Stroke FOUNDATION

Economic Impact of Stroke Report 2024

strokefoundation.org.au

Acknowledgement of Country

Stroke Foundation acknowledges the Traditional Custodians of Country throughout Australia, and their continuing connection to the lands, waters, skies and community. We pay our respects to Elders past and present; and extend that respect to all Aboriginal and Torres Strait Islander peoples.

Lived Experience Acknowledgement Statement

Stroke Foundation acknowledges the individual and collective contributions of all people with a lived experience of stroke, as well as their families, carers and supporters. The unique insights, journeys and perspectives of our stroke community guide our work, values and mission.

Cover Image: Patient receiving treatment by the dedicated Mobile Stoke Unit paramedics at the Royal Melbourne Hospital.

Stroke Foundation publishes the Economic Impact of Stroke Report periodically. Previous reports were released in 2013 and 2020. In 2024, the report is delivered thanks to the generous support of **Boehringer Ingelheim, the Angels Initiative** and **Medtronic**.

Following a tender process, **Monash University** researchers were commissioned by Stroke Foundation to write this report. **The report has been produced by the following researchers:**

Dr Joosup Kim[1,2]	Research co-lead
Prof Dominique Cadilhac[1,2]	Research co-lead
Ms Emilia Nivelle[1]	Health Economics, Senior Research Officer
Dr Lachlan Dalli[1,2]	Epidemiologist, Postdoctoral Research Fellow
Dr Ella Zomer[3]	Health economist, Postdoctoral Research Fellow
Dr Mulugeta Birhanu[1,2]	Epidemiologist, Postdoctoral Research Fellow
Dr Tara Purvis[1]	Health Services Researcher, Postdoctoral Research Fellow
Dr Muideen Olaiya[1,2]	Epidemiologist, Postdoctoral Research Fellow
Dr Stella Talic[3]	Epidemiologist, Postdoctoral Research Fellow
Prof Monique Kilkenny[1,2]	Epidemiologist, Professor

Affiliations:

1. Stroke and Ageing Research, Department of Medicine, School of Clinical Sciences at Monash Health, Monash University, Clayton.
2. Stroke Division, Florey Institute of Neuroscience and Mental Health, Austin Campus, Heidelberg.
3. Chronic Disease & Ageing, School of Public Health and Preventive Medicine, Monash University, Melbourne, Australia.

Suggested citation

Kim J., Nivelle E., Dalli L., Zomer E., Birhanu M., Purvis T., Olaiya MT., Talic S., Kilkenny MF., Cadilhac DA. on behalf of the Stroke Foundation, Economic Impact of Stroke 2024. Stroke Foundation 2024. Melbourne Australia. Pages 1-115. DOI: 10.26180/27049219

No part of this report may be reproduced without prior written permission from Stroke Foundation. Any direct reference to this work must be appropriately acknowledged.

Acknowledgements

An independent Expert Advisory Committee was established to provide advice on the scope, modelling, analysis, and findings enclosed within this report. Those with expertise in population health, clinical experts and lived experience representatives provided iterative feedback on each component of the project through a series of workshops, meetings, and review of written materials. Stroke Foundation thanks the members of the advisory committee for their time and valuable contributions.

We acknowledge the organisations that contributed their data in the projects that were used to derive many estimates in this report. This includes data provided for bespoke linkages of the Australian Stroke Clinical Registry with the following government-held datasets: Ambulance Victoria, Victorian Admitted Episodes Dataset, Victorian Emergency Minimum Dataset, Queensland Hospital Admitted Patient Data Collection and Emergency Data Collection, Pharmaceutical Benefits Scheme, Medicare Benefits Schedule, National Aged Care Data Clearinghouse, and the National Death Index. We acknowledge the staff who undertook the data linkage from the Centre for Victorian Data Linkage (Victorian Government Department of Health), Statistical Services Branch (Queensland Health), and the Data Integration Services Centre (Australian Institute of Health and Welfare).

