
6	Anxiety disorders	3.6
7	Breast cancer	3.4
8	Stroke	3.4
9	Lung cancer	2.9
10	Asthma	2.7

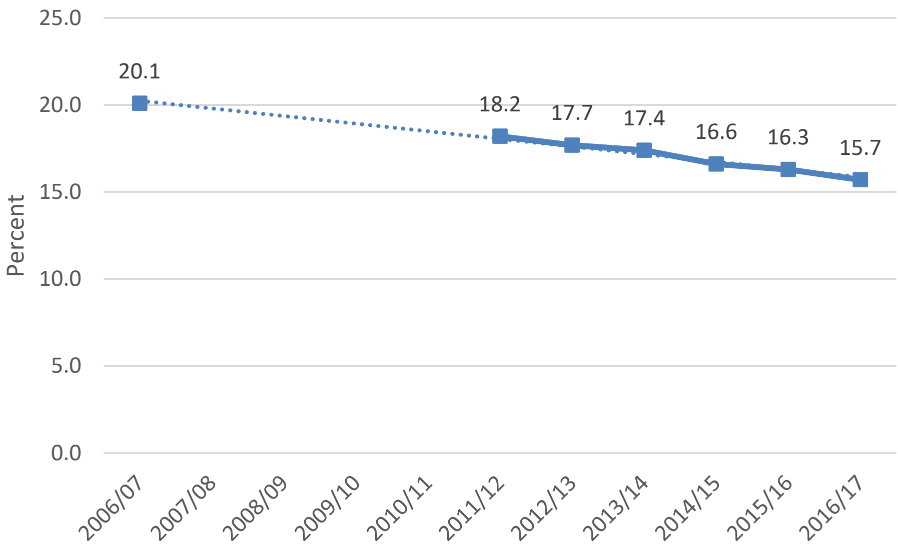
Source: Ministry of Health, 2016

Between 1990 and 2015 (projected from 2013 data – Ministry of Health 2016), health loss from stroke is estimated to have reduced from 4.7 percent to 3.6 percent of total health loss. This improvement is equivalent to a 23 percent reduction in the burden of stroke over 25 years.

1.2.2. Trends in risk factors

Ceteris paribus, the incidence of stroke and its burden would be expected to reflect the population prevalence of some of the major risk factors for stroke: Smoking, high blood pressure, myocardial infarction (a sub-group of ischaemic heart disease) and diabetes mellitus. Smoking rates in New Zealand have declined (see Figure 5 below) and this might have contributed to reduced risk of stroke, however other risk factors have increased in prevalence, including high blood pressure (see Figure 6), and ischaemic heart disease.

Figure 5 New Zealand current smokers aged 15+, 2006/07 to 2016/17*

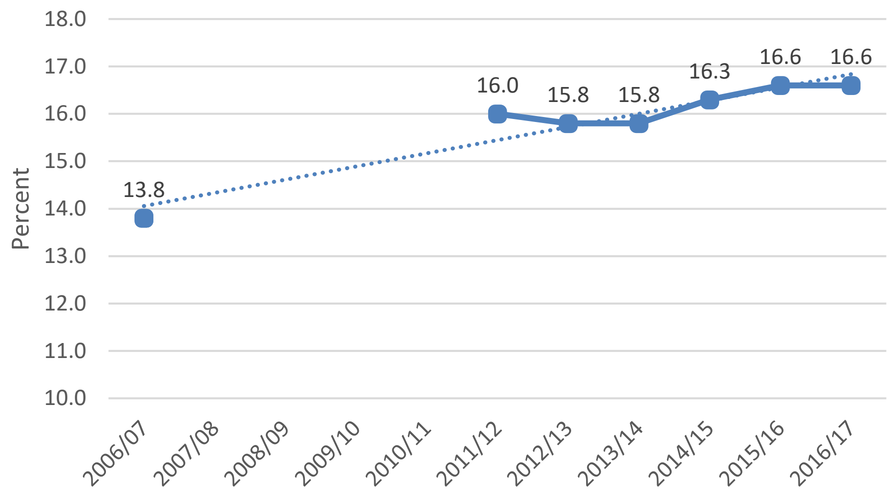


*The New Zealand Health Survey did not collect data about smoking between 2006/07 and 2011/12.

Source: NZIER, based on data from the New Zealand Health Survey 2016-17 annual data explorer

Figure 6 below shows a gradual increase in the prevalence of high blood pressure in New Zealand, from 13.8 percent in 2006/07 to 16.6 percent in 2016/17.

Figure 6 Prevalence of high blood pressure in New Zealand, 2006/07 to 2016/17*

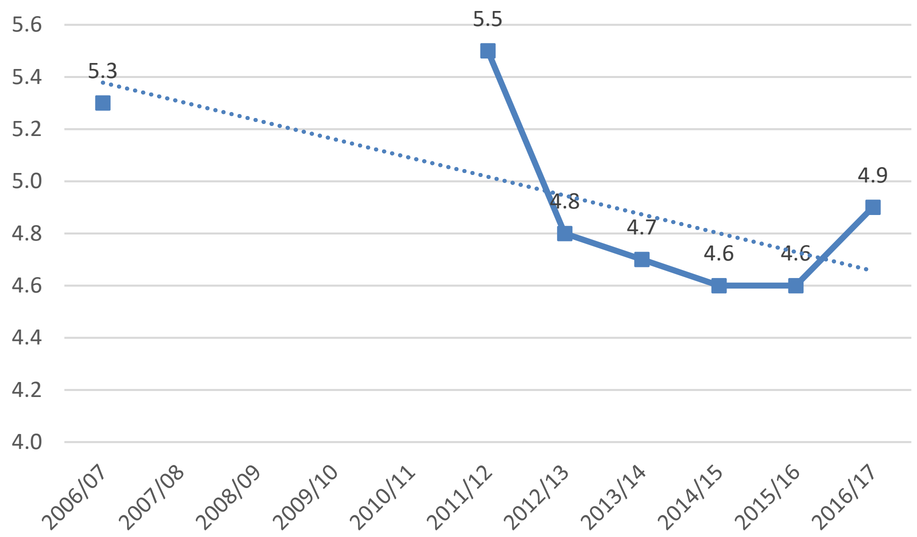


*The New Zealand Health Survey did not collect data about high blood pressure between 2006/07 and 2011/12.

Source: NZIER, based on data from the New Zealand Health Survey 2016-17 annual data explorer

Figure 7 below shows a possible declining trend in the prevalence of ischaemic heart disease in New Zealand, although recorded prevalence rates have been somewhat volatile.

Figure 7 Prevalence of ischaemic heart disease in New Zealand, 2006/07 to 2016/17*



*The New Zealand Health Survey did not collect data about ischaemic heart disease diagnosis between 2006/07 and 2011/12.

Source: NZIER, based on data from the New Zealand Health Survey 2016-17 annual data explorer

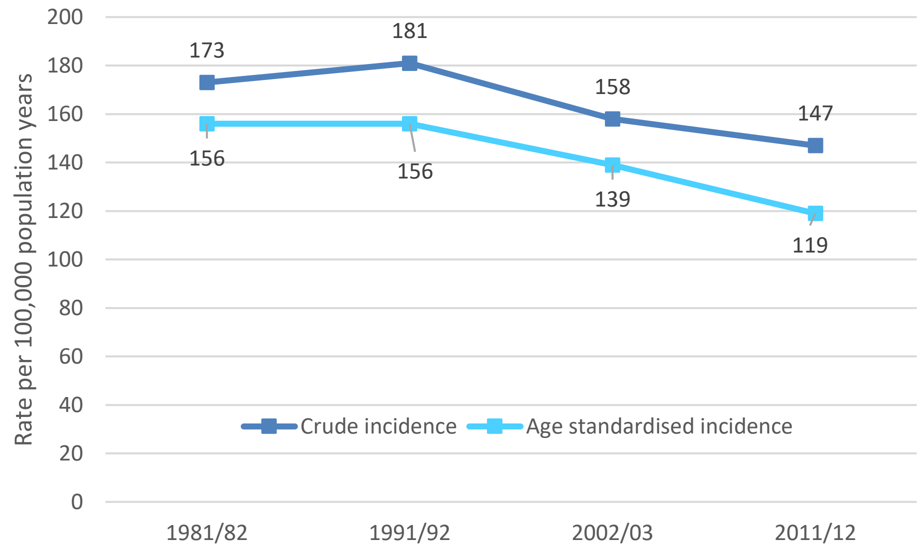
1.2.3. Trends in incidence and prevalence

Despite increases in some risk factors, both the incidence and prevalence rates of stroke are slowly falling. This may be due to decreases in key risk factors like smoking, and better management of others, like high blood pressure.

The incidence of stroke is a measure of the proportion of the population that experiences a stroke in any given year. The Auckland Regional Community Stroke (ARCOS) studies demonstrated that both the crude incidence and age-standardised incidence of stroke fell significantly between 1981/82 and 2011/12 (see Figure 8 below). Although the crude incidence of stroke fell by only 15 percent, the reduction in the age-standardised rate was 24 percent, indicating unsurprisingly that population ageing has hampered progress in reducing stroke incidence.

Figure 8 Incidence of stroke in New Zealand, 1981/82 to 2011/12

Based on the ARCOS (Auckland) studies



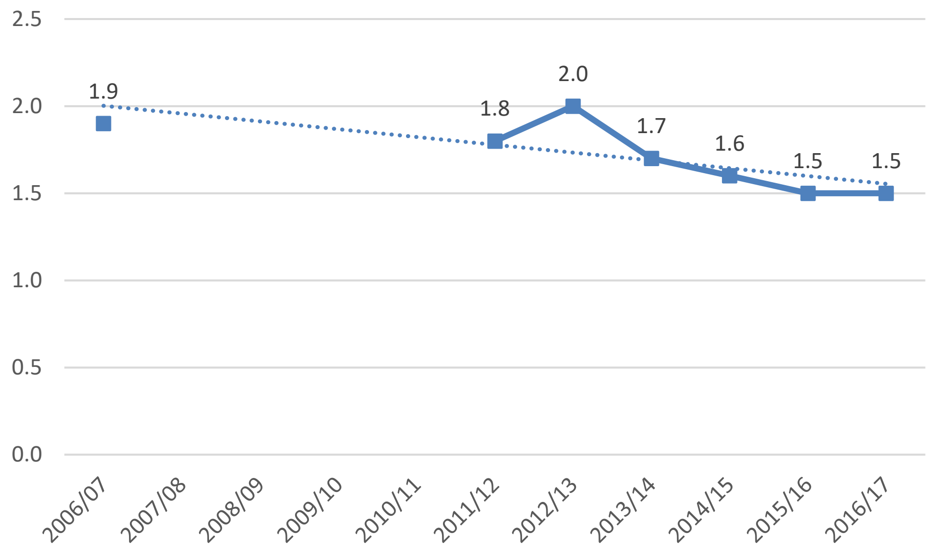
*The New Zealand Health Survey did not collect data about ischaemic heart disease diagnosis between 2006/07 and 2011/12.

Source: NZIER, based on data from Feigin et al., 2015

The New Zealand Health Survey indicates that the prevalence of stroke has also been falling. The prevalence of stroke is a measure of the proportion of the population that has ever had a stroke at any time (see Figure 9 below).

Figure 9 Prevalence of stroke in New Zealand, 2006/07 to 2016/17

Population aged 15+



*The New Zealand Health Survey did not collect data about stroke diagnosis between 2006/07 and 2011/12.

Source: NZIER, based on data from the New Zealand Health Survey 2016-17 annual data explorer

1.2.4. Trends in types of stroke

The ARCOS studies began collecting data separately on the three major types of stroke in 2002-03, at which time ischaemic stroke represented at least 71.2 percent of all hospitalised strokes, followed by primary intracerebral haemorrhage at 12.2 percent and subarachnoid haemorrhage at 5 percent. The change in the proportion of ischaemic stroke from 71.2 percent in 2002-03 to 80.8 percent in 2011-2012, while little change occurred in the proportions of other strokes and undetermined stroke types fell dramatically, suggests that the vast majority of undetermined strokes were actually ischaemic strokes.

Table 3 Pathological type of stroke in New Zealand, 1981/82 to 2011/12

Based on the ARCOS (Auckland) studies

	1981-82	1991-92	2002-03	2011-12
Ischaemic stroke	N/A	N/A	71.2	80.8
Primary intracerebral haemorrhage	N/A	N/A	12.2	13.1
Subarachnoid haemorrhage	6.6	4.3	5.0	4.2
Undetermined	N/A	N/A	11.7	1.9

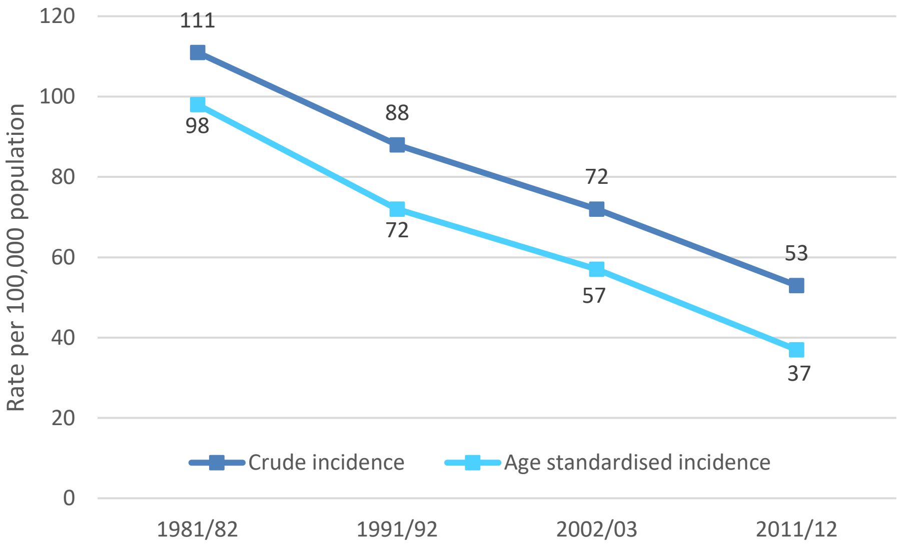
Source: Feigin et al., 2015

1.2.5. Trends in survival

Population-based data from the four ARCOS studies between 1981 and 2012 demonstrated that crude and age-standardised one-year mortality rate (number of deaths occurring within one year of a stroke per 100,000 population) decreased by 52 and 62 percent, respectively between 1981/82 and 2011/12 (Feigin et al., 2015). This is shown in Figure 10 below.

Figure 10 One-year stroke mortality rates in New Zealand, 1981/82 to 2011/12

Based on the ARCOS (Auckland) studies



Source: NZIER, based on data from Feigin et al., 2015

1.3. Equity

The burden of stroke in New Zealand is different for different people, but similarly to many health conditions, there is a significant disparity between Māori and Pacific populations on the one hand and the non-Māori, non-Pacific population.

According to the Ministry of Health (2016), Māori have up to 1.5 times the non-Māori stroke mortality rate, meaning Māori are 50 percent more likely to die of stroke than non-Māori. (see Table 4 below).

Table 4 Cerebrovascular disease amongst other causes of mortality

Selected causes of mortality 2016

Condition	Total deaths	Percentage of deaths		Māori rate		Non-Māori rate	
		Male	Female	Male	Female	Male	Female
All cancers	9,516	52.8	47.2	206.9	175.5	126.2	97.4
Lung cancer*	1,758	53.4	46.6	58.6	61.7	22.1	16.1
Colon, rectum and rectosigmoid junction cancer	1,268	50.4	49.6	19.6	9.8	16.6	13.3
Breast cancer	673	0.9	99.1	0.8	21.8	0.1	16.8
Prostate cancer	590	100.0	-	22.1	-	13.6	-
Melanoma of the skin	363	66.9	33.1	1.8	1.9	6.7	2.9
Cervical cancer	55	-	100.0	-	3.0	-	1.4
Ischaemic heart disease	4,662	57.1	42.9	135.5	63.6	61.6	31.0
Cerebrovascular disease	2,321	39.3	60.7	32.0	30.8	21.0	22.7
Diabetes mellitus	843	53.0	47.0	43.6	26.0	9.1	6.9

* Includes cancer of the trachea, bronchus and lung.

Rates per 100,000 population, age standardised to WHO World Standard Population

- = Not applicable

Source: Ministry of Health, 2016

Feigin et al. (2015) combined the four ARCOS studies from 1981-82, 1991-92, 2002-03 and 2011-12 to identify 30-year trends in stroke incidence, case fatality and mortality for New Zealand's four major ethnic groups. The results of this study suggest that 28-day case fatality has fallen from 33.1 percent in 1982-83 to 18.8 percent in 2011-12, with the biggest reductions being in the Māori, Pacific and Asian/other ethnicities. In 2011-12, NZ/European people experiencing stroke had the lowest probability of survival at 28 days. These trends are shown in Table 5 below.

Table 5 Thirty-year trends in 28-day case fatality by ethnicity

Based on the ARCOS (Auckland) studies

	1981-82	1991-92	2002-03	2011-12
NZ/European	32.7	23.6	21.2	19.5
Māori	30.0	24.4	23.5	16.7
Pacific	43.8	28.8	19.8	15.9
Asian/other	50.0	19.4	14.8	18.7
Overall	33.1	23.9	20.7	18.8

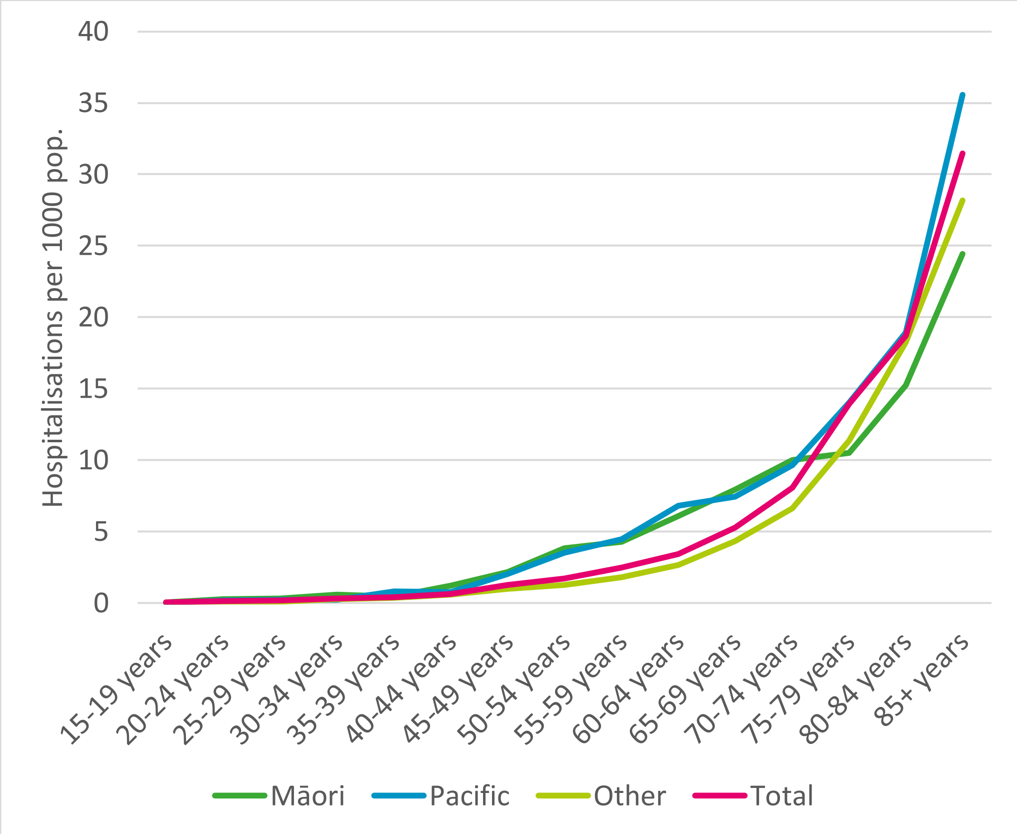
Source: Feigin et al., 2015

However, the age at which stroke occurs can have an important impact on the social and economic consequences of stroke outcomes.

From age 45, it becomes apparent that the rate of stroke hospitalisations is significantly higher for Māori and Pacific people than for people of other ethnicities (combined).

Figure 11 Stroke hospitalisation rate per 1,000 population, by ethnicity

Year Ended June 2017



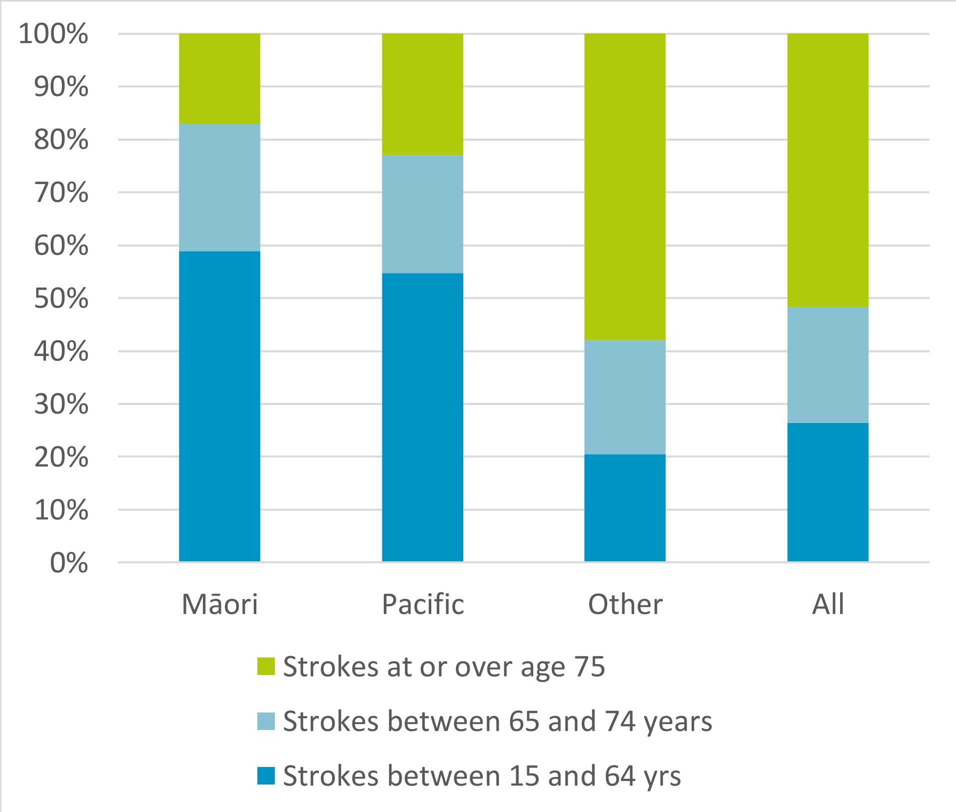
Source: NZIER, based on Ministry of Health data (Ministry of Health, 2018)

These differences translate into a very different picture of a typical stroke in Māori and Pacific than in people of European and other ethnicities (combined).

As shown in Figure 12 below, nearly 60 percent of strokes in Māori and Pacific people occur between age 15 and 65, compared with only 20 percent of strokes in people of European and other ethnicities (grouped).

Figure 12 Percentage of strokes in people of working age vs older people, by ethnicity

Based on 2016/17 hospitalisations with ICD-10 code I60-I69 (Cerebrovascular diseases)



Source: NZIER, based on Ministry of Health data (Ministry of Health, 2018)

Strokes in working age people can have a financially and emotionally devastating effect on families as a result of death or disability of a primary income earner or caregiver. Māori and Pacific families are nearly three times as likely as non-Māori, non-Pacific families to experience these effects first-hand.

As shown in Table 6 below, Māori people of working age are 4 to 12 times more likely to die of cerebrovascular disease than non-Māori people of the same age and sex.