Expert Advisory Committee

- Professor Geoffrey Cloud, Stroke Physician
- Professor Seana Gall, Epidemiologist
- Professor Tim Kleinig, Neurologist & President Australian and New Zealand Stroke Organisation
- Emeritus Professor Marj Moodie, Health Economist
- Jennifer Muller PSM, Lived Experience Representative
- Dr Brian Tress, Neuroradiologist and Lived Experience Representative

Stroke Foundation

- Dr Lisa Murphy, Chief Executive Officer
- Sarah Meredith, Executive Director Public Affairs and Media
- Dr Tope Adepoyibi, Executive Director Stroke Services and Research
- Kelvin Hill, National Manager Stroke Treatment
- Roman Serebrianik, National Manager Public Affairs and Media
- Melita Stirling, Stroke Quality Improvement Manager
- Dr Prema Thavaneswaran, Policy Advisor

Contributions

Incidence of stroke	Professor Judith Katzenellenbogen, Dr Lee Nedkoff, Dr Joosup Kim, Nita Sodhi-Berry, Dr Anna Balabanski, Emeritus Professor Amanda Thrift.
Prevalence of stroke and risk factors	Dr Mulugeta Birhanu, Dr Muideen Olaiya, Dr Joosup Kim, Professor Dominique Cadilhac.
Short-term cost estimates	Dr Joosup Kim, Emilia Nivelle, Dr Mulugeta Birhanu, Dr Lachlan Dalli, Professor Monique Kilkenny, Associate Professor Nadine Andrew, Professor Chris Bladin, Professor Dominique Cadilhac.
Medium and long-term cost estimates (and estimates of disability adjusted life years)	Dr Joosup Kim, Emilia Nivelle, Dr Mulugeta Birhanu, Dr Lachlan Dalli, Professor Monique Kilkenny, Associate Professor Nadine Andrew, Professor Dominique Cadilhac.
Productivity impacts	Dr Ella Zomer, Professor Dominique Cadilhac, Dr Stella Talic, Dr Zhomart Orman, Dr Joosup Kim.
Costs and benefits of achieving 30/60/90 National Stroke Targets	Emilia Nivelle, Dr Joosup Kim, Dr Tara Purvis, Julie Morrison, Professor Chris Bladin, Professor Dominique Cadilhac.
Costs and benefits of reducing uncontrolled hypertension (Primary Prevention)	Emilia Nivelle, Dr Joosup Kim, Dr Lachlan Dalli, Professor Alta Schutte, Professor Markus Schlaich, Professor Dominique Cadilhac.
Costs and benefits of improving provision of antihypertensive medications (Secondary Prevention)	Emilia Nivelle, Dr Joosup Kim, Dr Lachlan Dalli, Dr Stella Talic, Professor Dominique Cadilhac.
Costs and benefits of improving recovery/rehabilitation	Emilia Nivelle, Dr Joosup Kim, Associate Professor Elizabeth Lynch, Professor Natasha Lannin, Dr Natalie Fini, Catherine Burns, Professor Dominique Cadilhac.

Foreword

The Economic Impact of Stroke report is a pivotal document for informing conversations and decision-making about the allocation of resources to improve the prevention, treatment and management of stroke in Australia. It will inform all Australians, namely government, administrators, health professionals, researchers, and the stroke community with lived experience, on the actions required to enhance stroke prevention, treatment and recovery. While the economic impact of stroke and statistics are a feature of this report, real people are behind each number and the impact of each stroke is felt by survivors, their families, friends and carers, and the broader community.

We have no time to waste when it comes to stroke. Close to half a million survivors of stroke (440,481) are living in the Australian community and there were 45,785 new strokes in 2023. By 2050, this will grow to 72,000 strokes per year if we do not address the rising tide of modifiable stroke risk factors and improve stroke prevention for all Australians. The costs associated with stroke in 2023 were over $15.7 billion over a lifetime; over $350,000 per person. This includes $5.5 billion in healthcare costs, $6.3 billion in costs related to lost productivity in the workplace and at home, and $3.3 billion in costs related to the provision of informal care.

Significant progress has been made in stroke treatment over the past 20 years, resulting in improved outcomes for those who access timely evidence-based care. Investment in research, advancements in science and technology and Stroke Foundation's world-first Living Clinical Guidelines for Stroke Management, together with the inception and evolution of the Australian Stroke Clinical Registry, have been key drivers of this. These fundamental elements that underpin excellence in stroke care must be supported and sustained.

Despite progress in treatment options, assessment, and access to specialist care, Australia lags behind our international counterparts with similarly developed health systems in the timely delivery of therapies to return blood flow to the brain (reperfusion) and stroke unit access. We must collectively make a determined effort to improve stroke care if we are to maximise outcomes for people with stroke. The 30/60/90 National Stroke Targets and Stroke Unit Certification programs are national initiatives that aim to address barriers and develop solutions to providing best practice in stroke treatment. Support and funding for both initiatives are imperative.

Stroke rehabilitation and recovery require urgent attention and considerable investment into hospital and community stroke services. Adequate resourcing and specialist staffing is needed to enable survivors of stroke and their significant others to have access to the right rehabilitation services, in the right place, and at the right time. Research related to recovery must also be prioritised in order to advance practice and improve outcomes for patients, as has been done in the acute phase of stroke care in recent years. Access to evidence-based rehabilitation is the next frontier for the stroke community.

Stroke Foundation is proud to have partnered with Monash University and the Expert Advisory Committee to produce this report and is grateful for the support of Boehringer Ingelheim, the Angels Initiative and Medtronic that enabled its development. The benefits of improving stroke care are unambiguous and are detailed within. With this report, we must now collectively strive for change that will shift the dial on access to evidence-based stroke management over the continuum of care and for ongoing support to enable those affected by stroke to live well.

Dr Lisa Murphy
Chief Executive Officer
Stroke Foundation

Table of contents

Executive Summary **13**
1. Introduction **16**
1.1 Background 16
1.1.1 Definition of stroke 16
1.1.2 Risk factors for stroke 18
1.1.3 Recognition of stroke 19
1.1.4 Treatment and long-term care after stroke 20
1.1.5 30/60/90 National Stroke Targets 21
1.2 Differences with prior Economic Impact of Stroke Reports 22
1.3 Structure of this report 23
2. Conceptual framework and scope of this report **24**
2.1 Epidemiological estimates 25
2.1.1 Estimating incidence of stroke 25
2.1.2 Estimating prevalence of stroke and stroke risk factors 26
2.2 Estimates of costs 27
2.3 Estimates of costs in the short-term after stroke 28
2.4 Modelling the lifetime economic and health impact of stroke 31
2.5 Estimating the costs and benefits of programs 32
3. Incidence of stroke **32**
3.1 First-ever strokes 33
3.2 Recurrent strokes 36
3.3 Fatal first-ever strokes 38
3.4 Fatal recurrent strokes 38
4. Prevalence of stroke and stroke risk factors **40**
4.1 Prevalence of stroke 40
4.2 Prevalence of stroke risk factors 41
4.3 Transient ischaemic attack 43
5. Cost impacts **44**
5.1 Costs over a lifetime after stroke 47
5.2 Short-term healthcare costs 49
5.2.1 Ambulance Services 51
5.2.2 Emergency department, acute admissions and subacute Care 52
5.2.3 Outpatient care 54
5.2.4 Aged care services 54
5.3 Long-term costs 56
5.3.1 Healthcare costs 58
5.3.2 Productivity impacts 59
Employment impacts 59
Household productivity impacts 60
5.3.3 Informal caregiver impacts 61
6. Wellbeing impacts **63**
7. Costs and benefits of programs to prevent stroke, save lives and enhanced recovery **68**
7.1 Estimating effects of achieving National Stroke Targets 69
Treatment effects 69
Costs included 70
Cost and wellbeing impacts 70
Activities required to support achievement of National Stroke Targets 71
7.2 Estimating effects of reducing uncontrolled hypertension – primary prevention 73