Table 6 Percentage distribution of deaths from cerebrovascular disease in New Zealand

By age group, sex, and ethnicity, 2006

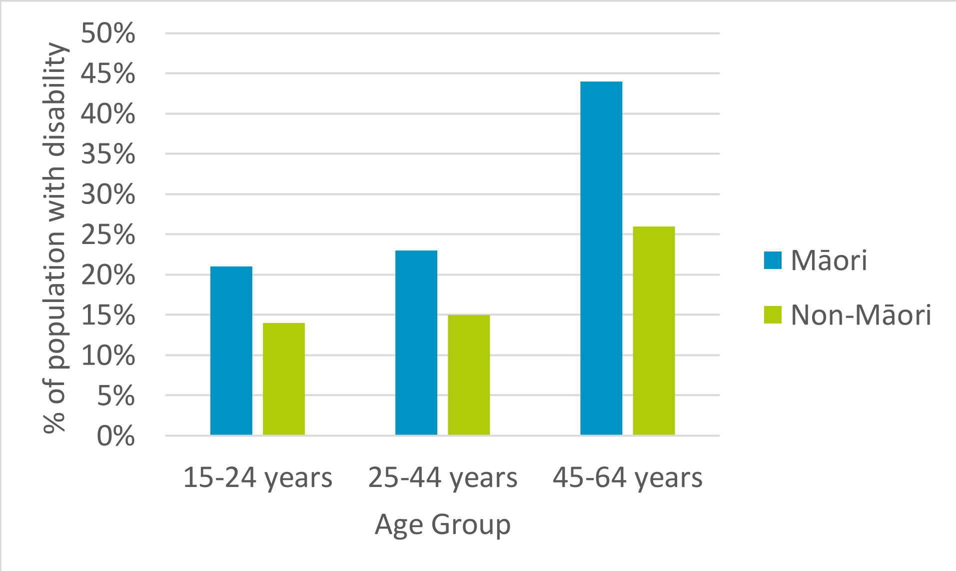
	Māori			Non-Māori		
	Total	Male	Female	Total	Male	Female
<25	0.0	0.0	0.0	0.0	0.0	0.1
25-44	11.1	7.4	13.6	1.3	1.7	1.1
45-64	24.4	31.5	19.8	5.2	7.1	4.1
65+	64.4	61.1	66.7	93.4	91.2	94.7

Source: Ministry of Health, 2009

The high incidence of stroke in working age Māori is one factor explaining the higher rates of disability observed amongst working age Māori – Māori are up to 70 percent more likely than non-Māori to experience disability between the ages of 15 and 64 (Statistics New Zealand, 2014).

Figure 13 Disability in working age Māori vs Non-Māori

By age group

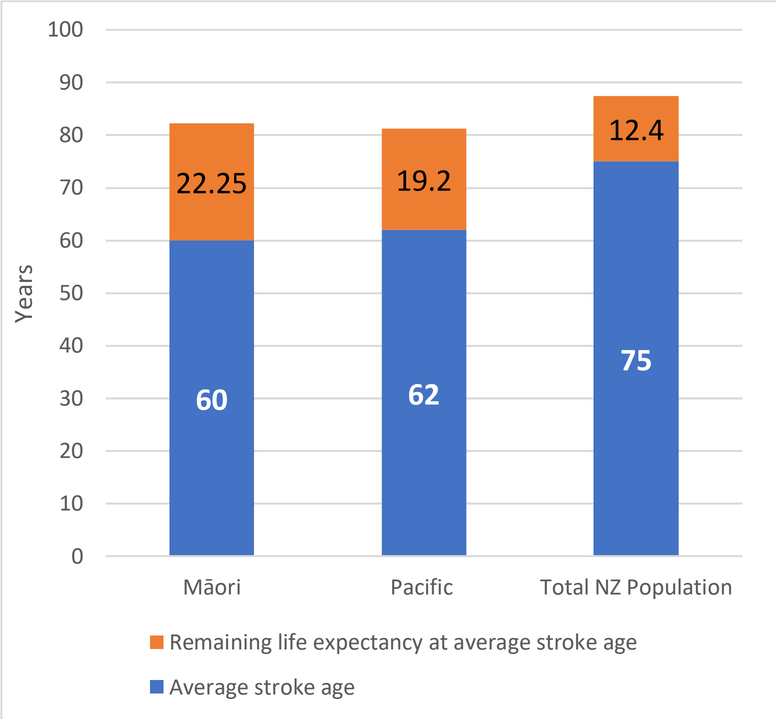


Source: NZIER, based on 2013 New Zealand Disability Survey (Statistics New Zealand 2014)

Combining these working age strokes with strokes in people aged under 75 shows that Māori and Pacific people are twice as likely to experience premature mortality due to stroke, even when access to treatment is equal. When Māori experience a stroke, on average they have over 22 years of expected life remaining, compared with 12 years for the total New Zealand population (see Figure 14 below). When strokes occur in younger people, many more years of life are at stake.

Figure 14 Life expectancy at average age of stroke in New Zealand

By ethnicity



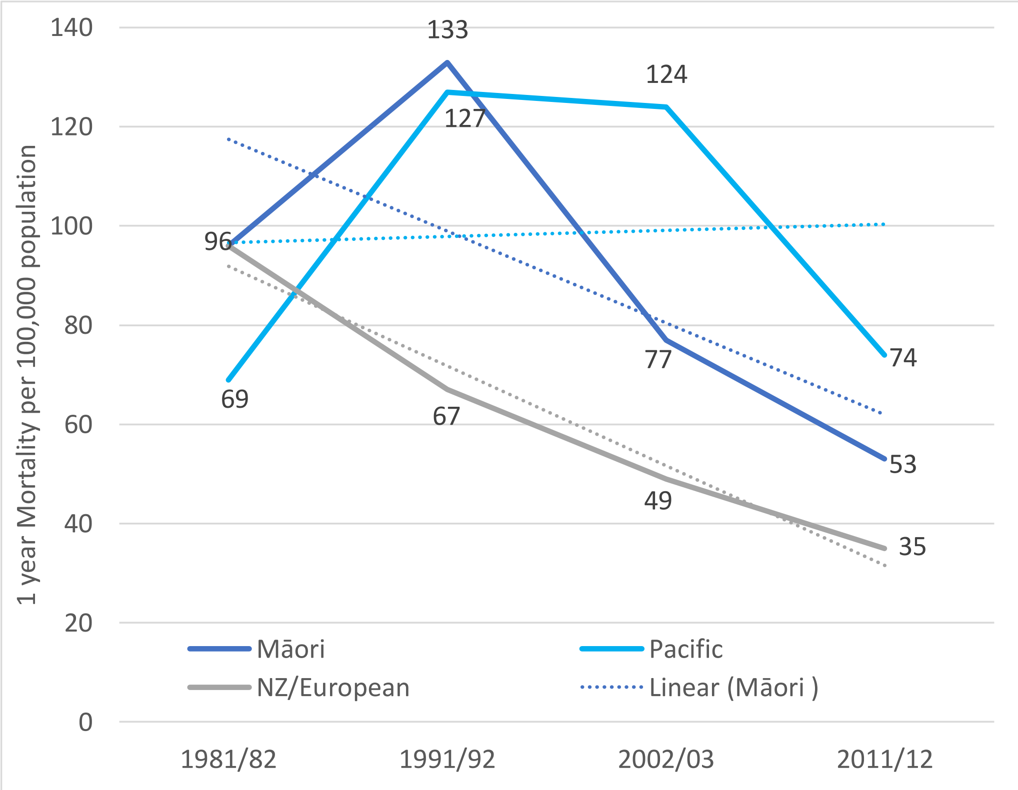
Source: NZIER, based on Statistics New Zealand Period Life Tables 2012-14 and Ministry of Health, 2016

Worsening prospect of a stroke in Māori and Pacific people

Recent trends have driven a wider disparity between these groups and European and other ethnicities: Feigin (2015) found that while NZ/Europeans experienced a 64 percent reduction in one-year age-standardised mortality from 1981/82 to 2011/12, Māori one-year age-standardised mortality fell by only 44 percent and Pacific one-year age-standardised mortality actually rose slightly (see Figure 15 below). This disparity is one underlying cause of the significant gap in life expectancy between Māori and Pacific and non-Māori, non-Pacific people in New Zealand (Ministry of Health, 2015).

Figure 15 One-year age-standardised stroke mortality rates in New Zealand, by ethnicity, 1981/82 to 2011/12

Based on the ARCOS (Auckland) studies



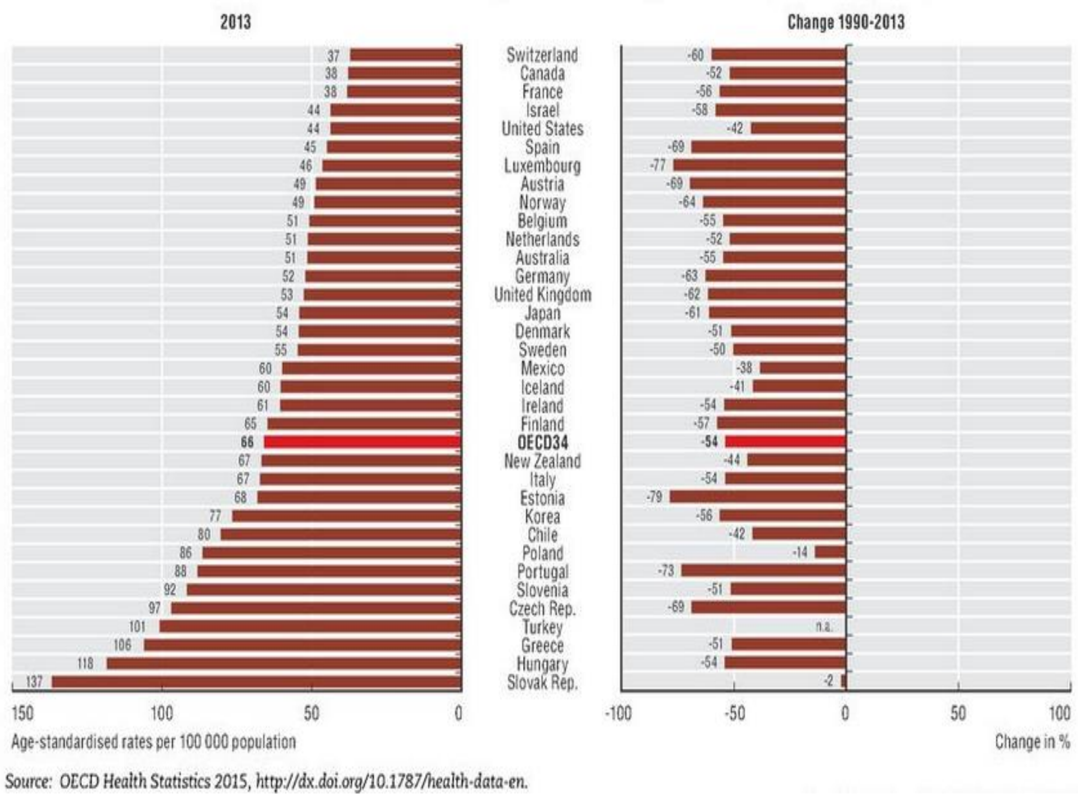
Source: NZIER based on data from Feigin et al., 2015

1.4. How do we compare internationally?

There has been a significant decrease in mortality from stroke over time in developed countries. This trend started in the early 1900s and has accelerated during the past 30 years (Wolfe, 2000).

OECD data, however, places New Zealand at above the OECD average for cerebrovascular disease mortality and suggests that the reduction in mortality achieved since 1990 has also been below the OECD average (see Figure 16 below).

Figure 16 Cerebrovascular disease mortality, 2013, and change from 1990 to 2013 (or nearest year)



Source: OECD Health Statistics, 2015

Australia, which has a lower than average mortality rate and has experienced a slightly higher than average reduction in mortality according to the OECD figures, has experienced a significant change in the fatal and non-fatal burden of stroke since 2003 with a 28 percent drop overall between 2003 and 2011, most of this being due to a large drop in the fatal burden of stroke (mortality fell by 29 percent). These changes would appear to surpass what New Zealand has achieved over the same time period and are shown in Figure 17 below.

Figure 17 Changes in fatal and non-fatal burden (age standardised rates) 2003-2011, Australia

Disease	Fatal burden (ASR)			Non-fatal burden (ASR)			Total burden (ASR)		
	2003	2011	% change	2003	2011	% change	2003	2011	% change
Coronary heart disease	16.8	11.0	–35.0	3.6	2.8	–21.0	20.4	13.8	–32.0
Stroke	6.7	4.8	–29.0	0.8	0.7	–13.0	7.5	5.4	–28.0
Atrial fibrillation and flutter	0.4	0.5	15.9	0.9	1.0	9.3	1.3	1.5	11.3
Non-rheumatic valvular disease	0.8	0.8	3.7	0.4	0.3	–23.0	1.2	1.1	–5.0
Cardiomyopathy	1.0	0.9	–3.0	0.1	<0.1	–36.0	1.0	1.0	–5.1
Aortic aneurysm	0.9	0.6	–31.0	<0.1	<0.1	–11.0	0.9	0.6	–30.0
Rheumatic heart disease	0.4	0.3	–7.8	0.2	0.1	–25.0	0.5	0.5	–13.0
Peripheral vascular disease	0.4	0.3	–35.0	0.1	0.1	1.0	0.5	0.3	–31.0
Hypertensive heart disease	0.3	0.3	–16.0	<0.1	<0.1	–56.0	0.3	0.3	–17.0
Inflammatory heart disease	0.2	0.2	10.7	<0.1	<0.1	–39.0	0.2	0.2	4.7
Other cardiovascular diseases	1.6	1.3	–21.0	0.3	0.3	–-6.7	1.9	1.6	–18.0

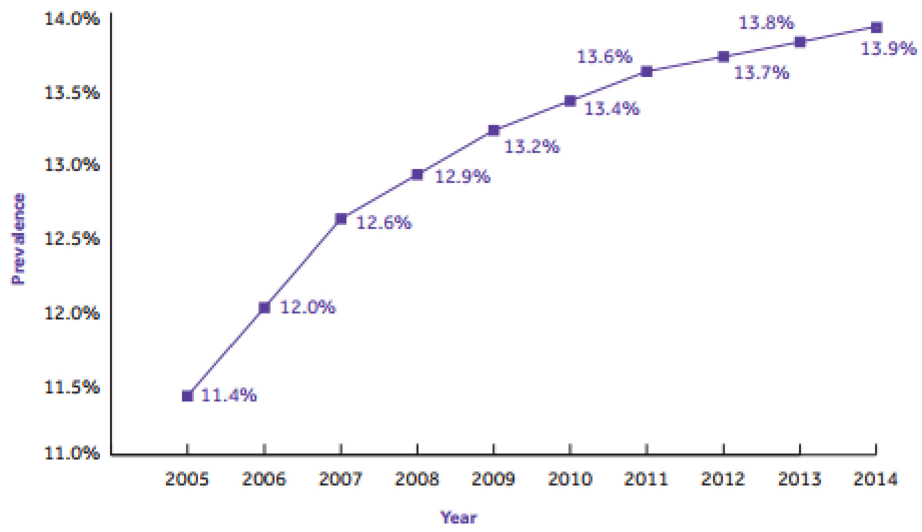
Source: AIHW, 2011

1.4.1. Explaining New Zealand's relatively poor outcomes

One explanatory factor for New Zealand's poor performance is the relatively high and increasing prevalence of stroke risk factors.

But New Zealand is not alone in experiencing increases in prevalence of some risk factors for stroke. For example, the UK has seen a similar increase in the prevalence of high blood pressure in recent years (see Figure 18 below). However, the UK prevalence of high blood pressure, as reported by the UK Stroke Association, is still lower than the New Zealand prevalence of high blood pressure, as reported by the New Zealand Health Survey 2016-17 (see section 1.2.2).

Figure 18 Prevalence of high blood pressure in the UK



Source: Stroke Association UK, 2017

Feigin (2015) also observed that risk factor prevalence increased significantly over 30 years.

Improvements in stroke outcomes, including mortality, are difficult to achieve nationally when some sub-populations are unable to access life-changing and life-saving treatment. In New Zealand, there is evidence that best practice treatment rates vary significantly by DHB, with those with the highest concentrations of Māori having particularly low rates (Liu et al, 2017 and Ministry of Health, 2018).

But beyond risk factors, there is evidence that high-volume hospitals may produce better patient outcomes (Bray et al., 2013). Two national clinical audits in England (the Stroke Improvement National Audit Program and the 2012 Sentinel Stroke Audit) revealed that hospitals with higher volumes of thrombolysis procedures also achieved shorter delays in administering thrombolysis to patients after arrival in hospital.

In a report for the UK Stroke Association, King College London (2017) found that 22 percent of stroke patients in England, Wales and Northern Ireland are being admitted to general medicine and diagnostic wards instead of specialist stroke wards, suggesting that admission to specialist stroke wards occurs in 78 percent – significantly more than in New Zealand where the rate was 29 percent (Child et al., 2011).

The province of Ontario, Canada's largest province by population (population approximately 14 million), was the first large jurisdiction in Canada, and in North America, to implement an integrated regional system of stroke care delivery. A system of coordinated stroke care, known as the Ontario Stroke System, was launched in 2000 and fully implemented in 2005, resulting in a major transformation in the delivery of stroke care across the province (Kapral et al., 2013).

In Ontario, the proportion of patients who received care at an acute stroke centre in 2010 was 46.5 percent (Kapral et al., 2013). This is no higher than New Zealand's current rate of 51 percent (Feigin et al., 2015). However, New Zealand's current rate has been achieved relatively recently: The 2009 Acute Stroke Services Audit noted that only 28 percent of New Zealand stroke patients received care through a stroke unit, compared with 49 percent of Australian stroke patients at the time (Child et al., 2012).

The 2009 National Acute Stroke Services Audit highlighted a range of priority areas where stroke care in New Zealand should be improved. Table 7 below shows how these measures place New Zealand clearly below Australia in acute stroke care. New Zealand outstrips Australia in use of a stroke register and staff access to stroke education. Thrombolysis was more likely to be available in New Zealand stroke units (67 percent versus 28 percent) but far less likely to be available on a 24-hour basis (43 percent versus 77 percent)(Stroke Foundation of New Zealand, 2010).

Table 7 Comparison of New Zealand and Australia on priorities for acute stroke services

Table 1: Priority areas by Australian and New Zealand totals and DHB stroke unit status

	Aust total	NZ total	SU	No SU
% of acute stroke patients in stroke unit on day of survey	51%	39%		
% of patients receiving stroke unit care	49%	28%		
Ambulance service protocols for rapid transfer	21%	10%	25%	0%
ED protocols for rapid triage	48%	43%	63%	31%
Stroke service offers thrombolysis	28%	67%	87%	54%
Thrombolysis offered 24 hrs	77%	43%	57%	29%
Aspirin given within 48 hours (if ischaemic stroke)	62%	21%	21%	21%
Staff access to continuing stroke education	42%	57%	87%	38%
IDUC within one week of admission	26%	20%	20%	21%
Incontinent patients with continence plan	32%	19%	9%	26%
DVT prophylaxis for patients unable to walk	68%	18%	19%	17%
Carotid artery imaging while in hospital:	50%	22%	19%	24%
Assessed by physiotherapy within 48 hrs	58%	41%	51%	34%
Assessed by occupational therapy within 48 hrs	37%	18%	24%	13%
Assessed by SLT within 48 hrs	60%	35%	43%	30%
Swallow screened during admission *	79%	57%	63%	54%
Assessed by dietitian within 48 hrs **	26%	9%	9%	9%
Use of a stroke register	24%	43%	63%	31%

* Includes SLT swallow assessment
** If dysphagia/nutrition/hydration problems.

Source: Stroke Foundation of New Zealand, 2010

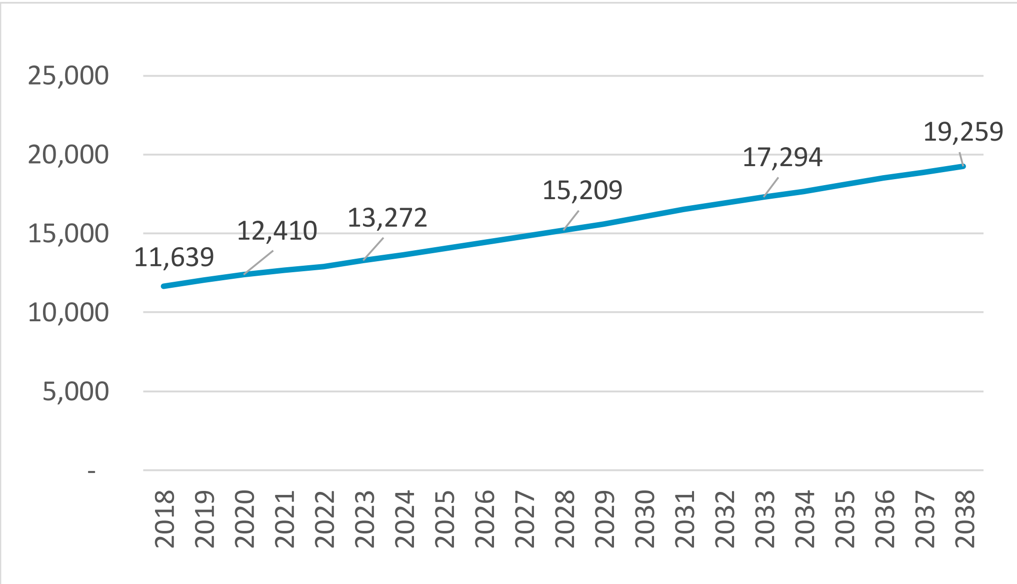
1.5. Projections

To provide a basis on which to consider the importance of investing now to minimise future costs of stroke in New Zealand, we projected cerebrovascular disease hospitalisations. Using the most recent available data on publicly-funded hospitalisations from the Ministry of Health (2016/17 hospitalisation data, Ministry of Health, 2019) and population projections based on the 2013 New Zealand Census, we derived the hospitalisation rate by ethnicity (Māori, Pacific and Other) and 5 year age band (from 15-19 to 85+ years). Assuming that the rate of hospitalisation within each grouping remains the same, we then applied the respective rate to each group's population estimate for years from 2018 to 2038.

Figure 19 below shows that the projected number of hospitalisations for cerebrovascular disease exceeds 19,000 per year by 2038, a sizeable increase from the 12,410 hospitalisations projected for 2020. This increase is due to both population growth and population ageing (most importantly, growth in the older age groups where stroke is more prevalent, due to the ageing of the baby boom generation).

Figure 19 Projected stroke hospitalisations in New Zealand

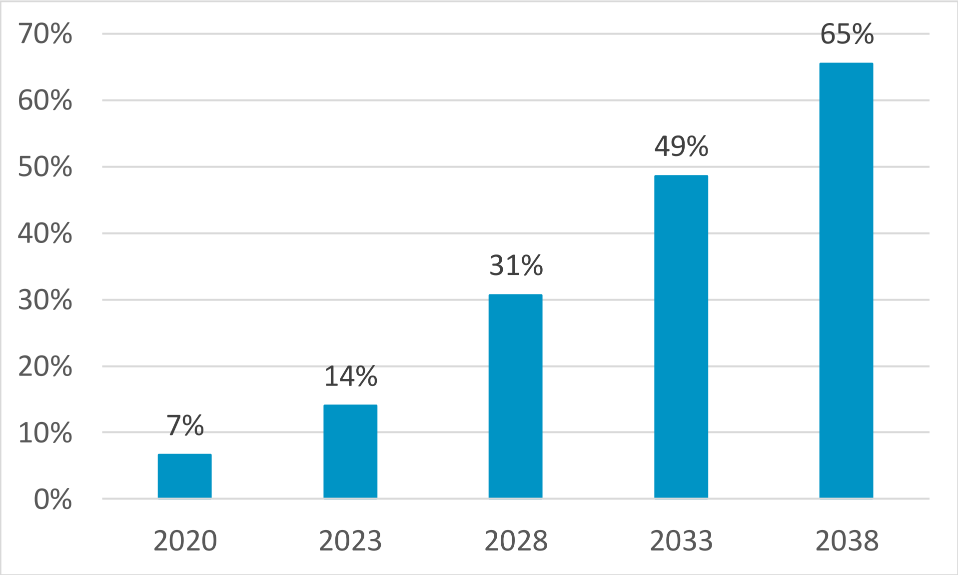
All publicly funded hospitalisations coded ICD-10 I60-I69



Source: NZIER

Figure 20 below shows the relative magnitude of the increase in hospitalisations projected compared with 2018 projected hospitalisations. By 2028, hospitalisations are expected to have increased by over 30 percent. By 2038, they are expected to have increased by 65 percent.