Treatment effects 73
Costs included 74
Cost and wellbeing impacts 74
7.3 Estimating effects of improving use of antihypertensive medications – secondary prevention 76
Treatment effects 76
Costs included 77
Costs and benefits 78
7.4 Estimating effects of improving access to community-based rehabilitation after stroke 79
Eligible population 80
Treatment effects 80
Costs included 80
Costs and benefits 80
8. Summary 82
9. References 84
10. Appendix 89
11.1 Incidence of stroke methods 90
11.2 Data sources for cost estimates 91
11.2.1 The Australian Stroke Clinical Registry 91
11.2.2 The Australian Stroke Clinical Registry - Victorian data linkage 91
11.2.3 PRECISE Data Linkage 92
11.3 Data analysis 92
11.3.1 Ambulance Services 92
11.3.2 Emergency department 93
11.3.3 Acute admissions 93
11.3.4 Subacute care 94
11.3.5 Outpatient care 94
11.3.6 Medications 95
11.3.7 Aged care services 95
11.4 Estimating long-term costs and outcomes 96
11.4.1 Estimating healthcare costs 96
11.4.2 Estimating employment impacts 97
11.4.3 Estimating household productivity impacts 98
11.4.4 Estimating informal caregiver impacts 100
11.4.5 Estimating disability adjusted life years 101
11.5 Supplementary Results 102
11.5.1 Short-term costs per person 102
11.5.2 Long-term costs for first-ever strokes 105
11.5.3 Long-term costs for recurrent strokes 106
11.5.4 Long-term costs by stroke type and age 107
11.5.5 Stroke Care Coordinators and Clinical Nurse Consultants 114

Tables

Table 1 Data sources for epidemiological estimates 25
Table 2 Estimated costs and data sources 27
Table 3 Data sources for estimates of costs in the short-term after stroke 29
Table 4 Data sources for Markov model structure 32
Table 5 Number of first-ever strokes in 2023 34
Table 6 Number of recurrent strokes in 2023 36
Table 7 Number and proportion of fatal first-ever strokes in 2023 38
Table 8 Number and proportion of fatal recurrent strokes in 2023 39
Table 9 Estimated number of people with stroke by age and sex in 2023 41
Table 10 National Health Survey variables 41
Table 11 Estimated number of people with risk factors for stroke in 2023 42
Table 12 Costs over a lifetime by stroke type for strokes occurring in 2023 47
Table 13 Healthcare costs over a lifetime related to strokes occurring in 2023 48
Table 14 Short-term total costs for first-ever strokes occurring in 2023 49
Table 15 Short-term total costs for recurrent strokes occurring in 2023 50
Table 16 Short-term average costs for first-ever strokes occurring in 2023 51
Table 17 Short-term average costs for recurrent strokes occurring in 2023 51
Table 18 Long-term costs for first-ever and recurrent strokes combined 56
Table 19 Long-term costs per person for first-ever and recurrent strokes combined 57
Table 20 Healthcare costs beyond the first 3 months after stroke 58
Table 21 Long-term total employment impacts for all strokes occurring in 2023 60
Table 22 Total household productivity impacts for strokes occurring in 2023 61
Table 23 Average household productivity impacts for strokes occurring in 2023 61
Table 24 Total informal caregiver impacts for strokes occurring in 2023 62
Table 25 Average informal caregiver impacts for strokes occurring in 2023 62
Table 26 Total years of life lived with disability and years of life lost after stroke 65
Table 27 Average years of life lived with disability and years of life lost after stroke 67
Table 28 National Stroke Targets compared to current performance 69
Table 29 Improvements in outcomes from achieving National Stroke Targets in 2023 71
Table 30 Economic impacts of achieving National Stroke Targets in 2023 71

Table 31 Improvements in outcomes from the prevention of first-ever stroke by meeting National Hypertension Taskforce targets in 2023 74

Table 32 Economic impacts from the prevention of first-ever stroke by meeting National Hypertension Taskforce targets in 2023 75

Table 33 Proportion of patients dispensed and continuing to use antihypertensive medications 76

Table 34 Proportion of patients with a recurrent stroke that had a stroke admission in the prior 12 months. 77

Table 35 Use of antihypertensive medications for prevention of recurrent stroke and its effect on health outcomes among stroke survivors in 2023 78

Table 36 Use of antihypertensive medications for prevention of recurrent stroke and its economic impacts among stroke survivors in 2023 78

Table 37 Improvements in acute stroke care from improving rehabilitation after stroke in 2023 81

Table 38 Economic impacts from improving rehabilitation after stroke in 2023 81

Figures

Figure 1 Types of stroke 17

Figure 2 Examples of impaired function following stroke 17

Figure 3 Symptoms of stroke 19

Figure 4 Example of a typical patient care journey after stroke 20

Figure 5 Project overview 24

Figure 6 Components of care included in the economic modelling. 30

Figure 7 Number of first-ever strokes in 2023 34

Figure 8. Age profile of first-ever strokes 35

Figure 9. Number of recurrent strokes in 2023 37

Figure 10. Age profile of recurrent strokes 37

Figure 11. Proportion of fatal strokes by stroke type 39

Figure 12 Typical patient pathway after stroke 44

Costs of stroke presented in Figure 6 components of care included in the economic modelling 46

Figure 13. Average lifetime costs for strokes occurring in 2023 48

Figure 14 Short-term average costs for strokes occurring in 2023 51

Figure 15. Distribution of short-term costs after first-ever stroke 53

Figure 16. Distribution of short-term costs after recurrent stroke 54

Figure 17. Costs of aged care services after stroke 55

Figure 18 Long-term costs per person for first-ever and recurrent strokes combined 57

Figure 19. Total years of life lived with disability and years of life lost by stroke type 64

Figure 20. Average years of life lived with disability and years of life lost by age 66

Glossary of Terms

Absenteeism	When an employee has unplanned leave from work.
Disability adjusted life year (DALY)	A measurement used to show the impact of disease by combining years of life lost due to early death and years lived with disability.
Discounting	A way of converting the value today, to a value in the future. For example, the value of a dollar today will be less in subsequent years. Cost savings and benefits beyond the first 12 months are 'discounted' for this reason. Discounted rates are reported as the 'net present value'.
Fatal stroke	A death within 28 days of a stroke event.
Haemorrhagic stroke	Stroke caused by a burst blood vessel in the brain or in the surrounding areas. There are two major types of haemorrhagic strokes (intracerebral haemorrhage and subarachnoid haemorrhage).
Incidence	The number of new events (e.g. strokes) occurring within a specified time period.
Ischaemic stroke	Stroke caused by a narrowed or blocked artery.
Modified Rankin Scale (mRS)	A scale from 0-6 that shows the level of disability or dependence after a stroke.
Population attributable risk	The number of events (e.g. strokes) that occur in a population due to a specific risk factor (e.g. high blood pressure). This shows the potential reduction in strokes if the risk factor was eliminated.
Presenteeism	Refers to employees who are at work but are less productive than usual because of illness or other medical conditions.
Prevalence	The number of people who have an existing case of a disease (e.g. all people who have had a stroke and are living).
Primary prevention	Actions taken to prevent disease or injury by reducing risk factors and improving overall health (e.g. preventing first-ever stroke).

Productivity adjusted life year (PALY)	A way of showing the impact of disease on a person's ability to work. This combines time spent in the workforce (and early retirement) with the quality of the work done.
Rates	How often an event or condition occurs over a specified period of time or in a particular population (e.g. 10 strokes occurring per 100,000 people).
Recurrent stroke	Another stroke occurring after a first-ever stroke.
Reference year	A year used as a baseline or starting point, for comparisons or measurements.
Secondary prevention	Treatment of disease or injury to prevent it from becoming worse (e.g. preventing recurrent strokes).
Societal perspective	A broad point of view that considers financial costs, personal costs to individuals affected and others, and how society operates.
Stroke	A sudden interruption to the regular blood flow to the brain causing damage to brain structures, loss of body functions, disability or death. Stroke is a serious medical emergency. There are two types of stroke: ischaemic stroke and haemorrhagic stroke.
Time horizon	A specific period of time over which outcomes or events are evaluated (e.g. 1 year, 5 years, a lifetime).
Transient ischaemic attack (TIA)	A temporary blockage that disrupts blood flow to the brain with the same signs and symptoms as stroke, but no lasting impact. Patients who have a transient ischaemic attack have a high risk of stroke.
Undetermined stroke	A classification of stroke where routine imaging to determine the type of stroke has either not been completed or was inconclusive to make a diagnosis of the stroke type.
Workforce drop out	Early retirement because of a medical condition.
Years of life lived with disability	A number that shows the impact of health conditions by calculating the number of years lived with a disability or medical condition.
Years of life lost	The difference between the age an individual died and their life expectancy