Figure 20 Projected growth in annual stroke hospitalisations from 2018



Source: NZIER

2. Quantifying the social and economic costs of stroke

This report describes the result of analysis based on a simple model that allows the major costs of stroke to be understood in the New Zealand context, making the best use of available New Zealand evidence supplemented as required by evidence from overseas studies.

Our results are then compared with previously published estimates to test our hypothesis that the actual social and economic costs of stroke may in fact be significantly larger.

2.1. The challenges

Stroke has wide reaching social and economic implications. However, while there is a high degree of confidence in the existence of causal links between stroke and stroke outcomes, most stroke research does not attempt to isolate longer term stroke outcomes from other contributing factors. Strokes occur in many people with pre-existing conditions. Te Ao et al. (2012) found:

- An 82 percent rate of comorbidities in stroke patients
- Some stroke patients have had previous strokes (10 percent).

Where older stroke survivors are concerned, there is a pre-existing risk of admission to institutional care which may not be known.

Furthermore, many costs, such as productivity costs and long-term institutional care costs, occur within sub-populations of stroke survivors and there is often little or no data pertaining to these subpopulations that allows for a detailed and accurate identification of their costs.

Further complications to the use of evidence arise because acute treatment of stroke, approaches to rehabilitation, and the availability of support services to enable independent living have all rapidly evolved in New Zealand in recent years, making much of the available evidence on outcomes outdated.

With a lack of a perfect way of quantifying the social and economic costs of stroke, the choice is between many alternative 'second best' approaches. All of these will produce imperfect results due to the lack of a single, consistent source of data that addresses all relevant dimensions of cost. Consequently, results can only be taken as indicative of broad magnitudes. The results presented in this report are no exception.

2.2. Our approach

This study focuses on the major social and economic costs of stroke and estimates these based on a simplified epidemiologic model to make the best use of recent New Zealand evidence. The underlying model is deliberately simple: A more complex model would have to rely on more assumptions to fill evidence gaps and there would still be a high degree of uncertainty around cost estimates. For the most part, our model is based on New Zealand data. Where needed, published studies from other jurisdictions have provided values that allow additional dimensions of social and economic costs to be included, in preference to excluding major cost components due to a lack of New Zealand data.

In our cost model, the social and economic burden of stroke is assumed to be primarily a function of:

- Initial response and hospitalisation
- Rehabilitation and ongoing support (including long term residential care)
- Employment effects and income support
- Burden on informal caregivers
- Quality of life and mortality.

Many of these impacts can be valued using existing values in the Treasury CBAx model.[2] Others require specific values to be extracted from published studies.

For employment-related effects, stroke survivors of working age are considered separately from stroke survivors aged 65 and older.

Amongst the thousands of hospitalised stroke events in New Zealand each year, some are second, third or subsequent strokes. The risk of recurrent stroke is particularly high in the first few months after a stroke. Based on the findings of Gloede et al. (2014), that the average direct first year costs of stroke are very similar for first stroke and recurrent stroke (AUD 30,110 and AUD 32,354, respectively), we make no distinction between the two. The mean duration of hospitalisation based on all inpatient admissions, however, does reflect the balance of first and recurrent strokes and any cost difference between them.

2.3. Scope, perspective and time horizon

According to Ranta (2018), over 95 percent of strokes are now hospitalised. Those least likely to be admitted include frail older people who choose to remain at home, people experiencing a minor stroke or transient ischaemic attack (TIA) with no ongoing effects, and older people in rest homes or private hospitals.

Consequently, strokes included in the cost model are those which result in a public hospital inpatient admission. This data is made publicly available by the Ministry of Health in the National Minimum Data Set (NMDS), last updated in 2018 with 2016/17 data.

The perspective of the cost model is societal. We do not distinguish fiscal costs from private costs. In some cases, such as health system costs, it is possible to identify costs as purely fiscal. Caregiver burden is purely private. Employment effects are a mixture of fiscal and private as these consist of a mixture of lost employment income, lost income tax revenue, and income support payments.

Our model includes only costs incurred in the first five years after a stroke. In some cases, where data is particularly poor, we include less than five years because going

[2] The Treasury CBAx model is a cost-benefit analysis tool for public sector interventions. It includes a database of common values, including some health care costs, and provides a tool for inflating previous years costs to current values and can be used to discount future years cost flows.

further would require heavy use of assumptions. A five-year time horizon is reasonable given evidence of how stroke costs tend to be heavier in the short term: Gloede et al. (2014) estimated the direct health system costs at 10 years post-stroke based on data from the North East Melbourne Stroke Incidence Study (NEMESIS). For ischemic stroke, the overall average annual direct costs at 10 years estimated at USD 5,207 were not significantly different than costs estimated at 3 and 5 years, suggesting that for patients who survive 5 years post-stroke, there is very little additional stroke-related cost.

2.4. Discount rate

Consistent with the Treasury CBAx approach and the 2019 version of the CBAx model used for the 2020 Budget, we discount all future costs at a rate of 6 percent per annum.

2.5. Excluded costs

The potentially relevant cost factors that are excluded from the model are costs associated with:

- Stroke prevention in at-risk individuals who have never been hospitalised as a result of stroke
- A non-hospitalised stroke or TIA event
- Stroke education and awareness
- Stroke in people aged under 15 years.

Although stroke prevention would be unnecessary if there were no strokes, we do not include primary stroke prevention activity as a cost of stroke, considering this instead as a cost associated with *risk* of stroke. For example, many people incur health care costs from pharmaceutical consumption and primary care checks aimed at preventing stroke, but we consider these to be associated with risk factors such as high blood pressure. Because high blood pressure is also a risk factor for other health outcomes, the cost of assessing, monitoring and treating it should be attributed more widely than just to stroke.

Costs specific to stroke occurring in people aged under 15 years are also excluded.[3] This is due to a lack of evidence on outcomes (most studies focus on adults), as well as the very different effects that a stroke in the very young might have (on educational outcomes, for example). Also, because stroke in the very young is likely to have different causes (not so much high blood pressure, for example, but pregnancy complications and medical conditions), the implications for prevention and cost savings are likely to be quite different.

2.6. Our sources of data and evidence

Table 8 below summarises the types and sources of evidence used to estimate the social and economic costs of stroke.

[3] In 2016/17, there were 61 hospital admissions of children aged 0-14 where stroke was the most likely reason for admission (Ministry of Health, 2018).

Table 8 Parameters for social and economic costs of stroke

Parameters	Probability/value	Source	Context
Pre-stroke variables			
Average age of working age stroke victim	49	Dixon, 2015	New Zealand study
	55	McAllister et al., 2013	New Zealand study
Living in own home	90%	Stroke Foundation of New Zealand, 2010	New Zealand data
Living in residential care	11% - 13%	Te Ao et al., 2012	New Zealand study
In paid employment	75.2% (of 18-64yr olds)	McAllister et al., 2013	New Zealand study
Quality of life pre-stroke	0.850 (EQ-5D)	Luengo-Fernandez et al., 2013	UK study
Aged 18-54	15.3%	Crichton et al., 2012	UK. South London Stroke Register (SLSR)
Aged 55-64	15.9%	Crichton et al., 2012	UK. South London Stroke Register (SLSR)
Aged 65+	68.8%	Crichton et al., 2012	UK. South London Stroke Register (SLSR)
Mean age of stroke victim	71.6 years	Feigin et al., 2015	
Stroke care			
Admission to stroke unit	51.3%	Feigin et al., 2015	New Zealand study (ARCOS)
Hospital admissions for stroke per year	9583 (2018 report) based on 2014/15 data	Ministry of Health, 2017b	NMDS data (NZ inpatient data – hospitalisations for cerebrovascular disease in 2014-15)
	12,410 (2020 update) projected from 2016/17 data	Ministry of Health, 2019b	NMDS data (NZ inpatient data – hospitalisations for cerebrovascular disease in 2016-17)
Average length of inpatient stay (days)	22.9 (stroke unit) – 25.9 (general ward), including rehabilitation	Te Ao et al., 2012	New Zealand study
	22.5	Ministry of Health, 2017b	NMDS data (NZ inpatient data – hospitalisations for cerebrovascular disease in 2014-15)
Stroke deaths			
Deaths in age <65 group	10% of all stroke deaths	Tobias, 2007	New Zealand
Death by 28 days	19%	Feigin et al., 2010	Auckland (ARCOS?) Follow-up study, all stroke types.

Parameters	Probability/value	Source	Context
Death by 6 months	21% (of those treated in stroke unit) - 30% (of those treated in a general ward) (cumulative)	Te Ao et al., 2012	Auckland Study. Comparison of outcomes for stroke patients admitted to stroke units
Death by 1 year	26% (of those treated in stroke unit) - 33% (of those treated in a general ward) (cumulative)	Te Ao et al., 2012	Auckland Study. Comparison of outcomes for stroke patients admitted to stroke units
Death by 5 years	49.4% (cumulative)	Feigin et al., 2015	New Zealand study
Stroke outcomes			
New admission to residential care	5% - 7% of strokes (Based on 16% - 20% at six months post stroke and 11-13 % in residential care pre-stroke)	Te Ao et al., 2012	New Zealand study
	20% of new stroke patients discharged to residential care for 65+	McNaughton et al., 2014	
	2% discharged to residential care for age under 65	Krueger et al., 2012	Canadian study
Quality of life after stroke	0.44 (general ward)– 0.53 (stroke unit)	Te Ao et al., 2012	12 months after event
Recurrent stroke			
Within 30 days	3.1%	UK Stroke Association, from Mohan et al., 2011	UK data
Within 12 months	11.1% (cumulative)	UK Stroke Association, from Mohan et al., 2011	UK data
In subsequent years	5% each year	Bpac^{NZ} (Better Practice Advisory Council New Zealand)	New Zealand source

Source: NZIER

2.7. Interpreting our results

Our analysis is based on the costs associated with stroke within the year of the stroke and for four additional years. Although in any given year, there are many people experiencing costs associated with strokes that have happened many years prior, we have not been able to quantify these longer-term costs. This is due in part to a lack of evidence (very few studies follow patients for longer than five years) but also due to an underlying complication, which is that as people age and time since a stroke elapses, it becomes more and more difficult to disentangle the long term effects of stroke from other potential causes and contributors to disability, morbidity and mortality. As a result, we believe there are many costs associated with stroke that we have not captured.

We present costs of stroke in different ways:

- The 5 year discounted cost of an annual cohort of strokes;
- The expected cost of a single stroke in New Zealand (This average cost estimate is useful for considering interventions that may reduce stroke incidence. For every stroke avoided, this would be the average amount saved); and,
- The annual cost of stroke to New Zealand in 2020.

In this 2020 update, we also present the societal cost savings associated with thrombectomy, the total potential cost of increased thrombectomy rates and the societal cost savings associated with this.

3. Underlying epidemiological model

The costs of stroke are a function of the epidemiology of stroke. Long term mortality, recurrent stroke, and disability are determinants of the long-term costs of individuals and of the burden of stroke to New Zealand.

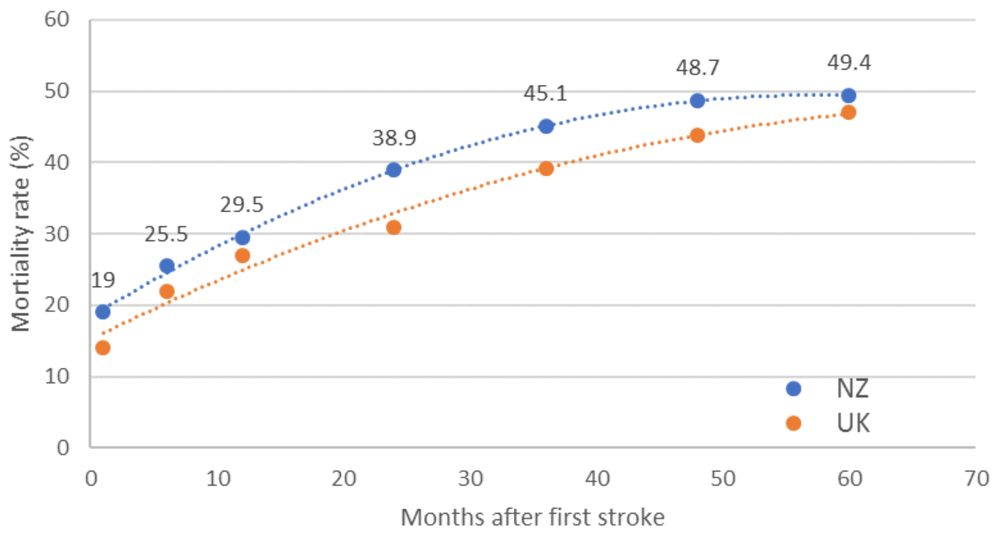
If an individual dies within a month, a year, two years, etc., he or she will not incur costs beyond that point, whereas others in the cohort may go on to incur substantial long-term costs. To estimate long-term costs, therefore, it is necessary to model long-term mortality.

The stroke death figures presented in Table 8 above provide a range of estimates. The two New Zealand sources (Te Ao et al., 2012 and Feigin et al., 2015) suggest different estimates, owing to different study populations and one study (Te Ao et al., 2012) separating those treated in an acute stroke unit from those treated in a general ward. Furthermore, the New Zealand estimates do not provide a mortality rate for each year, which would be directly applicable to a cost model with annual discounting.

To overcome the lack of data to fit a cost model, we fitted a trendline to the published New Zealand mortality estimates (from both Feigin et al. and Te Ao et al.). That trendline is shown in Figure 21 below. To provide some context for the New Zealand trendline, we also fitted a trendline to the UK mortality estimates from the Oxford Vascular Study (Luengo-Fernandez et al., 2013). The two trendlines are remarkably similar, with the New Zealand one indicating higher mortality at every stage.

Figure 21 Stroke mortality over 5 years

Trendlines fitted to published evidence from New Zealand and the UK



Source: NZIER, based on Feigin et al., 2015 Te Ao et al., 2012 and Luengo-Fernancdez et al., 2013

The cumulative mortality rates from the New Zealand trendline shown in Table 9 below were used to generate long term cost estimates. These are shown along with the number of hospitalised stroke patients who have died or are surviving at each stage, based on the number of individuals estimated from each year's hospitalisations (approximately 11 percent of patients have a same-year recurrent stroke). The 2018 report used figures from 2014 with no projections. For the 2020 update, stroke hospitalisations for 2020 were projected from 2017 hospitalisations data (resulting in 12,410 hospitalisations for 11,170 people) and the same mortality rates as were used in 2018 were applied to these projections.

Table 9 Mortality effects on an annual cohort of hospitalised stroke patients

Time period	Cumulative mortality		Deceased patients		Live patients	
	2018	**2020**	**2018**	**2020**	**2018**	**2020**
28 days	19%	19%	1639	2122	6987	9048
6 months	25.50%	25.50%	2200	2848	6426	8322
1 year	29.50%	29.50%	2545	3295	6081	7875
2 years	38.90%	38.90%	3355	4345	5270	6825
3 years	45.10%	45.10%	3890	5038	4735	6132
4 years	48.70%	48.70%	4201	5440	4425	5730
5 years	49.40%	49.40%	4261	5518	4365	5652

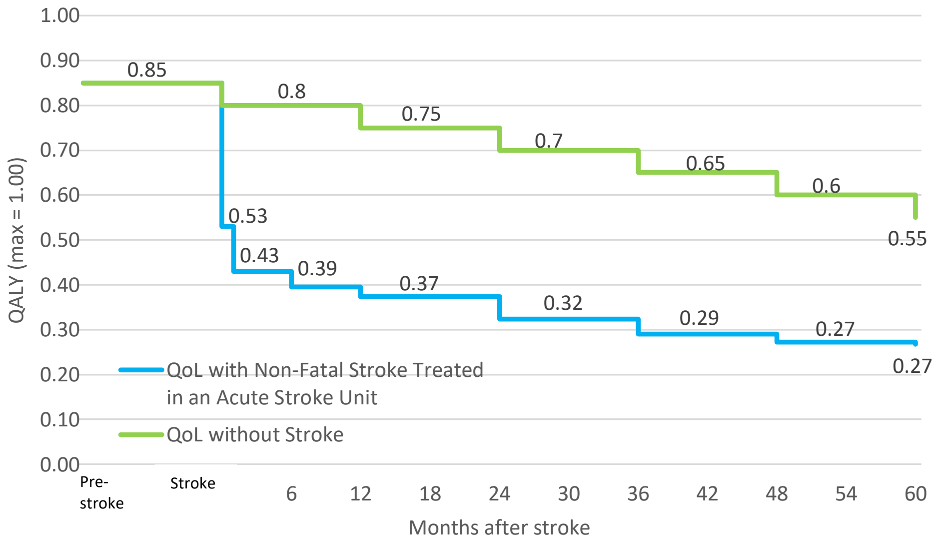
Source: NZIER

We also model Quality Adjusted Life Years (QALYs) lost due to stroke relative to a counterfactual informed by published studies providing estimates of quality of life loss over five years.

Figure 22 below shows:

- How quality of life might have been expected to decline if a non-fatal stroke had not occurred but, instead, progressively failing health nevertheless had a significant effect over five years (green line). This is expected due to the advanced age of most stroke survivors.
- What expected quality of life (adjusted for mortality) is over five years for a person who has a non-fatal stroke and is treated in an acute stroke unit (blue line) (based on Te Ao et al., 2012).

Figure 22 QALYs lost over 5 years after non-fatal stroke with treatment in an acute stroke unit

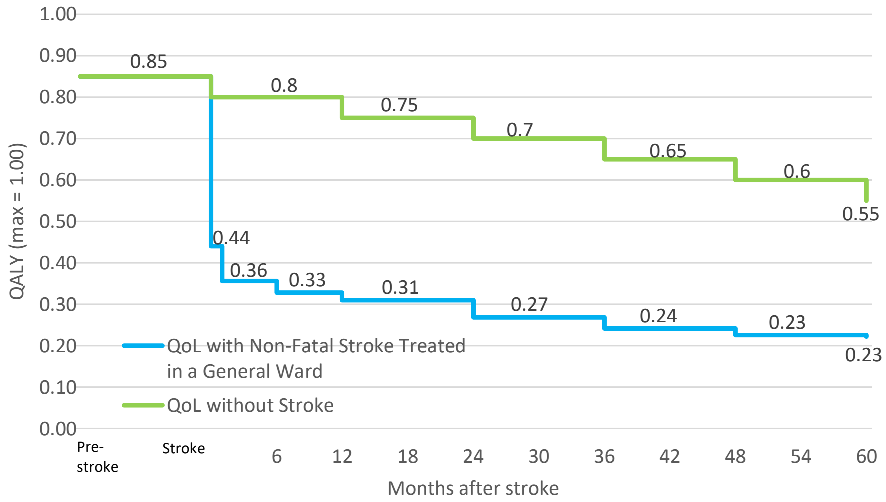


Source: NZIER

Figure 23 below, on the other hand shows how treatment in a general ward (based on Te Ao et al., 2012) is associated with a more significant initial drop in quality of life.

Our analysis is based on averages, so, given that 51 percent of New Zealand stroke patients are treated in an acute stroke unit, our model was based on the average of QALY loss associated with the two treatment options.

Figure 23 QALYs lost over 5 years after non-fatal stroke with treatment in a general ward



Source: NZIER

The mortality and quality of life models described above underlie our costing of each dimension of stroke over five years.

4. Cost of initial response and hospitalisation

The immediate and short-term costs of a stroke include the initial response (ambulance call-out and Emergency Department (ED) visit) as well as the initial episode of hospitalisation that follows.

4.1. Initial response

Although in the past, a significant proportion of people experiencing a stroke may not have sought medical care immediately or even at all, there is now evidence that 95 percent of strokes today do involve a hospital visit (Ranta, 2018). The majority of hospitalisations for stroke are likely to have been preceded by an ED visit and even before that, an ambulance call-out.

4.1.1. Ambulance call-outs

No New Zealand data was available on the proportion of stroke hospitalisations that are preceded by ED visits and ambulance call-outs. However, the FAST stroke campaign in 2017, which raised awareness of the symptoms of stroke and encouraged bystanders to call 111, led to 52 St. John Ambulance call-outs per week that were confirmed as stroke (27 percent of suspected stroke incidents) (National Stroke Network, 2017). Over the same period, Wellington Free Ambulance received 171 stroke-related calls per week (National Stroke Network, 2017). If 27 percent of these were also confirmed as stroke, that would be over 46 call-outs by Wellington Free Ambulance, per week confirmed as stroke. In total, call-outs for stroke under this assumption would be 98 per week.

In total, these figures indicate that ambulance call-outs for confirmed stroke incidents would have amounted to 5,096 ambulance call-outs, or 53 percent of all stroke hospitalisations.

The Treasury CBAx model provides a value for ambulance call-outs, being $841 per call-out (2018 dollars). Consequently, the total cost of ambulance call-outs per year is approximately $4.3 million. This translates into an expected ambulance cost of $447 per stroke, based on 9,583 strokes per year.

In 2020, these values are updated to $928 per ambulance call-out, with a total cost per year of $6.1 million. This translates into an expected ambulance cost of $492.

4.1.2. ED visits

In the absence of evidence and given that stroke is a medical emergency, particularly in those who are admitted to hospital, we assume that all hospitalisations for stroke are preceded by an ED visit. It is possible that even this underestimates the number of ED visits that are stroke related as it is likely that many minor strokes and TIAs result in ED visits with no subsequent hospitalisation.

The Treasury CBAx impact values database provides a value for ED visits, being $407 (2018 dollars). Consequently, the total cost of ED visits per year is approximately $3,900,281. This translates into an expected ED visit cost of $407 per stroke, based on 9,583 strokes per year.

In 2020, this value was updated to $406 per ED visit, which would reduce costs relative to 2018. This is unrealistic. Therefore we inflated the 2018 value using the Treasury CBAx tool, resulting in a cost of $447 and a total 2020 cost of $5.5 million.

4.2. First year inpatient cost

According to Ministry of Health (2017b) data showing publicly funded hospital discharges in 2014/15, there were 9,583 inpatient discharges for cerebrovascular events and the mean length of stay was 22.5 days.

The length of stay derived from New Zealand inpatient data is broadly consistent with Canadian and UK data, which suggest an average length of stay of 20 days (Krueger et al., 2012) for Canada and 19.5 days for the UK in 2010, down from 23.7 days in 2008 (Royal College of Physicians, 2011).

The CBAx impact values database contains a value for an average inpatient admission, which is the WIES value for 2015: $4,752. However, an inpatient stay for stroke is typically over three times the length of an average inpatient stay (see Table 10 below).

Table 10 Mean length of stay

Cerebrovascular disease compared with all causes

	Mean length of stay (days)
Cerebrovascular disease	
Total	22.5
Male	15.2
Female	30.4
All causes	
Total	6.9
Male	6.7
Female	7.1

Source: Ministry of Health, 2017b

Rather than basing estimated hospital costs on the CBAx value, therefore, we estimated the inpatient hospital stay for stroke patients based on Pharmac's cost manual (Pharmac, 2015), which provides specific costs that are likely to be more relevant to this context. We also make the following assumptions regarding the nature of the 22.5 day stay in hospital:

- 2 days in an intensive care unit (based on the Pharmac cost estimate for intensive care at $5,000 per day – 2014 dollars)

- 10.25 days in a medical ward (based on the Pharmac cost estimate for a medical ward at $1,000 per day –2014 dollars)
- 10.25 days in inpatient rehabilitation (based on the Pharmac cost estimate for hospital day stay ward, at $730 per day – $2014 dollars).