Key insights

In 2023

There were **440,481** Australians living with stroke

1 in **4 strokes** occurred in people **under 65 years**

45,785 Australians experienced a stroke (including **34,793** for the first time)

One stroke occurred every **11 minutes**

Cost of stroke

Lifetime costs associated with strokes that occurred in 2023 exceed

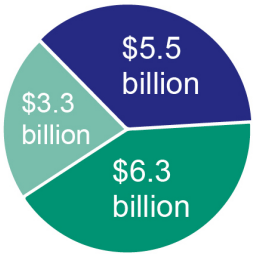
$15 billion

(almost $350,000 per person)

Costs in the first year after stroke were over

$7.7 billion

(almost $176,000 per person)



- Healthcare costs to government
- Costs related to unpaid care
- Lost productivity costs

Cost of stroke to the NDIS is more than

$1.3 billion

($143,000 per survivor of stroke)

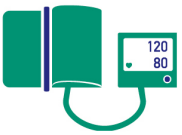
annually

Taking into account the cost of stroke in the first year after the event and the total annual NDIS stroke-related expenditure, stroke is estimated to cost the Australian economy $9 billion a year.

Cost savings from the implementation of initiatives to prevent stroke, save lives and enhance recovery

$26 million

through improvements in provision of acute care in line with the 30/60/90 National Stroke Targets



$315 million

by improving the rate of uncontrolled hypertension in line with the goal of the National Hypertension Taskforce

$118 million

by improving access to community rehabilitation services

Executive Summary

Stroke is a serious medical emergency. It happens when a blood vessel in the brain gets blocked (ischaemic stroke) or bursts (haemorrhagic stroke). This can cause disability and premature death. If we can prevent strokes, recognise them early, treat them quickly, and support the rehabilitation and recovery process, we can avoid many of the adverse effects of stroke and reduce the cost to the individual and society.

Number of stroke events

In **2023**, it was estimated that **45,785** people in Australia experienced a stroke. **Of these, 34,793 were a first-ever stroke and 10,992 were a recurrent stroke.** Based on the current trends in the incidence of stroke and expected population growth, it is estimated that the number of stroke events in Australia would increase to almost 55,000 first-ever strokes and almost 17,000 recurrent strokes per year (a total of 72,000 strokes) by 2050.

Stroke can occur in people of all ages. It was estimated that 1 in 4 (25%) of those who suffered a *first-ever stroke* in 2023 were under the age of 65 years, and 1 in 10 (10%) of those who suffered a *recurrent stroke* in 2023 were under the age of 65 years.

It is estimated that **440,481** people are living with a stroke in Australia in 2023 (244,756 males and 195,725 females), or 2.0% of the population of Australia (2.3% of males and 1.8% of females).[a]

Types of stroke

The majority of strokes are ischaemic strokes. Of the first-ever strokes, 81.2% were ischaemic strokes, 10.2% were intracerebral haemorrhages, 5.3% were subarachnoid haemorrhages, and 3.3% were undetermined strokes. Of the recurrent strokes, 85% were ischaemic strokes.

Over 14% of first-ever strokes, and 16% of recurrent strokes, resulted in a death within 28 days of the stroke event. In general, intracerebral haemorrhage more often resulted in deaths within 28 days of stroke (over 31%) compared to ischaemic stroke (over 11%) and undetermined stroke (over 12%), highlighting the need for further developments in the prevention and treatment of intracerebral haemorrhage.

[a] Data extrapolated from the Survey of Disability, Ageing and Carers (2018) and the data on population from the Australian Bureau of Statistics.

Risk factors for stroke

Many people in Australia have risk factors for stroke such as high blood pressure (hypertension), diabetes, high cholesterol, smoking, physical inactivity and being overweight. In 2023, almost 7.5 million males (69%) and over 6.5 million females (59%) living in Australia were overweight. High blood pressure was also common, affecting 24% of males and 22% of females.[b] A transient ischaemic attack (a temporary and self-resolving blockage of blood vessel with same signs as stroke, but no lasting impact) is an indication that someone may be at high risk of stroke. The Australian Institute of Health and Welfare estimates there may be 19,700 presentations to public hospital emergency departments for transient ischaemic attack each year, with 13,000 of these resulting in an admission to hospital.[c]

Costs and economic impact of stroke

Immediately after stroke, patients are typically managed through the hospital system. **In the first three months after stroke**, costs to the health system were estimated to be **$1.2 billion** for first-ever strokes (over $38,000 per person) and **$402 million** for recurrent strokes (over $36,000 per person).

Since there are far more ischaemic strokes than intracerebral haemorrhages, total costs related to ischaemic stroke were much greater than for intracerebral haemorrhage over the first three months after stroke. However, average costs over the first three months after stroke for first-ever intracerebral haemorrhages were $43,082, which was approximately one sixth greater than those related to first-ever ischaemic strokes ($36,611).

Due to long-lasting effects of stroke, economic impacts due to stroke are often incurred well into the future. These costs are borne by the person affected, their carers and the government. **Over a lifetime after stroke** (but excluding the first three months post-stroke), costs associated with stroke were over $300,000 per person; a total cost of over **$14 billion** to society, including almost $4 billion in costs related to healthcare services, and $10.1 billion in costs related to lost productivity in the workplace and at home, as well as the provision of informal care.

Premature death and disability due to a condition are often expressed in a summary measure of population health called disability adjusted life years (DALYs). Impairments from stroke can often remain in the long-term after a stroke. Over a lifetime, there were 215,251 DALYs associated with strokes occurring in 2023 (47,693 years of life lived with disability and 167,558 years of life lost).

[b] Data on measured blood pressure from the National Health Survey (2022) was extrapolated to population data from the Australian Bureau of Statistics.
[c] Data from the Australian Institute of Health and Welfare (2024) Heart, stroke and vascular disease: Australian facts, AIHW, Australian Government, accessed 24 July 2024.

30/60/90 National Stroke Targets

Substantial health and economic benefits are achievable if evidence-based treatments are provided in hospital according to 30/60/90 National Stroke Targets[d], with 4,085 DALYs avoided. The additional costs of providing acute care ($24,274,708) were offset by savings from improving employment; improving household productivity; and reducing informal care, with savings totalling over $26 million. Activities required to support the achievement of National Stroke Targets were estimated to cost almost $4 million. This cost included Stroke Unit Certification and additional employment of Stroke Care Coordinators in hospitals as recommended by the Australian Stroke Coalition.

Reducing high blood pressure

The potential benefits from the prevention of stroke are substantial. High blood pressure (hypertension) is the number one risk factor for stroke. When estimating the effects of reducing uncontrolled blood pressure according to targets for 2030 set by the National Hypertension Taskforce, it was estimated that 838 first-ever strokes and the 4,061 DALYs associated with these strokes would be avoided in 2023. Estimated savings from preventing these strokes were over $315 million. However, the benefits of reducing high blood pressure in Australia are much broader than stroke since it is also a major risk factor for other diseases such as heart disease, kidney disease and dementia.

Benefits from improving the use of medications to lower blood pressure after stroke were estimated. Each year, 130 recurrent stroke events could be prevented, and savings of over $9 million could be achieved from further improving adherence to these medications, with a relatively small additional cost to patients to access these medications.

Costs of recovery and rehabilitation

Supporting recovery and rehabilitation to reduce impairments from stroke were estimated. In a scenario where a greater proportion of patients were able to access community rehabilitation services, it was estimated that 3,296 DALYs could be avoided. The total additional therapist costs of providing rehabilitation (over $4 million), and an additional $13 million in healthcare costs over a lifetime were offset with large savings from improved productivity and reduced care by informal caregivers. An overall saving of over $118 million was estimated.