In 2020 dollars, these costs total $30,436 per stroke and imply an annual cost per year of $389,338,930 for the 12,410 projected stroke hospitalisations in 2020.

4.3. Total initial response and first year inpatient costs

Based on 12,410 projected hospitalisations in 2020, the costs associated with ambulance call-outs, ED visits and initial hospitalisation are presented in Table 11 below.

Table 11 Total cost of initial response and 1st year inpatient cost

	2018 Estimates (n=9,583)		2020 Estimates (n=12,410)	
	Total $(millions)	**Per stroke**	**Total $(millions)**	**Per stroke**
Ambulance call-outs	$4.3	$447	$6.1	$491
ED visits	$3.9	$407	$5.5	$447
Inpatient stay	$265.8	$27,733	$377.7	$30,436
Total	**$274.0**	**$28,587**	**$389.3**	**$31,373**

Source: NZIER

Because these costs are calculated based on the mean inpatient stay for all strokes in a year, they also reflect costs associated with recurrent strokes.

Te Ao et al. (2012) calculated the cost of care in the first year, including hospitalisation, rehabilitation, home support services, and residential care. In the first year, the cost of hospitalisation was the most significant cost, with total first year care costs amounting to $20,849 (2008 dollars) for those treated in a general ward and $24,275 (2008 dollars) for those treated in acute stroke units.

Inflating these estimates to 2020 using the Treasury CBAx tool generates costs of $35,030 (in a general ward) and $40,787 (in an acute stroke unit) so our estimates would appear to be conservative.

5. Cost of ongoing health care

Once a stroke hospitalisation has occurred, patients are known to be at high risk of further strokes. Concern about recurrent stroke is not only motivated by a desire to avoid the costs of hospitalisation and a repeat of other social and economic costs, but by the belief that recurrent stroke leads to greater disability, a higher risk of institutionalisation, an increased risk of dementia and a higher risk of death than the initial stroke (Barker-Collo et al., 2015). Secondary prevention costs will reflect not only those that address the morbidity caused by the stroke that has occurred but also those that address the increased risk of re-hospitalisation and recurrent stroke. Such costs will mainly include medication and general practitioner services.

In addition, because strokes carry a risk of subsequent stroke, every stroke has an expected cost of future hospitalisation.

5.1. Secondary stroke prevention

Costs associated with secondary prevention subsequent to a stroke were estimated in the NEMESIS study (Gloede et al., 2014). Table 12 below presents the costs we used to estimate secondary prevention costs in New Zealand. These are based on the findings of Gloede et al. (2014), adjusted for the proportions of ischaemic and haemorrhagic stroke, converted to New Zealand dollars and inflated to 2018 dollars. Costs reported in Gloede et al. (2014) are based on 3-5 years post-stroke and 10 years post-stroke. For our 5-year time horizon, we assume the 3-5 years' costs apply to the entire 5 years.

Total costs are calculated based on the number of survivors expected in each year and discounted.

Results show that the expected total cost of secondary prevention associated with a stroke is over $3,000, or in excess of $37 million for the 12,410 stroke hospitalisations projected for 2020.

Table 12 Secondary prevention costs after a stroke

	2018 Estimates (n=9,583)			2020 Estimates (n=12,410)		
	Cost per person per year	**Total cost over 5 years per person (discounted)**	**Expected cost per stroke**	**Cost per person per year**	**Total cost over 5 years per person (discounted)**	**Expected cost per stroke**
Medication cost	$914	$4,081	$2,140	$1,003	$4,478	$2,349
General practitioner care cost	$259	$1,156	$607	$284	$1,268	$666
Total	**$1,173**	**$5,238**	**$2,747**	**$1,287**	**$5,747**	**$3,015**

Source: NZIER

5.2. Recurrent stroke

According to Krishnamurthi et al. (2014), studies have identified that between 6 and 25 percent of stroke survivors will experience another stroke. By 5-years post-stroke, the cumulative risk of recurrent stroke has been estimated at between 30 and 40 percent.

According to the Better Practice Advisory Council of New Zealand (Bpac^{NZ}, 2010), 10 percent of stroke survivors have another stroke within a week, 14 percent within a month and 18 percent within three months. After this initial period, the risk falls to approximately 5 percent per year. Other sources estimate lower risks of recurrent stroke.

Our model is unable to distinguish between initial stroke and recurrent stroke for strokes that happen in the same year. For this reason, the hospitalisation cost of recurrent strokes that occur within the same year are already counted under initial hospitalisation costs.

Our estimates of recurrent stroke cost in subsequent years are based on the Bpac^{NZ} estimates of 5 percent risk in subsequent years.

Each recurrent risk is assumed to incur the same initial response and hospitalisation cost as was estimated in section 2: $31,373 but with a five percent probability of occurring each year up to five years post-initial-stroke. Future costs are discounted at the Treasury CBAx model default rate of 6 percent per annum. Table 13 below shows the expected cost of recurrent stroke in subsequent years.

Table 13 Expected cost of recurrent stroke in subsequent years

		2018 Estimates (n=9,583)		2020 Estimates (n=12,410)	
Time after stroke (months)	**Risk of recurrent stroke (%)**	**Expected cost of recurrent stroke**	**Discounted expected cost**	**Expected cost of recurrent stroke**	**Discounted expected cost**
24	5.0	$1,429	$1,272	$1,568	$1,396
36	5.0	$1,429	$1,200	$1,568	$1,396
48	5.0	$1,429	$1,132	$1,568	$1,242
60	5.0	$1,429	$1,068	$1,568	$1,172
Total expected per stroke		**$5,716**	**$4,672**	**$6,273**	**$5,127**
Total		**$54,776,428**	**$44,771,776**	**$77,847,930**	**$63,626,070**

Source: NZIER

Based on this estimation, the total 5-year cost of future recurrent strokes subsequent to one annual cohort of hospitalised strokes (based on 2020 estimates) is $63,626,070.

A single stroke is associated with a 5-year expected cost of recurrent stroke is $5,127.

6. Cost of residential care for older stroke survivors

Around 20 percent of all new stroke patients are discharged from hospital to institutional care (McNaughton et al., 2014). This is broadly consistent with the results of the Framingham study, which indicated that 26 percent of older stroke survivors were admitted to long term residential care as a result of stroke-related impairments (Fletcher-Smith et al., 2013).

A baseline estimate of the pre-stroke use of long term residential care in New Zealand is available from the National Acute Stroke Services: Audit 2009 (Stroke Foundation of New Zealand, 2010), which found that 90 percent of stroke survivors were living in their own homes prior to the stroke.

Based on this evidence, and the more conservative estimate of 20 percent of patients in total being discharged to institutional care (McNaughton et al., 2014), we estimate that 10 percent of older stroke survivors will become *new* users of long term residential care as a result of the outcome of stroke.

This is likely to be a conservative estimate of the impact of stroke on residential care admissions because amongst those who are discharged home, many will subsequently be admitted to residential care when it becomes apparent that their stroke-related disability makes living independently impossible. The ARCOS study found that 6 to 9 percent of those discharged home are in residential care 12 months later (Te Ao et al., 2012).

To estimate residential care costs associated with stroke, our model uses available data from the UK (augmented by assumptions as required), which suggests that:

- 68.8 percent of strokes occur in people aged 65 or older (Crichton et al., 2012).
- 33 percent of stroke survivors aged 65+ (the top end of the range suggested by Te Ao et al., 2012) admitted to residential care will not survive beyond 12 months, with half dying in the first six months.
- 33 percent of survivors die in each subsequent year of residential care, half in the first 6 months and the remaining half in the second six-month period.
- When residents die in care, their care cost is rounded up to the nearest six-month period. That is, a resident who dies 3 months into the year incurs 6 months of costs in that year. This is to reflect that although the average duration of residential care may be less than 12 months for these individuals, the intensity of care in the last months before death is likely to be higher.

The Treasury's CBAx impact values database indicates that the 2018 cost of residential care is $54,349. Updated to a 2020 value, this amounts to $59,645. Two years of residential care would have a present value in 2020 of $116,245.

Two scenarios are modelled. Both selected as conservative representations of the likely impact of stroke on residential care. The first scenario is the most conservative, implicitly assuming that only admissions directly from hospital are stroke-related. This is the most conservative assumption of causality and is almost certainly unrealistic but provides an absolute minimum estimate. The results of this scenario are shown in Table 14.

The second scenario adds the finding that by 12 months after the event, another 6 to 9 percent of survivors (assumed 7.5 percent) are newly admitted to residential care despite having been discharged home initially. This scenario, while still conservative in not allowing for later admissions to be caused by an earlier stroke, is likely to be a better representation of reality, supported by New Zealand evidence.

To avoid over-estimating costs, we assume that the new admissions to residential care over the first year arrive at the 12-month point. We further assume that the newly admitted residents face the same mortality rate as previous admissions to represent the ARCOS finding of additional admissions soon after being discharged home. The results of this scenario are shown in Table 15.

Table 14 Scenario 1 cost of residential care for stroke survivors

Allowing for admissions directly from hospital only

	2018 Estimates (n=9,583)			2020 Estimates (n=12,410)		
	Stroke survivors in residential care	**Cost of residential care**	**Discounted total cost per year**	**Stroke survivors in residential care**	**Cost of residential care**	**Discounted total cost per year**
Post stroke	446	-	-	578		
6 months	372	$10,119,243	-	482	$14,732,073	
1 year	299	$8,119,632	$17,206,486	387	$11,808,313	$26,540,386
18 months	249	$6,779,893	-	322	$9,851,244	
2 years	200	$5,440,154	$10,875,798	259	$7,915,761	$17,767,006
30 months	167	$4,542,528	-	216	$6,601,561	
3 years	134	$3,644,903	$6,874,325	174	$5,317,924	$11,919,485
42 months	112	$3,043,494	-	145	$4,427,251	
4 years	90	$2,442,085	$4,345,092	117	$3,567,105	$7,994,356
54 months	75	$2,039,141	-	97	$2,963,258	
5 years	60	$1,636,197	$2,746,426	78	$2,389,960	$5,353,218
TOTAL	**-**	**-**	**$42,048,128**			**$69,574,451**
Expected discounted cost per stroke			**$4,387.78**			**$5,606**

Source: NZIER

Table 15 Scenario 2 cost of residential care for stroke survivors

Allowing for additional admissions by 12 months

	2018 Estimates (n=9,583)			2020 Estimates (n=12,410)		
	Stroke survivors in residential care	**Cost of residential care**	**Discounted total cost per year**	**Stroke survivors in residential care**	**Cost of residential care**	**Discounted total cost per year**
Post stroke	446	-	-	578		
6 months	372	$10,119,243	-	482	$14,732,073	
1 year	299	$8,119,632	$17,206,486	387	$11,808,313	$26,540,386
18 months	584	$15,869,034	-	756	$23,081,880	
2 years	424	$11,529,878	$24,384,934	549	$16,774,243	$39,856,123
30 months	354	$9,627,448	-	458	$13,995,394	
3 years	284	$7,725,018	$14,569,465	368	$11,247,104	$25,242,498
42 months	237	$6,450,390	-	307	$9,388,317	
4 years	190	$5,175,762	$9,209,002	246	$7,529,524	$16,917,841
54 months	159	$4,321,761	-	206	$6,291,332	
5 years	128	$3,467,761	$5,820,784	166	$5,053,113	$11,344,445
TOTAL	-	-	**$71,190,671**			**$119,901,292**
Expected discounted cost per stroke			**$7,428.85**			**$9,662**

Source: NZIER

The results of this analysis indicate that the 2020 discounted cost of residential care over the 5 years following an annual cohort of strokes are likely to be at least $69 million to $119 million.

The 2020 discounted expected residential care cost of a stroke is therefore between $5,606 and $9,662.

7. Cost of long-term residential care for younger people experiencing stroke

According to Lakhan et al. (2009), 15 to 30 percent of all stroke survivors are permanently disabled. A very small percentage of people who experience stroke before the age of 65 will be severely and permanently disabled by stroke. No report was identified that would allow the number of cases of severe and permanent disability in this population to be quantified. This is a major evidence gap pertaining to an extreme outcome with high personal and fiscal costs.

Some individuals with severe and permanent disability will be discharged to a residential facility where round-the-clock care is available and rehabilitation efforts focus on restoring and maintaining as much function as possible to ensure the best possible quality of life within this setting. Some of these patients may eventually regain some function and return to living in the community but residential care is often a long-term situation.

In addition to being unable to quantify this group, there is very little evidence available pertaining to the long-term outcomes of this small percentage of patients as research tends to focus on mildly to moderately impaired survivors with a better prognosis of improved function and with the ability to respond to interviews and questionnaires for long-term follow-up.

To estimate costs associated with the long-term residential care of people under age 65 who experience severe disability, we make a conservative assumption that approximately two percent of stroke patients aged under 65 are discharged to a residential facility. This is a conservative estimate when compared with the percentage of moderate to severe traumatic brain injury (TBI) patients discharged to institutional care (12 percent according to Eum et al., 2015). The population with TBIs is significantly younger, with the study population (n=7,219) having a mean age of 42 overall and 53.5 for those who were institutionalised. However, the same study also found that half of those institutionalised return to private residences after varying periods of time. Our assumption is that two percent remain for 5 years at most in institutional care.

In the absence of long-term outcomes data specific to this group, we make a number of conservative assumptions:

- Patients aged under 65 have the same probability of death before discharge from hospital as older patients.
- Two percent of patients aged under 65 (instead of two percent of all patients) are discharged to long-term residential care for people under 65. In 2016/17, 26.6 percent of hospitalisations for cerebrovascular disease were in 15 to 64-year-olds. We assume the same percentage applies to the 12,410 hospitalisations projected for 2020. As a result, 66 people are discharged to long term residential care.
- Half of those discharged to residential care for under 65s survive or remain in care for only one year, and an additional ten percent (of those discharged

to residential care for under 65s) die or move out by the end of each subsequent year, leaving only 13 of the original 58 patients remaining in year 5.

The Ministry of Health funds the long-term residential care of people severely disabled by stroke. In 2018, the daily rate was approximately $200 per day (conversation with Kathryn Jones, Chief Executive Officer, Laura Fergusson Trust Canterbury). In 2020, this would be approximately $219.

Table 16 below shows the costs of long-term residential care estimated based on the above parameters.

Table 16 Long term residential care cost estimation

(people aged 15-64)

	Year of estimate	Total cost (000s)	Total cost (000s)		Discounted total cost (000s)		Expected cost per stroke	
Year Post-stroke			2018	2020	2018	2020	2018	2020
1	2018	$4,234	$9,798	$14,257	$9,249	$13,458	$795	$1,157
	2020	$6,161						
2	2018	$1,987						
	2020	$2,891						
3	2018	$1,590						
	2020	$2,314						
4	2018	$1,192						
	2020	$1,734						
5	2018	$795						
	2020	$1,157						

Source: NZIER

The expected discounted cost of long-term residential care for under 65s was $795 per stroke victim in 2018 (2018 dollars) and has risen to $1,157 per stroke victim in 2020. This demonstrates that although very few working age stroke survivors become long term users of residential care, even based on conservative assumptions, at $79,995 (inflated to 2020 dollars from our 2018 estimate) per year for those who do require this level of care, it still represents a significant cost of stroke.

In total, the discounted 5-year expected cost associated with long-term institutional care for stroke survivors aged under 65 in 2020 is over $13 million.

8. Cost of home and community support services

According to McNaughton (2014), 30 percent of New Zealand stroke patients are discharged home but are dependent on others for activities of daily living. Many of these will require home and community support services to support their continued independent living in the short term at least.

No estimates of the costs of such services used by stroke survivors in New Zealand were found. However, Te Ao (2014) provides an estimate of the cost of these services for people with TBI, which has a similar profile of impacts on physical, cognitive, neurological and behavioural function. In that study, the cost of community services for one year was $31,735 on average across those who used them.

In the Te Ao (2014) study, home and community support services were used by 3 percent of the study population. The study also included a large proportion of mild TBI, whereas our study focuses on hospitalised strokes and therefore excludes many mild strokes. For these reasons, we assume a higher rate of use (10 percent) and assume that these services are only required for the first year after a stroke.

Results indicate that the total cost of home and community support services per year in 2018 was estimated at $19.3 million and the expected cost per stroke at $2,014. In 2020, with inflation and an increase in the number of strokes, these costs are expected to be approximately $27.4 million and $2,209, respectively.

Table 17 Cost of home and community support services

Year of estimate	Annual cost per user of community services	Number of users	Total cost ($millions)	Expected cost per stroke
2018	$31,735	608	$19.3	$2,014
2020	$34,828	787	$27.4	$2,209

Source: NZIER

9. Cost of community rehabilitation

Rehabilitation in the community is a fact of life for many stroke survivors in the first year after a stroke.

No estimates of the costs of community rehabilitation services used by stroke survivors in New Zealand were found. A key issue to note is that community rehabilitation can be difficult for stroke survivors to access. The

However, according to a 2014 report published by the Royal Australasian College of Physicians (RACP, 2014), inadequate and inconsistent funding for rehabilitation services in New Zealand has led to inadequate service delivery in many parts of the country and in many populations. Māori are described in the report as having lower rates of access to rehabilitation.

In light of these facts, we have identified what the cost of community rehabilitation might be if stroke survivors accessed these services at the same rate as traumatic brain injury (TBI) survivors. Te Ao et al. (2012) provide an estimate of the cost of allied health care services for people with TBI, which has a similar profile of impacts on physical, cognitive, neurological and behavioural function. In that study, the cost of allied health care services for one year was $6,289 on average across those who used them.

In the Te Ao et al. study, allied health care services were used by 18 percent of the study population. This figure is less likely to be skewed by a lack of funded services because community rehabilitation for TBI survivors is funded by ACC. We use the same rate for survivors in the first year after a stroke and conservatively assume that there are no costs associated with rehabilitation in subsequent years: 74 percent of stroke patients survive and 18 percent of these access rehabilitation in the community for an average of one year.

Results indicate that the total cost of community services per year is over $11 million in 2020 and the expected cost per stroke is $919. Even if these services are not available to stroke survivors, these costs represent the value of the need for rehabilitation which is, to some extent, currently being absorbed by stroke survivors in one way or other.

Table 18 Cost of community rehabilitation

	Annual cost per user	Number of users	Total cost ($ millions)	Expected cost per stroke
2018	$6,289	1276	$8.0	$838
2020	$6,902	1653	$11.4	$919

Source: NZIER

10. Lost productivity

One major concern for stroke survivors of working age is the ability to maintain employment during rehabilitation or to return to work after a period of rehabilitation. For those who delay returning to work, or never return to work, there are two major social and economic costs:

- Lost productivity due to reduced employment, and
- Increased costs of income support payments.

Cost studies vary with regards to the inclusion of income support payments with some regarding these as a cost to society while others view them as a transfer payment where the benefits to the recipients are assumed to offset the costs to payers. The Treasury Guide to Social Cost Benefit Analysis recommends that transfer payments should be included as a cost when they have incentive effects such as inducing individuals to work less. In the case of income support post-stroke, we assume that individuals work less rather than responding to incentives. As a result, the cost of income support payments is not included as a social or economic cost of stroke.

Our model estimates lost productivity as a result of stroke using evidence from two New Zealand studies:

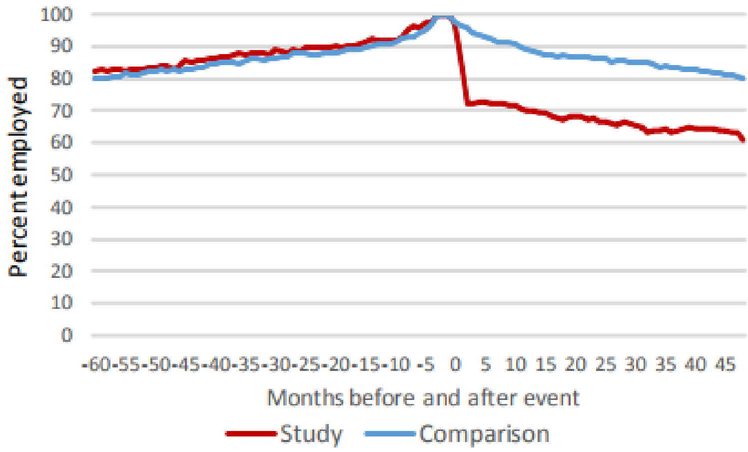
- Dixon (2015). This study used the Integrated Data Infrastructure (IDI) to link New Zealand health data to income and employment data and income support payment data for people aged 20 to 59 who were diagnosed (or experienced a first event) of any of eight selected health conditions between January 2008 and December 2009 and survived at least four years post-diagnosis.
- McAllister et al. (2013). This study compared income support for stroke survivors and injury survivors aged 18 to 64 in New Zealand. Details on pre- and post-stroke work status and income are provided along with a description of the income support that stroke survivors are eligible for.

10.1. Estimation of productivity losses

The Dixon study (2015) revealed that stroke had an immediate and significant impact on employment, reducing employment from an approximate average employment rate of around 85 percent in the counterfactual to an average employment rate of 65 percent four years post-stroke. This is shown in Figure 24 below.

Figure 24 Employment effect of stroke

Percent employed before and up to 4 years after stroke



Source: Dixon, 2015

The Dixon study shows that the effect of a stroke on employment is sustained over the four years after the event.

Another New Zealand study, (McAllister et al., 2013), which included a broader cohort of stroke sufferers found that 75.2 percent had been in paid work prior to the stroke and this fell to 48.8 percent 12 months after the stroke.

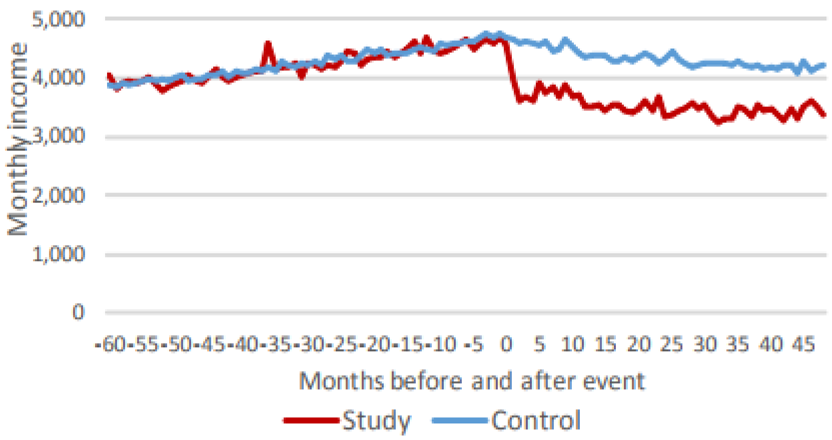
Although the studies appear to disagree, they are in fact reasonably consistent. The designs of the two studies are quite different in ways that potentially explain the difference in employment estimates:

- The Dixon study excluded people who did not survive at least four years post stroke whereas McAllister et al. did include stroke patients who died but only followed up for 12 months follow-up
- The Dixon Study used a population of working age stroke survivors all of whom were in full-time employment prior to the stroke and created a matched control population to be used as a time-compatible counterfactual, while McAllister et al. compared pre- and post-stroke employment in the same group
- The mean age in the Dixon study was 49.1 years while the mean age in the McAllister study was 55 years, the latter likely being more inclined to reduce employment subsequent to a stroke.

The Dixon study found that on average over the stroke group, monthly income was reduced by 26.1 percent between 7 and 12 months post-stroke and recovered very little over the longer term, remaining 25.2 percent lower at 37 to 48 months post-stroke, compared with the control group (see Figure 25 below). This included income support payments as well as employment income. 16.8 percent of those who experienced a stroke receive income support at 7-12 months, falling to 11.2 percent receiving income support at 37 to 48 months. Because the pre-stroke to post-stroke income effect is reduced by the presence of income support payments, the net effect on income as reported by the Dixon study represents a conservative estimate of the likely effect on productivity.

Figure 25 Effect of stroke on gross personal income

Monthly personal income before and up to 4 years after stroke



Source: Dixon, 2015

The economic cost of long run productivity losses associated with stroke in our model, is estimated using the human capital approach, which estimates production losses based on the remaining expected lifetime earnings of individuals who experience stroke. This approach is consistent with other reports on costs of health conditions. However, because other costs are estimated for only 5 years and there is insufficient evidence to support cost estimates over the longer term, we effectively assume that the average working age stroke victim has 5 years remaining in his/her working life. This is conservative given the average ages in the Dixon and McAllister studies.

The mean monthly pre-stroke earnings of stroke survivors in the Dixon study amounted to approximately $5721 (2018 dollars[4]). The 26.1 percent reduction found in the Dixon study implies mean monthly income would fall to $4,228, for a loss of $1,493 per stroke victim per month over the first year.[5] Because the Dixon study followed stroke patients for four years, the results reflect the effects of readmissions and recurrent strokes over that period.

To calculate the total value of these losses, we assume:

- 25 percent of all hospitalised strokes occur in people of working age (just under 2,400 strokes per year) (Stroke Foundation of New Zealand, n.d.),[6] and 25 percent of all hospitalised stroke patients are of working age.
- 75.2 percent of working age stroke were in paid employment prior to their stroke (McAllister et al., 2013).

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4 Inflated from 2013 estimates using the Treasury CBAx tool.

5 We assume the same loss of income for months 1 to 6 as for months 7 to 12.

6 Krueger et al., 2012 (Canada) report that 33 percent of hospitalised strokes occurred in people aged 0 to 69, which is broadly consistent with our estimate for working age individuals.

- Cumulative mortality in this group is assumed to follow the same pattern as described earlier (a conservative assumption, given that Ministry of Health (2016) data suggest that at least first year mortality was lower at 25 percent for working age individuals in 2006, compared with 29.5 percent for the whole stroke population, which would leave more individuals to experience reduced income).
- A 26.1 percent reduction in monthly earnings ($1,493) in the first-year post-stroke (Dixon, 2015).
- A 25.2 percent reduction in monthly earnings ($1,442) for an additional 4 years (based on Dixon (2015) finding for 37-48 months post stroke).

Our model does not include income losses in the year of death (based on an assumption of ill health preceding death) or thereafter.

These income losses sum up as shown in Table 19 below.

Table 19 Lost productivity of a single cohort of working age stroke survivors

	Year of Estimate	Year Post-Stroke					Total
		Year 1	Year 2	Year 3	Year 4	Year 5	
Previously employed stroke survivors	**2018**	1314	1176	1065	999	963	
	2020	1702	1523	1379	1294	1247	
Average income loss per employed person (undiscounted)	**2018**	$17,916	$17,304	$17,304	$17,304	$17,304	$87,132
	2020	$19,662	$18,990	$18,990	$18,990	$18,990	$95,622
Average income loss per employed person (discounted)	**2018**	$17,916	$16,325	$15,400	$14,529	$13,706	$77,876
	2020	$19,662	$18,021	$17,187	$16,420	$15,734	$87,024
Total income loss (undiscounted) (000s)	**2018**	$23,534	$20,343	$18,431	$17,288	$16,666	$96,263
	2020	$33,457	$28,920	$26,191	$24,567	$23,682	$136,818
Total income loss (discounted) (000s)	**2018**	$23,534	$19,192	$16,404	$14,516	$13,201	$86,846
	2020	$33,457	$27,445	$23,704	$21,243	$19,622	$125,470
Expected income loss per stroke (undiscounted)	**2018**	$2,456	$2,003	$1,712	$1,515	$1,378	$9,063
	2020	$2,696	$2,330	$2,110	$1,980	$1,908	$11,025
Expected income loss per stroke (discounted)	**2018**	$2,456	$2,003	$1,712	$1,515	$1,378	$9,063
	2020	$3,491	$2,864	$2,474	$2,217	$2,048	$13,093

Source: NZIER

Based on this estimation, the discounted expected value of lost productivity over five years following a stroke is $13,093 in 2020. Across all hospitalised strokes in a year, this to over $125 million in 2020 after discounting. Increased volumes as well as inflated costs have contributed to the over 40 percent increase on the 2018 figure ($86 million).

11. Informal caregiving

Informal care is a frequent part of stroke recovery or living with the effects of stroke for many stroke survivors. It is likely that as fewer people with disabilities are cared for in institutions than was the case in previous decades, the burden on informal caregivers has increased, especially in the short term, before formal services are established and the service user has adjusted to his or her new life.

Caregiver strain has been well-documented, including in the case of providing care to stroke survivors (e.g. Bugge et al., 1999). So, despite the challenges of valuing informal care, we sought to include this dimension of cost in the model.

Although we generally think of stroke survivors as recipients of informal care, it is also important to consider that before a stroke, many stroke patients may have been in an informal caregiver role themselves, including caring for children in the case of younger people experiencing stroke, caring for elderly parents, or caring for a spouse or partner. Our model also attempts to capture some of this lost caregiver value using similar evidence and assumptions.

11.1. Value of informal care

In the absence of a known hourly rate for informal care, we assume a value that is consistent with a major report on the value of informal care in New Zealand (Grimmond, 2014).

According to Grimmond (2014), the value of informal caregiving is 5 percent of GDP. We assume this ratio to remain constant over time. New Zealand's GDP in 2017 was $270.6 billion (Statistics New Zealand), which then corresponds to an informal caregiving value of $13.5 billion in 2017. Assuming the number of informal caregivers is a function of population growth, based on 431,649 informal caregivers in the 2013 Census, there would be roughly 590,000 informal caregivers in New Zealand in 2018. Additionally, informal caregivers in New Zealand provide on average 30 hours or more per week of care (Grimmond, 2014), which implies an average value of informal caregiving of $15.60 per hour in 2018.

By 2020, the number of informal care givers is estimated to be approximately 600,000 providing care at an average value per hour of $17.12.

11.2. Stroke survivors as recipients of informal care

According to McNaughton et al. (2014), 30 percent of stroke patients are discharged home but are dependent on others for daily living. Our model assumes that only 22 percent of stroke survivors will receive informal care at home, with or without, additional care services, but we assume this for only one year, due to a lack of evidence as to how informal caregiver needs evolve over time. We further assume that informal care amounts to no more than four hours per day.

We also assume that stroke patients who die within 28 days of a stroke are never discharged and thus, receive no informal care. Consequently, stroke survivors who die within six months of having a stroke receive five months of informal caregiving at most, and the remaining survivors receive a maximum of 11 months of informal caregiving.

Using the above assumptions, combined with mortality rates given in Table 9, and an estimated 8,626 stroke patients (based on 9,583 hospitalised strokes, including recurrent strokes) per year in New Zealand (updated to 11,170 stroke patients from 12,410 hospitalised strokes for 2020), we created a range of values of informal caregiving for stroke survivors using two scenarios to address the unknown timing of deaths in the first year after stroke, which impacts on the amount of informal caregiving. These two scenarios represent the lower and upper bounds of the value of informal caregiving respectively, for the assumed proportion who are dependent on it.

- In the first scenario, patients die at the *beginning* of the periods zero to one month, one month to six months, and six months to 12 months after a stroke.
- In the second scenario, patients die at the *end* of the periods zero to one month, one month to six months, and six months to 12 months after a stroke.

Table 20 and Table 21 below show the value of informal care for stroke patients in New Zealand who die at the beginning and end of periods, respectively. Due to uncertainty in the hourly rate of informal caregiving, we present the value of informal caregiving using the above estimated hourly rate of $15.60 (updated to $17.12 in 2020) and the average New Zealand hourly rate of $32.02 ($30.21 in 2017 (Statistics New Zealand, 2017) inflated by The Treasury CBAx discount rate of 6 percent) in 2018 (updated to $35.14 in 2020).

Table 20 Scenario 1 – Value of informal care for stroke survivors

(Deaths occur at beginning of period)

Months of informal caregiving	Stroke survivors receiving informal caregiving		Value of informal caregiving ($ millions)			
	2018 Estimate	2020 Estimate	2018 Low Value	2018 High value	2020 Low Value	2020 High Value
5	103	133	$1.0	$2.1	$1.5	$3.0
11	1,824	2,362	$40.7	$83.5	$57.8	$118.7
Total	**1,927**	**2,495**	**$41.7**	**$85.7**	**$59.3**	**$121.7**

Source: NZIER

Table 21 Scenario 2 – Value of informal care for stroke survivors

(Deaths occur at end of period)

Months of informal caregiving	Stroke survivors receiving informal caregiving		Value of informal caregiving ($ millions)			
	2018 Estimate	2020 Estimate	2018 Low Value	2018 High value	2020 Low Value	2020 High Value
5	168	217	$1.7	$3.5	$2.4	$5.0
11	1,927	2,495	$43.0	$88.3	$61.1	$125.4
Total	**2,095**	**2,713**	**$44.7**	**$91.8**	**$64.5**	**$132.3**

Source: NZIER

The value of informal caregiving for stroke survivors in New Zealand over a period of one year was estimated to range from $42 million to $92 million in 2018. This is updated to $59 million to $132 million in 2020. Using this range our estimates for the expected informal caregiver cost per stroke and total cost of informal caregiving related to stroke are presented in Table 22 below.

Table 22 Total and expected annual cost of informal caregiving

	2018 Estimate		2020 Estimate	
Measure	**Low**	**High**	**Low**	**High**
Value of informal caregiving (p.a.) ($ millions)	$41.7	$91.8	$59.3	$132.3
Average annual cost of informal caregiving	$19,925	$47,626	$21,866	$53,037
Expected annual cost of informal caregiving per stroke	$4,356	$9,577	$4,779	$10,663

Source: NZIER

The average cost of informal caregiving in cases where informal caregiving is required is estimated to be between $21,866 and $53,036 in 2020. The expected contribution of informal caregiving to the cost of stroke is estimated at between $4,779 and $10,663 per stroke in 2020.

11.3. Stroke survivors' informal caregiving roles

Some stroke survivors have informal caregiver responsibilities themselves before they experience a stroke. One study found that 2.1 percent of stroke patients had been acting as informal caregiver to a family member prior to their stroke (Crichton et al., 2012).

Using the estimated 8,626 stroke patients each year (updated to 11,170 in 2020) 181 of these (updated to 234 in 2020) would have been in an informal caregiver role themselves. We assume that in the first-year post-stroke, survivors do not act as informal caregivers. This means the loss in value from these stroke survivors being unable to act as informal caregivers over a period of one year is between $4.4 million (based on valuing their time at $15.60 per hour, consistent with Grimmond (2014) for four hours of caregiving per day) and $9.0 million (based on valuing their time at the average hourly rate of $32.02) in 2018. In 2020, these values are updated to: $6.2 million to $12.8 million.

12. Mortality and quality of life

In addition to health system costs and productivity losses, stroke is responsible for mortality and a loss of quality of life, both short and long term.

Although other studies sometimes convert the burden of disease as measured in DALYs into a dollar figure using the value of a 'statistical' life (VSL), the New Zealand Treasury discourages this approach. In particular, the values may be considered too high for an older population.

Instead, we opt for an alternative approach to putting a value on years of life lost and quality of life lost: We quantify the losses in terms of quality-adjusted life years (QALYs) and value these in monetary terms using the current monetary value of a QALY in the Treasury CBAx impact values database, which was $59,722 in 2018.

In the 2020 CBAx impact values database, the value of a QALY was updated to $33,306, representing a significant reduction in value since 2018. If the 2018 value were inflated to 2020, a QALY would be worth $65,542.

In the UK, the current National Institute for Health and Care Excellence (NICE) threshold for cost-effectiveness imposes a value limit of £30,000 per QALY. Converted to New Zealand dollars on 5 February 2020, this amounts to approximately $60,251 New Zealand dollars. With higher incomes in the UK than in New Zealand, it would be sensible to conclude that an updated 2020 value for a QALY of $65,542 is too high. At the same time, it seems implausible that New Zealanders would value a QALY at less than they did two years ago. For this reason, the 2020 updated estimates continue to use the value published in the 2018 CBAx impact values database of $59,722.

12.1. Mortality

A fatal stroke results in a number of life years lost. Without putting a value on years of life lost, the effect of a death in this type of analysis has the perverse result of making costs appear lower because those individuals are no longer alive to experience lower employment income and incur continuing health care costs. For this reason, we attempt to capture a conservative yet meaningful mortality cost. This involved focusing exclusively on premature mortality.

Premature mortality is defined as mortality that occurs before age 75. This concept provides a useful way to think about the impact of stroke deaths. Since every individual must eventually die, it is unclear how stroke death at age 90 should be treated in thinking about social and economic costs. By focusing exclusively on those who die before age 75, we provide a conservative estimate of the value of years of life lost.

Combining the Ministry of Health total stroke deaths by age group in 2014 (shown Table 23), and the Statistics New Zealand Complete Period Life Tables 2012-14, we find that premature deaths due to stroke result in an average of up to 22.37 years of life lost and a total of up to 10,736 years of life lost over all premature stroke deaths that occurred in New Zealand in 2014. This represents 43 percent of total years of life lost to stroke in 2014 (25,024) (see Table 23 and Figure 26 below). Note that these figures are based on comparing stroke deaths to the general population, not to matched controls.

Table 23 Years of life lost to stroke deaths

New Zealand, 2014

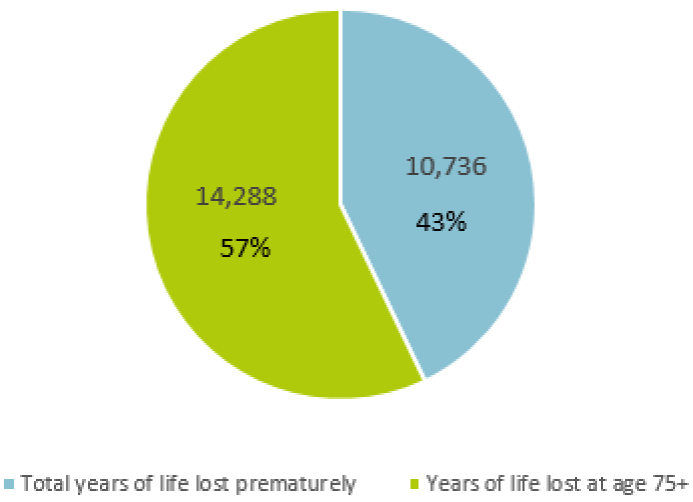
Age	Total deaths from all causes	Total stroke deaths	Stroke deaths as % of total	Approximate average years of life lost per death	Approximate total years of life lost
0	331	0	0	81.33	0
1	27	0	0	80.70	0
2	8	0	0	79.73	0
3	10	0	0	78.75	0
4	10	0	0	77.76	0
5-9	37	0	0	73.80	0
10-14	27	0	0	69.84	0
15-19	126	0	0	64.92	0
20-24	162	1	0.6%	60.10	60.10
25-29	153	0	0.0%	55.26	0.00
30-34	170	1	0.6%	50.40	50.40
35-39	233	5	2.1%	45.58	227.89
40-44	393	20	5.1%	40.79	815.87
45-49	588	25	4.3%	36.08	901.94
50-54	987	50	5.1%	31.47	1,573.42
55-59	1,265	56	4.4%	26.98	1,511.00
60-64	1,688	63	3.7%	22.63	1,425.61
65-69	2,321	101	4.4%	18.46	1,864.51
70-74	2,860	158	5.5%	14.59	2,305.61
Total Premature	**11,396**	**480**	**4.2%**	**22.37**	**10,736**
75-79	3,600	306	8.5%	11.04	3377.40
80-84	4,861	469	9.6%	7.95	3727.76
85+	11,307	1,314	11.6%	5.47	7182.26
TOTAL	**31,164**	**2,569**	**8.2%**	**9.74**	**25,024**

Source: NZIER, based on data from Ministry of Health (2014)

In the absence of updated data, we continue to use these estimates for the 2020 update.

Figure 26 Years of life lost prematurely to stroke

Proportion of total years of life lost to stroke, prematurely and non-prematurely (age 75+)



Source: NZIER, based on Ministry of Health and Statistics New Zealand data

Although this data suggests that premature deaths result in 22.37 years of life lost on average, we conservatively value only the first five of these years. This is due to the likelihood that many stroke patients may have died prematurely of other causes due to underlying risk factors and is consistent with our estimation of other social and economic costs up to 5 years, a limit imposed by a lack of longer-term evidence.

The cost of premature mortality can be quantified and valued in terms of QALYs. Each year of life lost in full health would have a value equal to one QALY. However, many people experiencing stroke are not in perfect health, so each additional year of life that would be expected if a fatal stroke is avoided will be worth somewhat less than that.

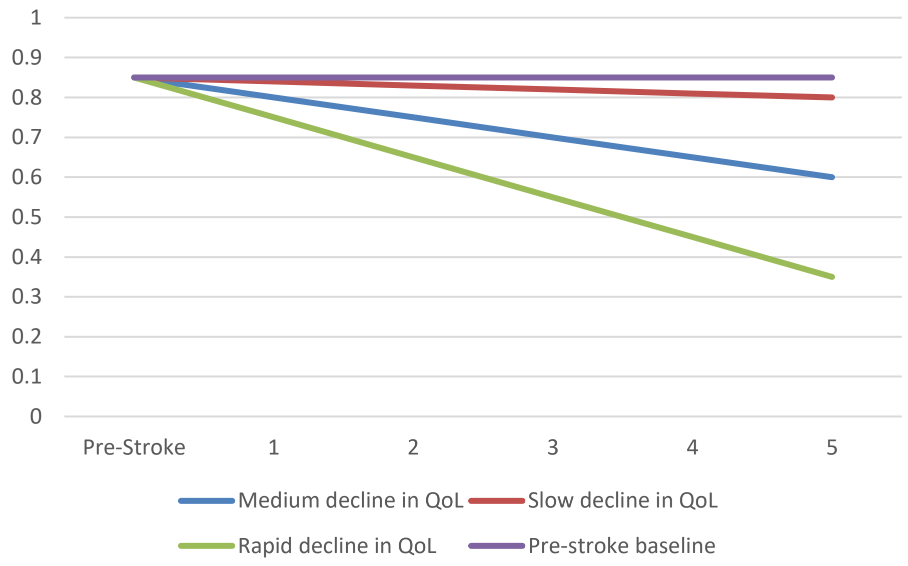
Luengo-Fernandez et al. (2013) elicited QALY values for people experiencing TIA and matched controls (based on age, sex, education, marital status, history of diabetes, angina/myocardial infarction, stroke, hypertension, and disability). The matched controls had a QALY value of 0.850. Because the average age of matched controls in the study was 75, this QALY value is a conservative estimate of the quality of life of stroke patients who die prematurely.

Based on a pre-stroke quality of life worth 0.850 QALYs and an assumed survival of 5 years in the absence of stroke, we assume that the first year of life lost prematurely is worth 0.850 QALYs.

Quality of life in subsequent years when a premature death is avoided is not known. However, ageing and deteriorating health due to comorbidities would result in a reduction in quality of life over time.

Because it is not known how quality of life would decline over time, we estimate the QALY cost of premature death based on three profiles of declining quality of life as the counterfactual. These are shown in Figure 27. We then value these years of life using the 2018 monetary value of a QALY in the Treasury CBAx impact values database, which is $59,722, and discount future years by 6 percent per annum, consistent with the Treasury CBAx tool discount rate. Results are presented in Table 24, Table 25 and Table 26 below.

Figure 27 Scenarios for declining quality of life in a premature death counterfactual



Source: NZIER

Table 24 Average value of life years lost due to a premature stroke death

Mid-estimate from medium decline in QoL

Year post-stroke	Year of Estimate	QALY value of years lost prematurely to stroke	QALY value of year saved due to avoided stroke	Undiscounted cumulative value of life years lost due to a stroke	Discounted value of life years lost due to a stroke	Discounted cumulative value of years lost due to a stroke
1	**2018**	0.8	$47,778	$47,778	$47,778	$47,778
	2020		52,434	$52,434	$52,434	$52,434
2	**2018**	0.75	$44,792	$92,569	$42,256	$90,034
	2020		49,157	101,591	46,647	$99,081
3	**2018**	0.7	$41,805	$134,375	$37,207	$127,240
	2020		45,879	$147,470	$41,523	$140,604
4	**2018**	0.65	$38,819	$173,194	$32,593	$159,834
	2020		$42,602	$190,072	$36,836	$177,440
5	**2018**	0.6	$35,833	$209,027	$28,383	$188,217
	2020		$39,325	$229,397	$32,583	$210,023

Source: NZIER

Table 25 Average value of life years lost due to a premature stroke death

Low estimate from rapid decline in QoL

Year post-stroke	Year of Estimate	QALY value of years lost prematurely to stroke	QALY value of year saved due to avoided stroke	Undiscounted cumulative value of life years lost due to a stroke	Discounted value of life years lost due to a stroke	Discounted cumulative value of years lost due to a stroke
1	**2018**	0.75	$44,792	$44,792	$44,792	$44,792
	2020		49,157	$49,157	$49,157	$49,157
2	**2018**	0.65	$38,819	$83,611	$36,622	$81,413
	2020		42,602	91,759	40,427	$89,584
3	**2018**	0.55	$32,847	$116,458	$29,234	$110,647
	2020		36,048	$127,807	$32,625	$122,209
4	**2018**	0.45	$26,875	$143,333	$22,565	$133,212
	2020		$29,494	$157,301	$25,502	$147,711
5	**2018**	0.35	$20,903	$164,236	$16,557	$149,769
	2020		$22,940	$180,241	$19,007	$166,718

Source: NZIER

Table 26 Average value of life years lost due to a premature stroke death

High estimate from slow decline in QoL

Year post-stroke	Year of Estimate	QALY value of years lost prematurely to stroke	QALY value of year saved due to avoided stroke	Undiscounted cumulative value of life years lost due to a stroke	Discounted value of life years lost due to a stroke	Discounted cumulative value of years lost due to a stroke
1	**2018**	0.84	$50,166	$50,166	$50,166	$50,166
	2020		55,055	$55,055	$55,055	$55,055
2	**2018**	0.83	$49,569	$99,736	$46,763	$96,930
	2020		54,400	109,455	51,623	$106,678
3	**2018**	0.82	$48,972	$148,708	$43,585	$140,515
	2020		53,744	$163,199	$48,641	$155,319
4	**2018**	0.81	$48,375	$197,083	$40,616	$181,131
	2020		$53,089	$216,288	$45,904	$201,223
5	**2018**	0.8	$47,778	$244,860	$37,844	$218,976
	2020		$52,434	$268,722	$43,445	$244,668

Source: NZIER

Based on the range of scenarios for the counterfactual, the 2018 cost of a premature stroke death using QALYs to value 5 years of life lost prematurely is between $149,769 and $218,976. For 480 premature stroke deaths per year (based on 2014 data, shown in Table 23), the total value of 5 years of life lost prematurely due to stroke is between $72 million and $105 million.

These figures were updated for 2020 with no change to the number of premature deaths (due to a lack of more up-to-date data), which may be reasonable given continued improvements in survival rates. Costs estimated in 2018 were inflated to 2020 values. These updates yielded a 2020 cost of premature stroke death ranging from $166,718 to $244,668.

For 480 premature stroke deaths per year (based on 2014 data, shown in Table 23), the total value of 5 years of life lost prematurely due to stroke is estimated at between $80 million and $117 million in 2020.

The expected premature death cost per stroke in 2018 was estimated to be between $7,502 and $10,968. Due to the reduced mortality resulting from continued use of the same stroke death figures, the 2020 expected cost of premature death per stroke is slightly lower, at $6,448 to $10,293. This would be consistent at least in direction of change, if not magnitude, with a falling stroke mortality rate.

The ranges of estimates are summarised in Table 27 below.

Table 27 Range of estimates for QALY cost of premature death

	Year of Estimate	Low estimate	Mid estimate	High estimate
QALY cost per premature death	**2018**	$149,769	$188,217	$218,976
	2020	$166,718	$210,023	$244,668
Total annual cost (based on 480 premature deaths) ($ millions)	**2018**	$72.0	$90.3	$105.1
	2020	$80.0	$100.8	$117.4
Expected cost per stroke	**2018**	$7,502	$9,428	$10,968
	2020	$6,448	$8,123	$10,293

Source: NZIER

12.2. Quality of life for survivors

To estimate the cost of quality of life effects on survivors, we use three key studies providing utilities based on EQ-5D:[7]

- Luengo-Fernandez et al. (2013), based on the UK's Oxford Vascular Study, estimate that quality of life pre-stroke in the relevant population is 0.850 on average.
- Te Ao et al. (2012), based on New Zealand data, estimate that post-stroke quality of life values range from 0.44 to 0.53 twelve months after the event. The lower value associated with treatment in a general medical ward and the higher value associated with treatment in an acute stroke unit. The values are explained by the authors as being different mainly due to differences in the rate of discharge to residential care, which is associated with a significantly lower quality of life than discharge to the patient's own home.
- Cadilhac et al. (2010), based on the North-East Melbourne Stroke Incidence Study (NEMESIS), estimate that stroke is associated with a loss of 0.1886 in the value of quality of life at 12 months after the event and 0.2533 at 5 years after the event. They also estimate that utilities in a stroke-free population typically decline by only 0.01 to 0.04 over five years.

Based on approximately half of New Zealand stroke sufferers being treated in an acute stroke unit, and the Te Ao et al. (2012) estimates described above, the expected loss of quality of life for survivors amounts to 0.365 QALYs immediately following a stroke. Because the quality of life values from Te Ao et al. are based on 12 months after a stroke, the loss of quality of life over the first year is likely to be conservatively estimated. The value of this loss of quality of life is $21,799 per stroke survivor.

Based on 9,583 hospitalised strokes per year assumed for 2018 and 12,410 projected for 2020 and 11.1 percent of patients having recurrent stroke within a year, if we assume only one recurrent stroke within the year, the number of stroke patients is 8,626 in 2018 and 11,169 in 2020. Of these, 29.5 percent die within the year, so we assume the QALY loss estimated above applies only to the remaining 70.5 percent, or 6,081 individuals in 2018 and 7,818 in 2020. The value of quality of life lost to these remaining individuals is approximately $170 million in 2020. See Table 28 below.

[7] EQ-SD is a standardized instrument for measuring generic health status. It has been widely used in population health surveys, clinical studies, economic evaluation and in routine outcome measurement in the delivery of operational healthcare.

Table 28 Value of quality of life lost by stroke survivors

In the first 12 months after a stroke – High estimate
Based on Luengo-Fernandez et al., 2013 and Te Ao et al., 2012

	Year of Estimate	Pre-stroke	12 months post-stroke	Loss of QoL
Quality of life[1]	**2018 & 2020**	0.850*	0.485**	0.365
Monetary value per person[2]	**2018 & 2020**	50,764	28,965	21,799
Survivors	**2018**	8,626	6,081	
	2020	11,169	7,818	
Total monetary value of quality of life ($ millions)	**2018**	$438.0	$176.0	$132.6
	2020	$567.0	$226.4	$170.4
Strokes	**2018**	9,583		
	2020	12,410		
QoL cost per stroke	**2018**			$13,834
	2020			$13,733

[1] Not updated

[2] Not updated due to reduced value in CBAx impact values database

*Luengo-Fernandez et al., 2013

**Te Ao et al., 2012

Source: NZIER

Based on a total quality of life cost of $170 million in 2020 and 12,410 strokes per year in 11,169 individuals, the expected quality of life cost of a stroke in the first 12 months after a stroke is $13,733. These estimates do not include the quality of life lost by those who die within the first 12 months.

The quality of life values at 12 months post-stroke estimated by Te Ao et al. (2012), while based on New Zealand subjects, are significantly lower than those estimated by Cadilhac et al. (2010), based on the North-East Melbourne Stroke Incidence Study. The latter found a reduction in quality of life of 0.1886 at 12 months after a stroke. This would imply a post-stroke quality of life of 0.6634. Table 29 below estimates the value of lost quality of life based on this alternative value.

Table 29 Value of quality of life lost by stroke survivors

In the first 12 months after a stroke – Low estimate
Based on Luengo-Fernandez et al., 2013 and Cadilhac et al., 2010

	Year of Estimate	Pre-stroke	12 months post-stroke	Loss of QoL
Quality of life[1]	**2018 & 2020**	0.85	0.6634	0.1886
Monetary value per person[2]	**2018 & 2020**	50,764	39,620	11,264
Survivors	**2018**	8626	6081.33	
	2020	11,169	7,818	

	Year of Estimate	Pre-stroke	12 months post-stroke	Loss of QoL
Total monetary value of quality of life	2018	$437,865,470	$240,942,295	$68,500,101
	2020	$566,983,116	$309,761,046	$88,065,331
Strokes	2018	9583		
	2020	12,410		
QoL cost per stroke	2018			$7,148
	2020			$7,096

[1] Not updated.

[2] Not updated due to reduced value in CBAx impact values database.

*Luengo-Fernandez et al., 2013;

**Te Ao et al., 2012

Source: NZIER

The quality of life values estimated by Te Ao et al. (2012) used above are based on the rates of admission to residential care subsequent to a stroke. Because the vast majority of these are long-term or permanent, it is reasonable to assume that quality of life will not improve substantially. However, because many of those admitted to residential care will die within a year or two, average quality of life for stroke survivors may well increase over the longer term.

What actually happens to quality of life over the following years is unknown and could not be reasonably estimated for this report. However, even if those with the worst quality of life die earlier, increasing the average quality of life of survivors as time goes by, the average quality of life of survivors is unlikely ever to reach the pre-stroke value.

If we assume quality of life of survivors in years 2 to 5 is halfway between the pre-stroke value and the Te Ao et al. estimated value at 12 months post-stroke, or 0.668, the quality of life lost in the second and subsequent years is 0.182.

The assumption made above is consistent with evidence from a UK study (Ara & Brazier, 2010) which estimated that quality of life for a 67-year-old with a history of stroke is 0.668. Our estimate of quality of life lost in the second and subsequent years is also consistent with the findings of the North East Melbourne Stroke Incidence year. This is therefore, likely to be a reasonable assumption for second and subsequent years' quality of life.

In addition, what matters most for cost estimation is not the starting point or end point of quality of life, but the loss of quality of life. In total, over five years, our model assumes that stroke results in a loss of 1.613 QALYs per stroke victim. This is a much smaller impact than what was reported in the North East Melbourne Stroke Incidence Study, which found that the mean QALY loss after stroke amounted to 5 to 6 QALYs over five years.

Table 30 below shows how our estimates add up.

Table 30 Estimated value of quality of life lost by stroke survivors

Based on the second to fifth years after a stroke

	Year of Estimate	12-24 months post-stroke	24-36 months post-stroke	36-48 months post- stroke	48-60 months post-stroke
Quality of life[1]	2018 & 2020	0.668	0.668	0.668	0.668
Monetary value per person[2]	2018 & 2020	$39,894	$39,894	$39,894	$39,894
Loss of QoL	2018 & 2020	0.182	0.182	0.182	0.182
Value of lost QoL per person	2018 & 2020	$10,869	$10,869	$10,869	$10,869
Total lost QoL value discounted	2018	$50,349,898	$42,681,469	$37,622,493	$35,013,722
	2020	$64,822,642	$54,953,156	$48,437,191	$45,080,198
QoL cost per stroke discounted	2018	$5,254	$4,454	$3,926	$3,654
	2020	$5,570	$4,773	$4,261	$4,028

[1] Not updated.

[2] Not updated due to reduced value in CBAx impact values database.

Source: NZIER

The results for year 1 post-stroke and subsequent years post stroke are combined in Table 31 below. In 2018, nearly $300 million in lost quality of life was estimated for the five years that follow a year in which 8,519 individuals experience a stroke. In 2020, the total loss of quality of life, given an estimated increase in the number of individuals experiencing a stroke, is estimated at over $366 million. In both years, this amounts to an expected loss of quality of life of approximately $30,000 per stroke.

Table 31 Quality of life cost of stroke over five years

	Total QoL cost	
Year of Estimate	2018	2020
Year Post-Stroke		
Year 1	$130,921,971	$153,388,010
Year 2	$50,349,898	$64,822,642
Year 3	$42,681,469	$54,953,156
Year 4	$37,622,493	$48,437,191
Year 5	$35,013,722	$45,080,198
Total	$296,589,553	$366,681,197

Source: NZIER

13. Total cost of stroke in New Zealand

Based on our most conservative assumptions and lowest cost results across all cost components, we estimated in 2018 that the total discounted five-year cost associated with the 9,583 hospitalised strokes, was over $925 million.

In 2020, these estimates were updated to reflect increased prices and increased volume of strokes, this time projected from the most recently available hospitalisation data. The resulting estimate for the total discounted five-year cost of the strokes expected to result in hospitalisation in 2020 is approximately $1.3 billion.

Even if the costs of premature death and quality of life are omitted, the total discounted five-year cost is still over $800 million.

Table 32 Total discounted costs of one year of strokes in New Zealand ($ millions)

	Section of report	2018 Total	2020 Total
Ambulance call-outs	4.1.1	$4.3	$6.1
ED visits	4.1.2	$3.9	$5.5
1st year inpatient cost	4.2	$265.8	$377.7
Medication cost	5.1	$20.5	$37.4
General practitioner care cost	5.1	$5.8	$10.6
Recurrent stroke	5.2	$44.8	$63.6
Aged residential care (65+)	6	$42.0	$69.6
Residential care (<65)	7	$9.2	$14.4
Support services	8	$19.3	$27.4
Community rehabilitation	9	$8.0	$11.4
Lost productivity	10	$86.8	$125.5
Informal caregiving	11	$41.7	$59.3
Caregiving lost by stroke		$4.4	$6.2
SUB TOTAL	**12.1**	**$556.7**	**$814.8**
Premature death	12.2	$71.9	$103.6
Quality of life	12.2	$296.6	$384.1
TOTAL	**13**	**$925.1**	**$1,302.5**

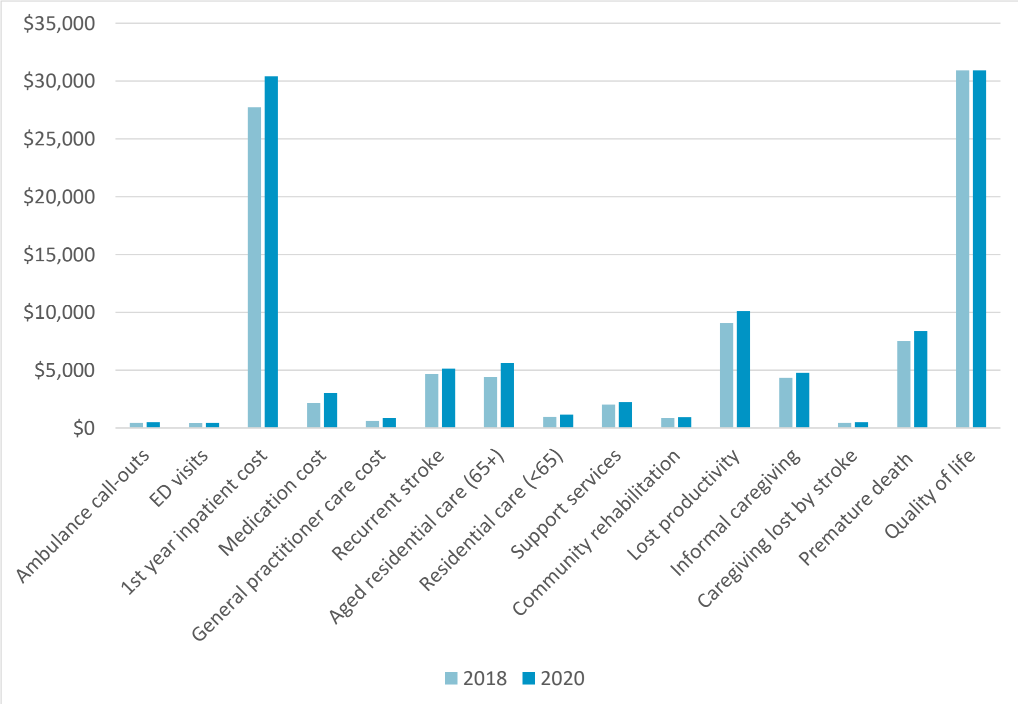
*Because annual costs of hospitalisation are based on actual annual hospitalisation (2014), this cost includes initial stroke and recurrent stroke hospitalisation.

Source: NZIER

As shown below, the cost of first year inpatient hospitalisation dominates the other costs of stroke. However, loss of quality of life, loss of productivity followed by the cost of premature death, informal caregiver burden, and the health system costs of recurrent stroke, represent significant costs associated with stroke.

Figure 28 below shows that loss of quality of life in survivors and hospitalisation costs (which include the complete initial inpatient stay and hospitalisation for recurrent stroke) are the most significant costs. Lost income and the cost of premature death are also significant drivers.

Figure 28 The 5-year costs of a year of strokes in New Zealand



Source: NZIER

Every time a stroke occurs, the discounted expected cost over 5 years estimated at $96,000 in 2018, now stands at nearly $105,000 for strokes occurring in 2020. If the cost of premature death and quality of life are omitted, the discounted expected cost over 5 years is still over $65,000 in 2020 (see Table 33 below).

Table 33 Expected 5-year costs of a stroke in New Zealand

	Per stroke 2018	Per stroke 2020
Ambulance call-outs	$447	$491
ED visits	$407	$447
1st year inpatient cost	$27,733	$30,436
Medication cost	$2,140	$3,015
General practitioner care cost	$607	$854
Recurrent stroke	$4,672	$5,127
Aged residential care (65+)	$4,388	$5,606
Residential care (<65)	$965	1,157
Support services	$2,014	$2,209
Community rehabilitation	$838	$919
Lost productivity	$9,063	$10,110
Informal caregiving	$4,356	$4,779
Caregiving lost by stroke	$459	$503
SUB TOTAL	$58,088	$65,653
Premature death	$7,502	$8,351
Quality of life	$30,950	$30,950
TOTAL	**$96,539**	**$104,953**

Source: NZIER

13.1. The annual cost of stroke in New Zealand

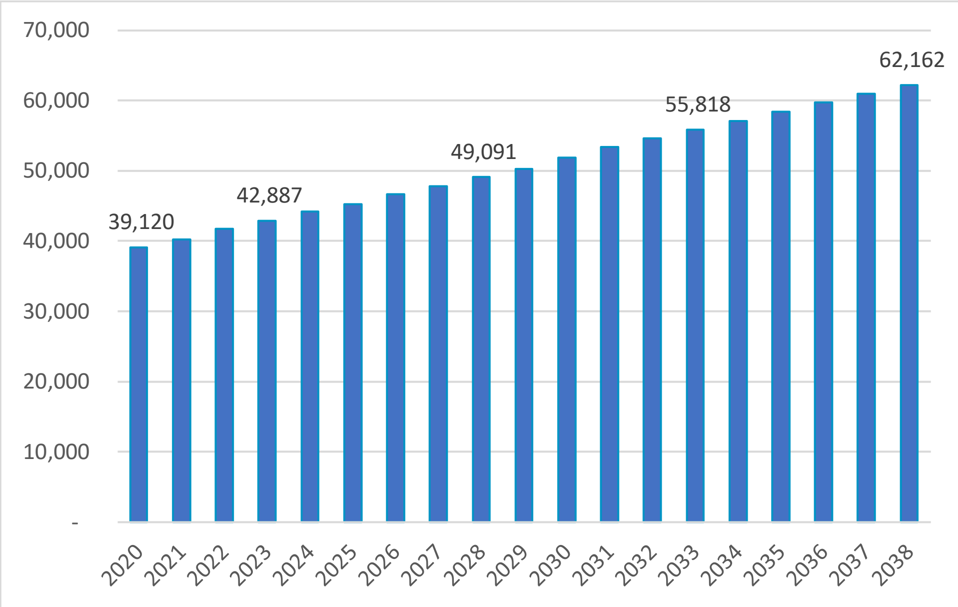
In any given year, there are thousands of new strokes as well as many more thousands of people living with the long-term effects of stroke. These costs in total provide a picture of the growing annual social and economic burden of stroke.

To do this consistently with our framework, we calculate the costs associated with each cohort of strokes over a five-year period. This is conservative because many people survive beyond five years and continue to experience disability and recurrent strokes. However, data on these longer-term effects is scarce so we restrict the estimation of annual costs to strokes that are expected to have occurred in 2020 or in the previous four years.

In 2020, we estimate that there will be approximately 39,000 New Zealanders living as survivors of a recent stroke (a stroke that has occurred within the last five years). This figure will creep up every year even if survival rates stop improving, just due to population growth and population ageing. These two factors alone are expected to increase the population of stroke survivors to over 62,000 by 2038. With increased survival, the 2038 figure will be even greater, further emphasising the need to ensure that survival comes with functional independence as much as medical technology can achieve, to avoid the high costs of residential care and lost productivity as well as lost quality of life for this population.

Figure 29 Projected population of stroke survivors in New Zealand

Based on strokes in the previous 5 years



Source: NZIER

The costs associated with this population in 2020 are estimated in Table 34 below totalling nearly $1.1 billion.

Table 34 Cost of stroke to New Zealand in 2020 ($ millions)

	2020 cost
2020 new strokes	$743.1
2019 stroke survivors	$127.8
2018 stroke survivors	$104.8
2017 stroke survivors	$69.3
2016 stroke survivors	$54.4
Survivors of earlier strokes	Costs excluded due to lack of long-term evidence
Total	$1,099.3

Source: NZIER

Given the projected increase in the 'stroke population', the annual cost of stroke is expected to reach $1.7 billion by 2038 (2020 dollars, based on current treatment, costs, incidence and outcomes).

14. Previously published estimates

While the total costs of stroke estimated in this report may appear unrealistically large, they compare well with estimates from other jurisdictions.

A UK systematic review (Leal et al., 2009), of the direct cost of stroke to the health and social care system of the UK in 2006/07 estimated that cost at just over £2.5 billion. Of the estimated costs, inpatient costs and residential care costs amounted to 44 percent and 36 percent of total costs, respectively, for a total of 80 percent of costs, with outpatient care, medication, productivity loss and informal caregiving making up the remaining 20 percent. However, the review also revealed that most studies did not report on costs beyond 12 months, which limits the estimation of any long-term costs to a small fraction of the total.

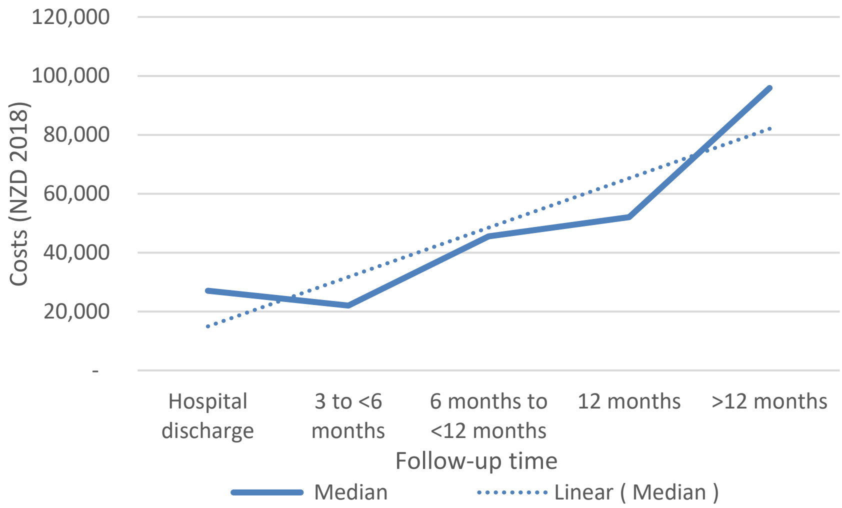
Gloede et al. (2014) estimated the direct health system costs at 10 years post-stroke based on data from the North East Melbourne Stroke Incidence Study (NEMESIS). For ischemic stroke, the overall average annual direct costs at 10 years estimated at USD 5,207 and were not significantly different than costs estimated at 3 and 5 years, suggesting that for patients who survive 5 years post-stroke, there is very little additional stroke-related cost after discounting. It also suggests that the 5-year total direct cost is approximately USD 26,000. Average lifetime costs per stroke were USD 68,769 for ischaemic stroke and USD 54,956 for intracerebral haemorrhage.

Converting these figures to 2020 New Zealand dollars at a relatively high value NZD for 2014 (which has the effect of keeping the NZD value low) indicates average lifetime costs of $105,869 for ischaemic stroke and $84,604 for intracerebral haemorrhage. Given that ischaemic strokes are the majority of strokes, these estimates are very similar to our own estimate of the cost of stroke.

Luengo-Fernandez et al. (2009) conducted a systematic review of studies reporting costs associated with stroke and ischemic stroke. When results were categorised according to follow-up time, they showed a clear pattern of costs increasing from hospital discharge to over 12 months after the event. The reported costs have been converted to New Zealand dollars from the US dollars reported in the study and inflated to 2018 using the Treasury CBAx tool (see Figure 30 below).

Figure 30 Median stroke cost estimates* by follow-up time

From 71 published studies reporting costs (per stroke) of stroke or ischemic stroke



*Costs included varied

Source: Luengo-Fernandez et al., 2009

The estimates also suggest that initial hospitalisation is a significant cost at over $27,000, (see Table 35 below).

The total cost of a stroke including more than just first year costs, according to this study, would amount to $105,234 in 2020 NZ dollars – again, similar to our estimate of just under $105,000 per stroke.

Table 35 Median cost estimates* by follow-up time

From 71 published studies reporting costs of stroke or ischemic stroke

Follow-up duration	Median cost (2018)	2020 update
Hospital discharge	$27,015	$29,648
3 to <6 months	$22,011	$24,156
6 months to <12 months	$45,533	$49,970
12 months	$51,994	$57,061
>12 months	$95,894	$105,234

Source: Luengo-Fernandez et al., 2009

15. Opportunities to reduce the burden

Despite improvements in lifestyle choices that impact on stroke risk and improvements in stroke outcomes over the last two decades, there continues to be a significant gap between what is achievable and what our current health and disability currently delivers.

It is important to consider that although interventions to improve stroke outcomes may increase costs to the health system, if these interventions improve functional outcomes, reducing caregiver burden, minimising productivity losses, and improving quality of life, they may nevertheless be good investments from a societal cost-benefit perspective. We consider the opportunities to reduce the burden of stroke from this perspective.

15.1. Developments in acute ischaemic stroke treatment

Our previous report on the social and economic costs of stroke focused on thrombolysis as an opportunity for increased investment to improve stroke outcomes, and continued investment to improve thrombolysis rates continues to be warranted, particularly where rates are lower.

But this 2020 Update follows a 2018 breakthrough associated with two high quality and significant trials: DAWN and DEFUSE 3.

- DAWN was a randomised clinical trial across 26 centres in Canada, Australia, Europe, and the US, comparing mechanical thrombectomy with standard medical therapy, with primary outcomes of disability at 90 days and functional independence at 90 days and multiple secondary and safety outcomes.
- DEFUSE 3 was a randomised clinical trial across 38 US hospitals, comparing mechanical thrombectomy with standard medical treatment, with primary outcomes of Modified Rankin Scale (a well-accepted scale used to evaluate the degree of disability in patients who have suffered a stroke) and multiple secondary and safety outcomes. DEFUSE 3 had broader inclusion criteria than DAWN and unlike DAWN was not industry sponsored.

These trials demonstrated that for appropriately selected patients, mechanical thrombectomy offers a window of up to 24 hours, within which major improvements in post-stroke functional independence can be achieved. Many patients eligible for thrombectomy do not respond to intravenous thrombolysis. Until thrombectomy was shown to be safe and effective in these patients beyond the six-hour thrombolysis window, there was no active intervention available to prevent brain damage, limiting such patients to the small gains possible through rehabilitation and a high likelihood of long-term dependence on support services and nursing care.

The 24-hour window also provides easier access for patients whose stroke occurs far away from major centres. But the most noteworthy results of the trials are that many patients experience materially improved outcomes from thrombectomy post-thrombolysis, achieving functional independence where severe disability would have been the expected outcome.

The model of care in which thrombectomy is an effective and safe option for the appropriate cohort of stroke patients includes: the admission of patients to an emergency department in the nearest hospital with acute or hyperacute stroke unit; immediately employ CT or magnetic resonance (MR) angiography to undertake investigations to support diagnosis and identify best treatment; start treatment with intravenous thrombolysis as appropriate; and then transfer urgently those who might benefit from thrombectomy to the nearest hospital offering thrombectomy (currently only offered by Christchurch, Auckland City, and Wellington Regional Hospitals).

Acute ischaemic stroke is the most common stroke sub type. According to a South Australian Study (Chia et al., 2016), approximately 7 percent of these patients would currently be eligible for thrombectomy. Ranta (2018) estimates that this translates into 400 eligible patients in 2018, increasing to 500 by 2028. These figures suggest that approximately 3.4 percent of all stroke hospitalisations (ICD-10 I60-I69) would be eligible for thrombectomy, that is 426 in 2020.

15.1.1. Thrombectomy cost-effectiveness

There is substantial high- quality evidence of the safety, clinical effectiveness and cost-effectiveness of thrombectomy in eligible patients.

A UK policy paper on clinical commissioning of thrombectomy (NHS 2018) drew from an extensive search of the international research literature to establish the effectiveness of mechanical thrombectomy. Sixteen research studies; seven trials, and a nine systematic literature reviews and meta-analyses all reported strongly positive results, with the proportion of patients functioning independently at 90 days post-stroke increasing by 19 to 35 percent. The safety of thrombectomy was demonstrated in that there was no increase in total mortality or in the probability of intracranial haemorrhage relative to the comparator best treatment.

The improvement in outcomes demonstrated, now by multiple thrombectomy trials, is well-recognised. The Ministry of Health has responded to this with a National Service Improvement Programme Action Plan (Ministry of Health, 2018) for stroke clot retrieval. Evidence reviewed for the Plan provided the following:

- For every five people treated one more person was alive and independent 90 days post-stroke; and,
- For every six people treated one less person was left severely disabled and requiring hospital level residential care.

A NICE (2018) evidence review of thrombectomy which resulted in a favourable finding for the cost-effectiveness of the procedure also based its conclusions on these two important dimensions.

These measures of effectiveness, recognised by both the New Zealand Ministry of Health and the NICE, provide a basis for an indicative cost-benefit analysis of thrombectomy from a societal perspective for New Zealand. To estimate the cost of thrombectomy, we use:

- The volume estimate for 2020 extrapolated from the Ranta (2018) estimate,
- The Ministry of Health's (2018) expectation that the majority of thrombectomies would fall into the B02B Diagnosis Related Group (DRG) with a cost of $46,360
- A 28.5 percent reduction in total hospital stay, based on a study associated with the DEFUSE 3 trial (Tate et al, 2018), which we apply from the end of the stay (typically in a lower cost inpatient rehabilitation ward)
- Our estimates of the costs of stroke developed for this report.

We assume that only 25 percent of thrombectomy patients are aged 70 or younger and that for these individuals, a life saved by thrombectomy translates into another five years of life. This means that for three-quarters of patients who may benefit from thrombectomy, consistently with our costing which was based on premature mortality, we do not estimate a value for any mortality gains. We assume, however, that age is no barrier to significant improvements in functional independence and, therefore, apply the probability of such gains to all eligible patients.

We conservatively assume that all patients who would have needed hospital level residential care would be elderly and that the duration of this care would be a maximum of two years.

We further assume that 5 percent of thrombectomy patients who are alive and independent or are independent instead of severely disabled are able to return to paid work or unpaid work, and conservatively value this as equivalent to part-time (20 hours per week, 48 weeks per year, for 5 years) work at the 2020 minimum wage ($18.90 from 1 April 2020).

Table 36 Cost-benefit analysis of thrombectomy in New Zealand

Based on 426 thrombectomy patients estimated for 2020

Cost component	Expected discounted value per person	Total discounted value
Thrombectomy	$46,360	$19,749,360
Change in hospital stay (28.5% reduction)	-$6,269	-$2,670,594
Change in Premature mortality cost (additional 21 people alive and independent)	-$166,718	-$3,501,078
Change in Residential Care cost (71 people not left severely disabled and requiring hospital level residential care – two years assumed in Aged Residential Care)	-$141,620	-$10,055,020
Change in QoL cost for those functionally independent rather than severely disabled (71 people as above, 0.4 QALYs[1] per year over 2 years)	-$19,344	-8,240,544
Change in Productivity cost (paid or unpaid work, 5 people)	-81,015	-$405,075

Total change in cost	**-$12,026**	**-$5,122,951**

[1] Consistent with our QALY loss model in section 3.

Source: NZIER

Our results show that even with conservative assumptions, thrombectomy has the potential to be cost saving from a societal perspective. The bulk of these cost savings are expected to be within the health and disability sector, in the form of shortened stays in hospital and reductions in residential care costs for patients who would have been left severely disabled.

Based on assumptions that are consistent with our conservative cost estimates, it is essential to value the quality of life change for people who avoid disability to show that thrombectomy is cost-effective. However, even if our value of a QALY (from the 2018 CBAx impact values database) is halved, to less than $30,000, thrombectomy would still provide value for money.

This result is consistent with the NICE (2018) finding that thrombectomy does imply an additional cost, but that QALYs are gained within the acceptable threshold value of a QALY.

15.1.2. Equity considerations

It is important to note that if *all* eligible patients had access to thrombectomy, outcomes would improve for Māori and Pacific patients as well as others and the value to Māori and Pacific people would likely be greater due to their younger age at the time of stroke. The average age of stroke onset for Māori is 61 years, compared to 64 years for Pacific people and over 75 years for European New Zealanders (Feigin et al. 2006). This means Māori and Pacific gains from reduced disability and improved productivity would be greater. In fact, our estimates of the cost of premature mortality would be fairly largely attributed to Māori and Pacific people.

Our costing model only applied costs to the first five years after a stroke due to a lack of evidence for longer term outcomes. However, with a significantly younger age at stroke onset, Māori and Pacific people could potentially benefit from many more years of quality of life gain and save the health and disability system the cost of many more years of residential care costs. There is also some evidence that the chance of being dependent at 12 months post-stroke is three times higher for Māori compared to Pakeha (McNaughton et al. 2002, Ministry of Health 2003), meaning that a disproportionate amount of the quality of life gain from thrombectomy would be enjoyed by Māori and Pacific people.

Because of these issues, access to thrombectomy for all eligible patients would not only improve outcomes for Māori and Pacific patients, it should be expected that outcomes for Māori and Pacific patients would improve disproportionately, reducing the existing equity gap.

Currently Māori and Pacific patients have inequitable access to stroke treatment generally (Ministry of Health, 2018). Additional equity improvements would be gained as a result of improving existing access to thrombolysis in provincial hospitals, an outcome that would be expected if investments that support thrombectomy are made.

It is important to note that despite being a significant benefit of full access to thrombectomy for all eligible patients, the value of equity improvement has not been included in our indicative cost-benefit analysis as no monetary value currently exists to value this policy objective. Pursuing an equity objective can be expected to cost more due to the requirement for services to reach out where economies of scale may be unfavourable, and underinvestment in existing services must first be remedied.

15.1.3. Thrombectomy challenges

Despite the evidence in favour of offering thrombectomy to all eligible stroke patients and the strong support from key health system planners (the Ministry of Health, the NHS, the NICE, etc.), there are significant challenges to offering thrombectomy on this level in New Zealand.

Currently, there are only three hospitals – Auckland City, Wellington Regional and Christchurch – resourced to provide thrombectomy in New Zealand. Only Auckland provides a 24-hour service.

According to a report on thrombectomy in New Zealand published in 2018 (Burnell et al, 2018), 312 patients were treated with thrombectomy in New Zealand between 2011 and the end of April 2018:

- 241 at Auckland City Hospital
- 57 at Christchurch Hospital
- 14 at Wellington Hospital.

Half of these patients were transferred from another hospital. This is a model that works well when the transferring hospital is able to rapidly initiate and conduct patient assessment in conjunction with the tertiary stroke centre and organise timely transfers for patients assessed as eligible. However, in practice, the 'mothership' model, where patients present directly to a tertiary centre providing thrombectomy, is generally seen as the most efficient pathway, resulting in best outcomes (Dutta, 2018).

Patient assessment, which consists of stroke diagnosis, localisation, severity assessment, pre-stroke functional status, and co-morbidities needs to be both rapid and thorough as the effectiveness of thrombectomy is highly time-dependent (Dutta, 2018). Whatever the window of time in which thrombectomy may be beneficial, a fifteen-minute delay translates into 25 fewer patients per 1000 achieving functional independence (Dutta, 2018).

As many patients will experience stroke far away from the three providing hospitals, their first point of access will require the resources necessary to ensure these patients have access to the thrombectomy pathway. This includes a requirement for highly specialised (and high cost) skills and equipment to be available 24/7. The existing low rates of thrombolysis in DHBs with a high rate of Māori residents (Ministry of Health, 2018) indicate that barriers are particularly high in those areas (similar time dependency and need to transfer indicate that access barriers for thrombolysis are also likely to apply to thrombectomy for Māori). Delays across the patient pathway within and transferring from such hospitals have the potential to increase disparities as thrombectomy volumes grow in the larger hospitals.

In many countries with public health systems, the most significant challenge to ensuring adequate supply of thrombectomy will be an inadequate supply of neurointerventionists trained in performing the procedure, indicating that workforce issues are likely to be a major barrier. Access to imaging technology and appropriate staffing to assess a patient for eligibility prior to transfer is also an issue for many New Zealand hospitals.

The Ministry of Health has indicated that reducing transfer delays is of critical importance to improving equity of access to thrombectomy (Ministry of Health, 2018). This will require significant investment in workforce development, employment, and technology.

15.1.4. Thrombectomy cost projections

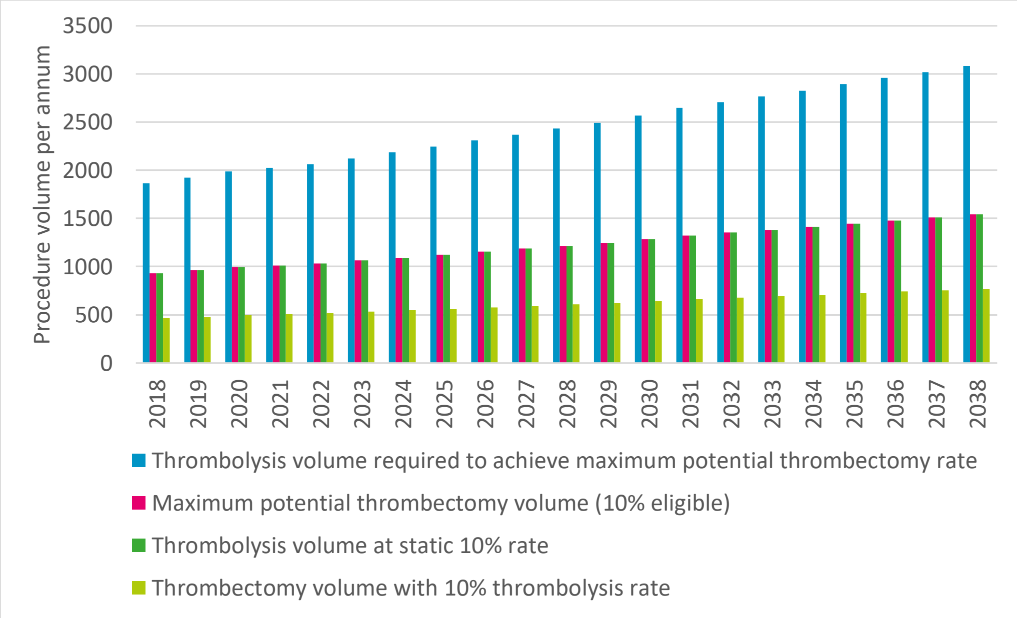
The Ministry of Health noted that a key development toward achieving access to thrombectomy for all eligible patients is the extension of thrombolysis services to more patients, especially those in DHBs with a high proportion of Māori and Pacific population, where thrombolysis rates are lower. Because the patient pathway to thrombectomy most commonly involves thrombolysis, and similar resources are required, low rates of thrombolysis effectively prevent many eligible patients in 2020 from accessing thrombectomy.

According to McMeekin et al (2017), approximately 10 percent of ischaemic stroke patients should be eligible for thrombectomy. This translates into a maximum of 993 patients in 2020 (based on approximately 80 percent of stroke hospitalisations being for ischaemic stroke). This estimate is significantly higher than the 426 in 2020 which was projected from the Ranta (2018) estimate and represents a scenario in which both maximum thrombectomy and thrombolysis rates are achieved.

According to Ranta (2018), to achieve a 10 percent thrombectomy rate, New Zealand would first need to increase the thrombolysis rate to 20 percent. This is a significant increase from the current ten percent target.

Given the rate of growth expected in stroke hospitalisations, we estimate that the numbers of thrombolysed patients and thrombectomy patients needed to be achieved by 2038 are 3,081 and 1,541, respectively (see Figure 31 below).

Figure 31 Projected theoretical and current state demand for thrombolysis and thrombectomy

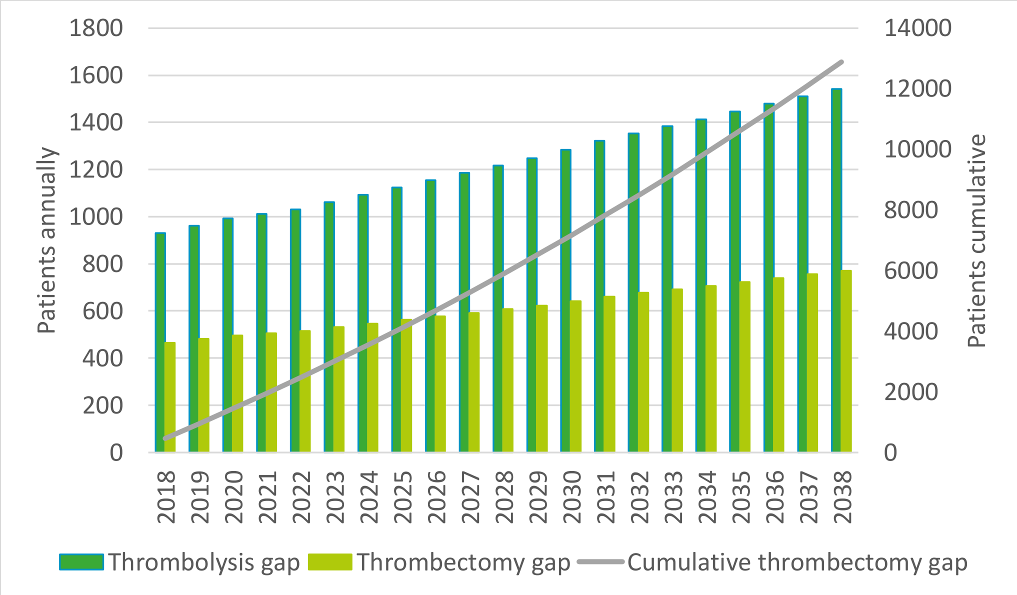


Source: NZIER

If the current thrombolysis rate is not improved, we estimate that by 2038 the gap between the number who would be eligible for thrombectomy and the number who will actually receive it will be over 770 per annum (see Figure 32 below), or in cumulative terms, from 2018 to 2038 up to 13,000 eligible patients would have failed to access life-saving and life-changing thrombectomy.

Given the current distribution of access to stroke services, we expect that a disproportionate fraction of these patients will be Māori or Pacific. Avoiding this outcome requires additional investment in both thrombolysis and thrombectomy.

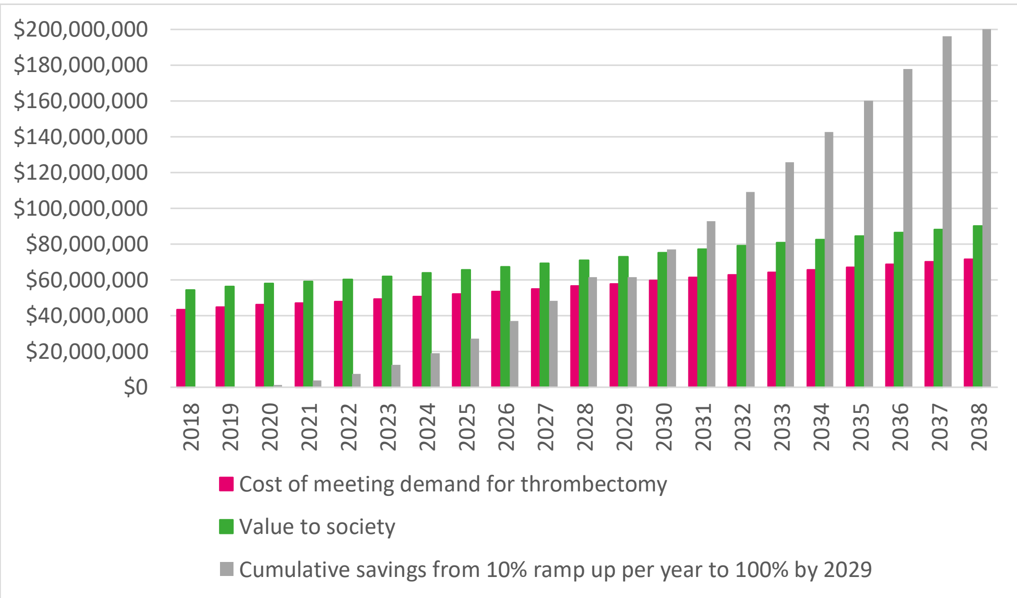
Figure 32 Growing gap in thrombolysis and thrombectomy at continued 7% thrombolysis rate



Source: NZIER

Despite the significant annual expenditure needed to meet the expected demand for thrombectomy, the savings to society are expected to exceed this expenditure. If 10 percent of patients eligible for thrombectomy receive the procedure in 2020 and this service expands to allow an additional 10% of the eligible population every year, reaching 100 percent by 2029, cumulative savings to society would ramp up to over $200 million by 2038 (in 2020 dollars).

Figure 33 Potential cumulative savings from thrombectomy



Source: NZIER

15.2. Improving stroke management and rehabilitation

Stroke management and rehabilitation can reduce the burden of stroke by minimising the risks of readmission and recurrence, reducing the need for residential care, and improving functional outcomes which sees individuals resuming paid employment and reducing the need for financial assistance and informal care.

Research has revealed that optimal stroke management and rehabilitation are key to delivering better outcomes. Differences in stroke rehabilitation have been found to explain differences in outcomes across health systems (Teasell et al., 2009).

Possible areas for improvement of stroke management in New Zealand include:

- Rapid assessment and treatment following TIA/non-hospitalised stroke
- Increased use thrombolysis in ischaemic stroke
- Increased use of organised stroke units
- Increased rate of early home-supported discharge.

Outcomes associated with these improvements in stroke care were estimated in a Canadian study (Krueger et al., 2012). The results indicated that optimal acute stroke care in Canada, including all of the above would produce a reduction in the number of:

- Hospitalisations by 3.3 percent
- Acute hospital care days by 25.9 percent
- Residential care days by 12.8 percent
- Deaths in hospital by 14.9 percent.

Additional improvements could be obtained from:

- Improved hyperacute stroke care
- Increased intensity of rehabilitation therapy
- Use of modern ICT to increase access to specialist skills.

In terms of stroke sub-type, increased focus on aneurysmal sub-arachnoid haemorrhage (aSAH) may be warranted.

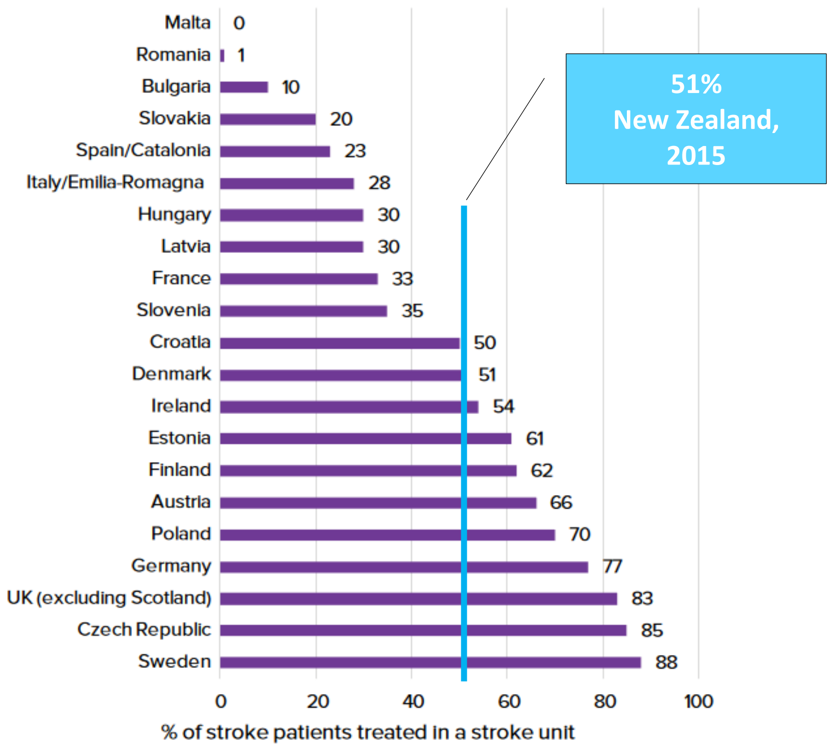
15.2.1. Increased use of organised stroke units

The outcomes associated with organised stroke units have been the subject of multiple clinical trials and meta-analyses, with the Stroke Unit Trialists' Collaboration (SUTC) Cochrane reviews of stroke unit trials being particularly noteworthy. The latest SUTC 2013 update included 28 trials and found that stroke units are consistently associated with improved outcomes, with increased survival, independence and ability for stroke survivors to continue living in their own home (Stroke Unit Trialists' Collaboration, 2013).

Variations in the delivery of care and associated processes have been found to explain a significant portion of the variation in outcomes across six European countries (Ayis et al., 2013). Increased organisational care (such as what is delivered through specialised acute stroke units) was associated with higher probabilities of survival.

Despite the increase in hospitalisation for stroke in recent years in New Zealand, Feigin et al. (2015) identified underutilisation of acute stroke units (with only 51.3 percent of stroke patients treated in acute stroke units, based on data from the ARCOS studies).

Figure 34 Variation in use of acute stroke units across Europe compared with New Zealand

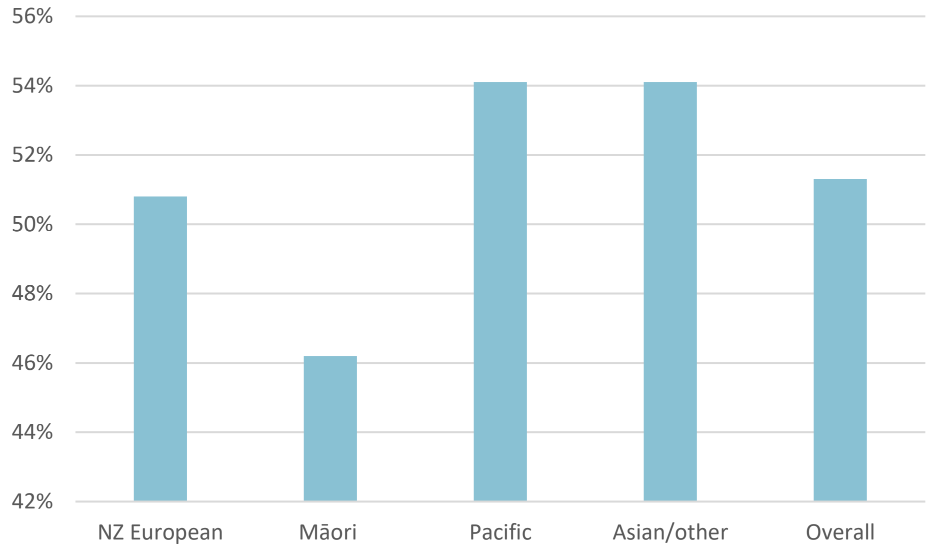


Source: NZIER, based on King's College London (2017), Feigin et al., 2015

Ethnic disparities in admission to stroke units represent a particular opportunity to improve outcomes, reduce long term costs and reduce ethnic disparities. Figure 35 below shows how Māori are less likely to be admitted to acute stroke units than other ethnicities. This is particularly important because Māori suffer strokes at a significantly younger age on average, leading to higher probabilities of income and employment effects as well as longer-term disability. Increasing the admission rate of Māori stroke sufferers to acute stroke units may improve outcomes and reduce long term costs associated with disability and employment significantly.

Figure 35 Admission to acute stroke unit

By ethnicity (In the ARCOS studies)



Source: NZIER based on data from Feigin et al., 2015

15.2.2. Increased rate of early home-supported discharge

Early home-supported discharge has been associated with reduced length of stay and improved outcomes in stroke survivors.

15.2.3. Improved hyperacute care

The time immediately following a stroke is critical to stroke outcomes. Outcomes depend on a chain of events and circumstances including:

- How people experiencing a stroke (and anyone witnessing a stroke) react, which depends on their ability to recognise the significance of the event
- Whether emergency services (rather than GP services) are called, how fast this happens and how they respond (i.e. triaging stroke events as urgent or non-urgent)
- The extent to which hospital processes can be triggered prior to arrival
- How quickly patients are processed on arrival in emergency rooms and delays in obtaining brain imaging
- The availability of stroke specialists and delays in obtaining appropriate evaluations and treatment
- The administration of thrombolysis for patients with ischaemic stroke, which is sometimes delayed due to non-availability of clinicians, or lack of consent).

Table 37 Processes for rapid assessment and treatment NZ versus Australia

Process	Total (N=21 Centres)	
	NZ	Australia
Ambulance arrangements	10%	21%
ED protocol for rapid triage	43%	48%
Transfer protocols	29%	51%

Source: Stroke Foundation of New Zealand, 2010

Internationally and in New Zealand two major improvements have been sought to ensure better outcomes for stroke patients. These are:

- Increased access to specialised stroke units
- Reductions in door-to-needle time (DNT) – the time from arrival in emergency rooms to the administration of thrombolysis.

Reductions in door-to-needle time

Much of the improved outcomes associated with acute stroke units is associated with the ability to provide access to thrombolysis for ischaemic stroke patients. In recognition of the increasing evidence that thrombolysis improves outcomes substantially and cost-effectively, most countries have introduced thrombolysis targets, reporting and auditing. New Zealand is no exception.

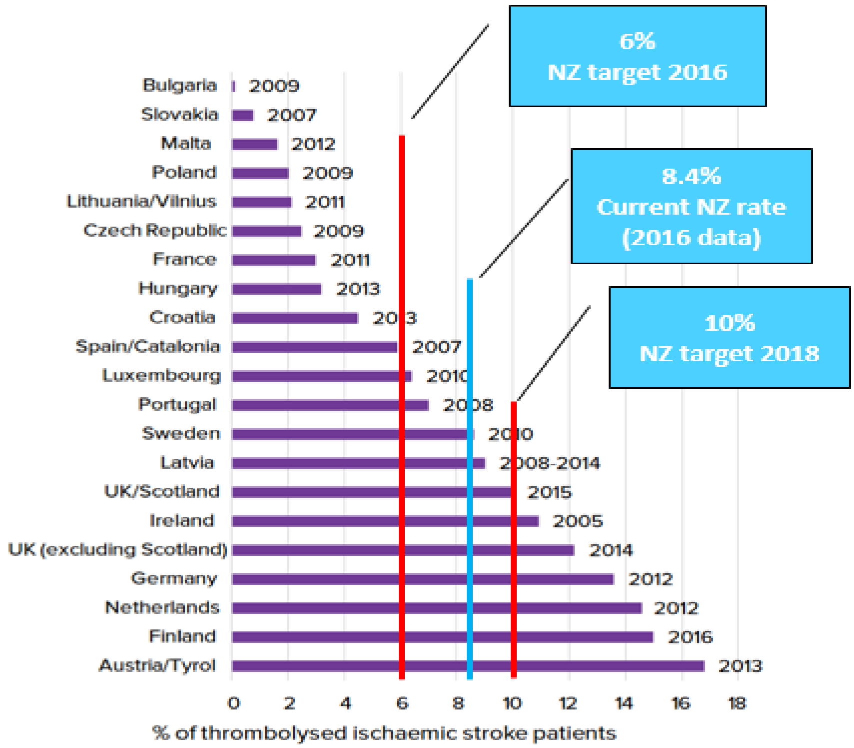
In recognition that thrombolysis within 4.5 hours after ischaemic stroke onset improves outcomes, The National Stroke Network introduced the National Stroke Thrombolysis Register on 1 January 2015. All stroke thrombolysis patients are entered into the register. National targets for thrombolysis rates and treatment delays were set to support clinicians to improve hospital processes and thrombolysis rates (Liu et al., 2017). The experience of other countries has been that stroke registries have supported quality improvement and increased timely stroke thrombolysis rates (Bray et al., 2013).

By mid-2015 the thrombolysis rate in New Zealand hospitals was 6.4 percent, having more than doubled relative to the 2009 rate of 3 percent in 2009, meeting the Ministry of Health thrombolysis target of 6 percent (Joshi et al., 2016). Liu et al. (2017) found that a further increase to 8.4 percent had been achieved by mid-2016 with some of the largest improvements in the smaller DHBs. The thrombolysis target was increased to 8 percent for 2017 and 10 percent for 2018. However, Liu et al. (2017) raised concerns that 24/7 access to acute stroke thrombolysis is not being accurately reported and is almost certainly inadequate in some DHBs.

Liu et al. (2017a) surveyed DHBs across New Zealand on thrombolysis services in 2011 and 2016. Significant improvements were identified, with all hospitals having developed thrombolysis guidelines and audited thrombolysed patients in the National Stroke Thrombolysis Register by 2016, which represented a major improvement compared with 2011 when only seven (39 percent) DHBs reported regular audit. Increased numbers of neurologists and other clinicians rostered to provide thrombolysis were also observed in both larger and smaller DHBs. Nevertheless, the study identified that in 2016, staffing and training remained important challenges for smaller and geographically isolated DHBs to achieve thrombolysis targets.

Although New Zealand thrombolysis rates have improved, rates of thrombolysis in some European countries had already exceeded New Zealand's 2018 target up to a decade ago (see Figure 36 below).

Figure 36 Thrombolysis rates across Europe compared with New Zealand rate and targets



Source: NZIER based on King's College London (2017), Joshi et al., 2016, and Liu et al., 2017

There is room to not only increase treatment rates, but also reduce treatment delays. Earlier treatment is associated with better outcomes, and every 15-minute acceleration in the start of treatment can result in 4 percent greater odds of walking independently on discharge (Joshi et al.,2016).

A Canadian study revealed that 35 to 49 percent of eligible patients do not receive thrombolysis due to a time delay of more than 4.5 hours between stroke onset and arrival at hospital, highlighting what is also likely to be a critical issue for increasing thrombolysis rates in New Zealand as well (Ganesh, et al., 2014).

However, it is possible that guidelines around timing require some reconsideration: A systematic review and meta-analysis of intravenous thrombolysis (Wardlaw et al., 2013) showed that, although treatment within guidelines is more effective, patients who did not meet strict criteria for thrombolysis based on age and timing of treatment were as likely to obtain some benefit from thrombolysis as those who did meet the criteria.

The argument is sometimes made that higher thrombolysis rates should only be expected where there are higher patient volumes. However, this argument is not supported by evidence, which suggests that although thrombolysis rates tend to be higher in larger centres, there is no association with patient volumes (Scherf et al., 2016).

Hospital pre-alerting

In patients travelling to hospital via ambulance, the sending of a ‘pre-alert’ message can significantly improve the timeliness of treatment which, in turn, increases the probability of a patient being able to undergo thrombolysis within the critical time.

Many jurisdictions have succeeded in reducing door-to-needle time with effective pre-alerting. However, a cohort study of patients admitted to acute stroke units in West Midlands (UK) (Shepherd et al., 2016) hospitals showed that, in that context, while only 29 percent of patients were eligible for pre-alerting according to criteria set out in the local protocols, the ED was pre-alerted about 53 percent which led to disagreements between emergency medical services (EMS) and ED staff, and frustration on the part of EMS staff who were found to have inconsistent understanding of pre-alert protocols. To avoid undermining the credibility of pre-alerts and impacting patients who are genuinely eligible for thrombolysis the authors recommended that simplified pre-alert protocols might result in more appropriate use of pre-alerting.

15.2.4. Increased intensity of rehabilitation therapy

Rehabilitation therapy is long-term support aimed at helping stroke survivors regain independence and live with any remaining disabilities after a stroke. Rehabilitation can involve different specialists, including physiotherapists, speech therapists and occupational therapists who help patients overcome problems with: memory and concentration; speaking, reading and writing; emotions and feelings; sight; swallowing and eating; strength, balance and movement; and physical pain. Rehabilitation can also include encouragement and support to reduce risk factors and move towards independent living.

The ways in which these services are delivered may explain why outcomes are different in different countries.

McNaughton et al. (2005) compared stroke rehabilitation practice and outcomes between New Zealand and the United States. The study found that the average length of stay in rehabilitation was shorter in the US than in New Zealand (18.6 days compared with 30 days). Within the rehabilitation stay, however, physical and occupational therapy time per patient was considerably higher in the US. Therapists in the US were involved in more active therapies for a greater proportion of the time. Outcomes were also observed to be better for US participants, with fewer discharged to institutional care (13.2 percent compared with 21.5 percent) and larger increases in functional independence scores.

Another key result of the McNaughton study was that New Zealand rehabilitation therapists spend significantly more time on assessment and non-functional activities (activities not directly related to the patient's functional enhancement, i.e. selecting a wheelchair, filling out forms). Professionals in the two countries also tended to focus on different activities: US occupational therapists spend a significant portion of time working with upper limbs, which in New Zealand is largely an activity performed by physiotherapists.

The study noted that the New Zealand stroke patients were of older age. However, the US stroke patients' measures of initial stroke severity were higher. The increased intensity of rehabilitative care in the US was considered to be largely responsible for improved outcomes in functional independence.

This evidence is consistent with findings across numerous studies, that more intensive stroke rehabilitation services are associated with better outcomes, even when initial severity scores are higher. For example, Andrews at al. (2015) found that patients who received higher-intensity therapy were less likely to be readmitted to hospital within 30 days than patients who had lower intensity therapy, even though the presence of more comorbidities or greater stroke severity had been the reasons for higher intensity therapy in the sample.

No study was identified that determined what might be a critical threshold of rehabilitation intensity or identified whether a ceiling effect applies. Nevertheless, the evidence in favour of higher intensity rehabilitation services is strong enough for the NICE to recommend that adults having stroke rehabilitation in hospital or in the community are offered at least 45 minutes of each relevant therapy for a minimum of 5 days a week (Dworzynski et al., 2013).

Use of modern ICT to improve access to specialist skills

In recognition that access to specialist skills for stroke management is a barrier to timely and effective treatment in several central region DHBs, the Ministry of Health funded the Telestroke pilot. Telestroke provides 24/7 access to specialist skills for managing stroke by enabling neurologists to provide support to less experienced clinicians in different DHBs remotely via videoconferencing equipment. Over the 10-week trial there was an increase in the treatment rate of out-of-hours thrombolysis, from 7 percent to 19.8 percent, and the average time from presentation to hospital and treatment was reduced Ministry of Health (2017a).

15.3. Screening and follow-up

Many health risks are subject to universal or selective screening and the risk factors for stroke can all be the subject of screening programmes with potential benefits not only in stroke prevention but in other health conditions that share the same risk factors.

One potential stroke-specific screening programme could involve screening for unruptured intracranial aneurysm in asymptomatic individuals or implementing guidelines to encourage screening for aneurysm in symptomatic individuals.

The cost-effectiveness of screening for intracranial aneurysm is a function of screening costs, morbidity and mortality risks, long term costs related to ruptured aneurysms, and the costs and risks associated with aneurysm surgery.

Yoshimoto et al. (1999) created a mathematical model of an aneurysm screening programme and demonstrated that such a programme has the potential to be cost-effective, as judged against other interventions that are publicly funded on the grounds of cost-effectiveness. However, their model also demonstrates that there are two critical factors in the cost-effectiveness of screening:

- The prevalence of subarachnoid haemorrhage from ruptured aneurysm
- The risk of neurological impairment from aneurysm surgery.

These two factors are noteworthy for consideration of future interventions to reduce the burden of stroke. The prevalence of sub-arachnoid haemorrhage (SAH) is different in different sub-populations. Screening programmes can be designed to target a sub-population where the risk of SAH is greater (i.e. in those with family history or in higher risk age groups). Also, the risk of neurological impairment from aneurysm surgery may be reduced with improvements in surgical techniques or with the development and improvement of alternative interventions, such as endovascular techniques, which were not considered in the Yoshimoto and Wakai model.

According to Zhao et al. (2017), the treatment techniques and management guidelines for intracranial aneurysm have been continually developing since the 1990s. There are now a number of surgical and endovascular techniques available but clinicians are still divided on how to proceed in the case of microaneurysms due to the lack of knowledge of the rates of rupture or progression to saccular aneurysms. This lack of knowledge is due to a lack of data from large clinical studies, which raises the importance of continued stroke research.

15.4. Stroke research

Investment in stroke research in New Zealand in either absolute or relative terms was not within scope for this report. However, evidence from previously published studies provides some insight.

A UK study compared funding for stroke research to funding for cancer, coronary heart disease, and dementia (Luengo-Fernandez et al., 2012) based on 2008 funding levels. It found that only 3 percent of funding to these four areas of health research was allocated to stroke (4 percent if only government funding is included). Levels of research funding were not aligned with the burden of disease, with stroke research attracting only £48 per stroke patient, compared with £241 per person with cancer and £118 per person with dementia.

According to Pendlebury (2007), studies from the UK, Europe and the US are highly consistent in showing significantly lower funding for stroke research compared with cancer and heart disease.

Luengo-Fernandez et al. (2015) followed up their earlier study with an update based on 2012 research funding and found that funding for stroke research had increased to 7 percent of the total for cancer, coronary heart disease, stroke and dementia (from 3 percent in 2008). Government funding for stroke research in particular had increased (from 4 percent to 12 percent of total government research funding across the four health conditions). Summary figures for 2008 and 2012 are shown in Table 38 below.

Table 38 UK research funding for cancer, CHD, dementia and stroke

2012 and 2008, £ thousands (%)

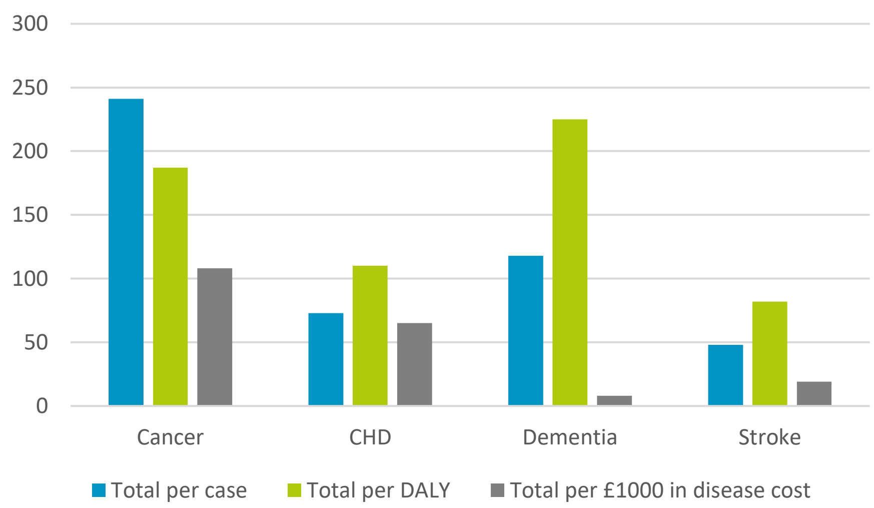
	2012			2008		
	Charity	Government	Total	Charity	Government	Total
Cancer	387,414 (76)	156,640 (45)	544,055 (64)	323,771 (76)	266,640 (66)	590,411(71)
CHD	91,486 (18)	74,699 (21)	166,185(19)	85,031 (20)	84,229 (21)	169,260 (20)
Dementia	16,637 (3)	73,481 (21)	90,118 (10)	13,913 (3)	36,331 (9)	50,244 (6)
Stroke	13,323 (3)	42,641 (12)	55,964 (7)	5,833 (1)	17,522 (4)	23,355 (3)
Total	**508,859 (100)**	**347,462 (100)**	**856,321 (100)**	**428,548 (100)**	**404,723 (100)**	**833,270 (100)**

Source: Luengo-Fernandez et al., 2015

Despite the encouraging increase in stroke research funding, however, the authors argue that stroke research remained under-funded when considered alongside the burden of disease. This is illustrated in Figure 37 below, which shows that total funding per case and per DALY are lowest for stroke and total funding per £1000 of disease cost is significantly lower than for cancer and CHD and only slightly higher than for dementia.

Figure 37 Total UK research funding for cancer, CHD, dementia and stroke in 2012

Per case, per DALY, and per £1000 of disease cost



Source: NZIER, based on Luengo-Fernandez et al., 2015

If stroke research is underfunded worldwide this will have an impact on screening and treatment in New Zealand and will hinder progress in reducing the social and economic burden of stroke.

Similar analysis (Gross et al., 1999) of research funding by the US agency responsible for biomedical and public health research (the National Institutes of Health) also found that stroke research was underfunded. Attracting only 2.4 percent of total National Institutes of Health (NIH) funding (Table 39 below), stroke research was found to be underfunded relative to the burden of disease, illustrated by the significant distance from the 45 degree line in Figure 38, a distance that equates to underfunding by USD 95 million (1996).

Table 39 NIH research funding

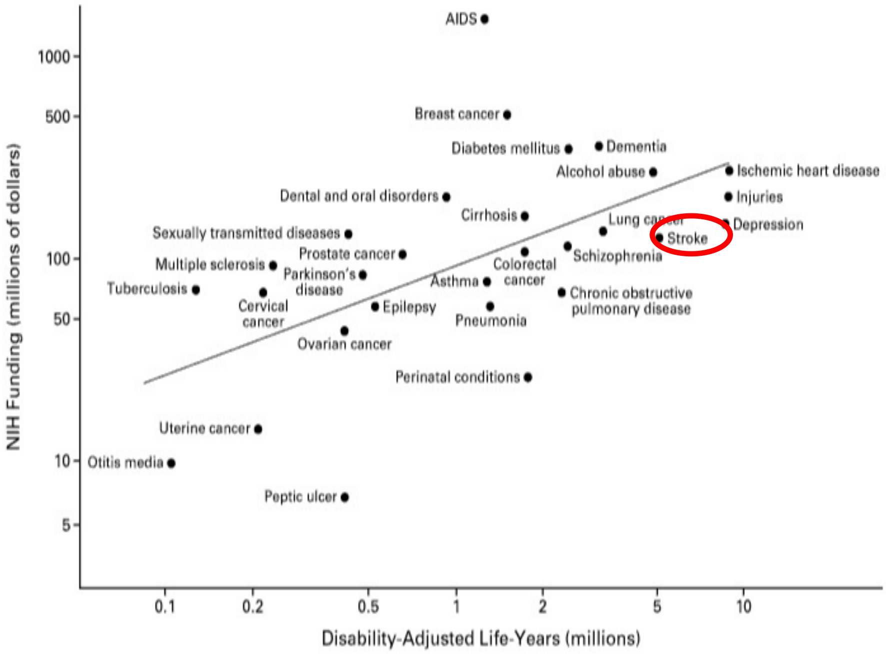
Percentage by condition/disease, 1996

Condition/disease	NIH Research funding (% of total)
AIDS	28.7
Breast cancer	7.8
Dementia	6.2
Diabetes mellitus	6.1
Ischemic heart disease	5.5
Alcohol abuse	5.2
Injuries	4.0
Dental and oral disorders	3.8
Cirrhosis	3.4
Depression	2.9
Lung cancer	2.6
Stroke	2.4
Schizophrenia	2.3
Colorectal cancer	2.1
Sexually transmitted diseases	2.1

Source: Gross et al., 1999

Figure 38 Under and over-funding relative to burden of disease

NIH, 1996, (USD)



Source: Gross et al., 1999

Figure 39 Difference between actual and predicted funding* by the NIH

(USD)

Condition or Disease	Mortality	Disability-Adjusted Life-Years†	Years of Life Lost
		millions of dollars	
Chronic obstructive pulmonary disease	−83	−79	−76
Perinatal conditions	−81	−97	−109
Peptic ulcer	−79	−36	−72
Pneumonia	−79	−41	−66
Uterine cancer	−61	−23	−58
Ovarian cancer	−57	−12	−41
Stroke	−39	−95	−29
Lung cancer	−31	−36	−36
Prostate cancer	−27	25	−14
Colorectal cancer	−27	−13	−25
Otitis media	−23	−15	−25
Cervical cancer	−21	22	−28
Parkinson's disease	−17	18	−1
Epilepsy	−9	−8	−17
Asthma	−2	−20	−7
Tuberculosis	−2	35	−1
Multiple sclerosis	14	41	9
Cirrhosis	53	53	40
Depression	53	−140	72
Injuries	54	−89	−4
Sexually transmitted diseases	56	46	57
Schizophrenia	61	−29	68
Ischemic heart disease	70	−24	68
Dental and oral disorders	149	102	152
Diabetes mellitus	167	155	168
Alcohol abuse	170	48	160
Dementia	185	144	207
Breast cancer	257	272	249
AIDS	1,287	1,307	1,252

* Negative numbers indicate underfunding in relation to burden of disease.

Source: Gross et al., 1999

15.4.1. Paediatric stroke

Although stroke is uncommon in children and youth, its effects are worthy of separate consideration due to the significant impact of brain injury at an early stage in life and this sub-population may be worthy of increased research effort.

There is a growing body of research showing that belief in a protective effect of high plasticity of the young brain is misplaced: There is now significant evidence that early brain injury associated with paediatric stroke results in long-term neuropsychological impairment.

Children who have experienced stroke have been found to perform significantly worse than the general population on a number of measures of cognitive outcome. The average cognitive profile of child survivors of stroke is at the low end of the population average range (Westmacott, 2009). Stroke-related brain injury that occurs before 5 or 6 years of age in particular has been found to be most associated with widespread cognitive dysfunction across multiple domains, including overall cognitive ability, academic skills, verbal ability, attention, and executive function.

Stroke is a significant cause of acquired brain injury and morbidity in children and youth. Despite, significant progress in recognising, managing and preventing stroke in children, death rates remain high. Of child stroke survivors, 60 percent will have permanent neurological deficits (International Alliance for Pediatric Stroke. n.d.).

According to the UK Stroke Association, haemorrhagic strokes account for about 55 percent of childhood strokes. Children with some, few or no routine vaccinations have a seven-fold increased risk of stroke compared to children who received all or most vaccinations (Fullerton, 2015).

In 2014, a multidisciplinary panel of clinicians was convened by the International Paediatric Stroke Study group to identify evidence gaps and set priorities for clinical research into child cardiac disease and stroke (Sinclair et al., 2015).

The panel noted the following significant evidence gaps:

- Paediatric stroke incidence
- Predictors of paediatric stroke
- Primary and secondary paediatric stroke prevention
- Hyperacute treatment of paediatric stroke
- Outcomes of stroke in the paediatric population.

The panel identified an urgent need for additional research to improve the quality of evidence in guideline recommendations for cardiogenic stroke in children (Sinclair et al., 2015).

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