[d] Australian Stroke Coalition website: https://australianstrokecoalition.org.au/portfolio/targets/

1. Introduction

The economic and wellbeing impacts of stroke are widely recognised. Routinely updating estimates of these impacts for stroke is important for policy, planning and advocacy. Establishing contemporary health impacts and cost estimates also enables modelling of programs to illustrate how it might be possible to reduce the costs of stroke with prevention, acute treatment and long-term recovery.

In this report, the health and economic impacts of stroke were estimated for the 2023 population to provide contemporary insights for this condition within the Australian context to facilitate priority setting. We ensured robust engagement and review processes and used best available data from academic, government, and non-government sources. Prior commissioned reports on this topic were reviewed, and we highlight key differences and the rationale for our approach to ensure transparency. In the following sections of this introduction, we provide relevant background information related to stroke and information about the structure of this report.

1.1 Background

This section outlines the definition of stroke, the types of strokes that people have, the risk factors that may lead to stroke and the available treatment pathways for stroke. There is also a discussion of the newly created and endorsed 30/60/90 National Stroke Targets, an initiative that is focused on ensuring Australians have access to world-leading stroke care backed by the nation's stroke leaders and experts.

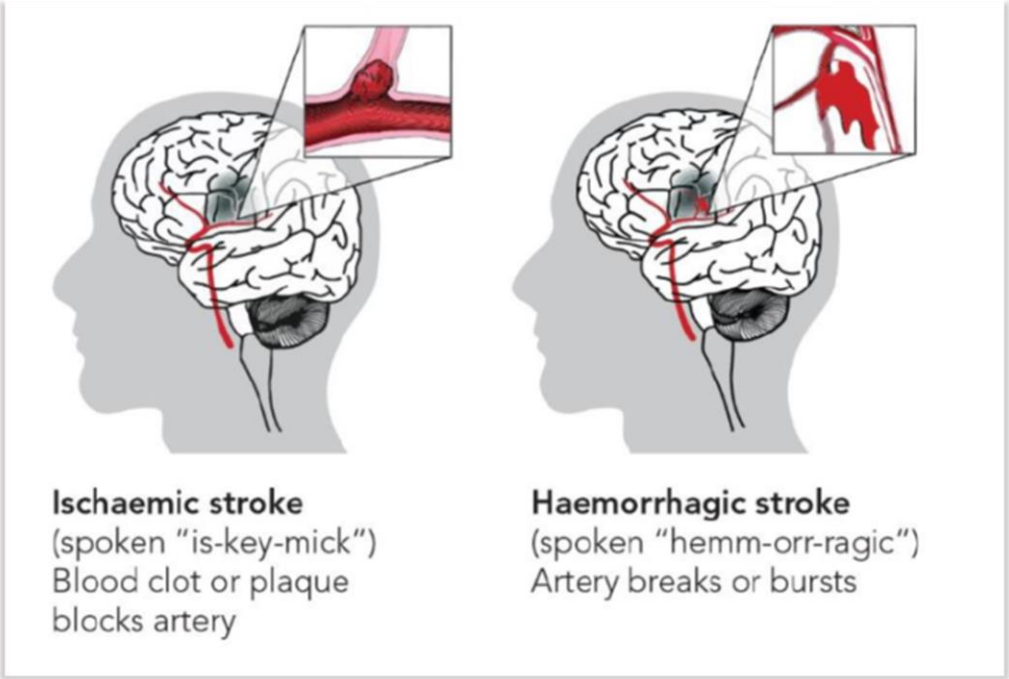
1.1.1 Definition of stroke

Stroke attacks the brain, the human control centre, changing lives in an instant.

The brain is fed by blood carrying oxygen and nutrients through blood vessels called arteries. A stroke happens when blood cannot get to your brain, because of a blocked or burst artery. As a result, brain cells begin to die due to a lack of oxygen and nutrients. When blood supply to the brain is disrupted due to blocked or burst arteries, brain cells begin to die at a rate of 1.9 million cells per minute.[1]

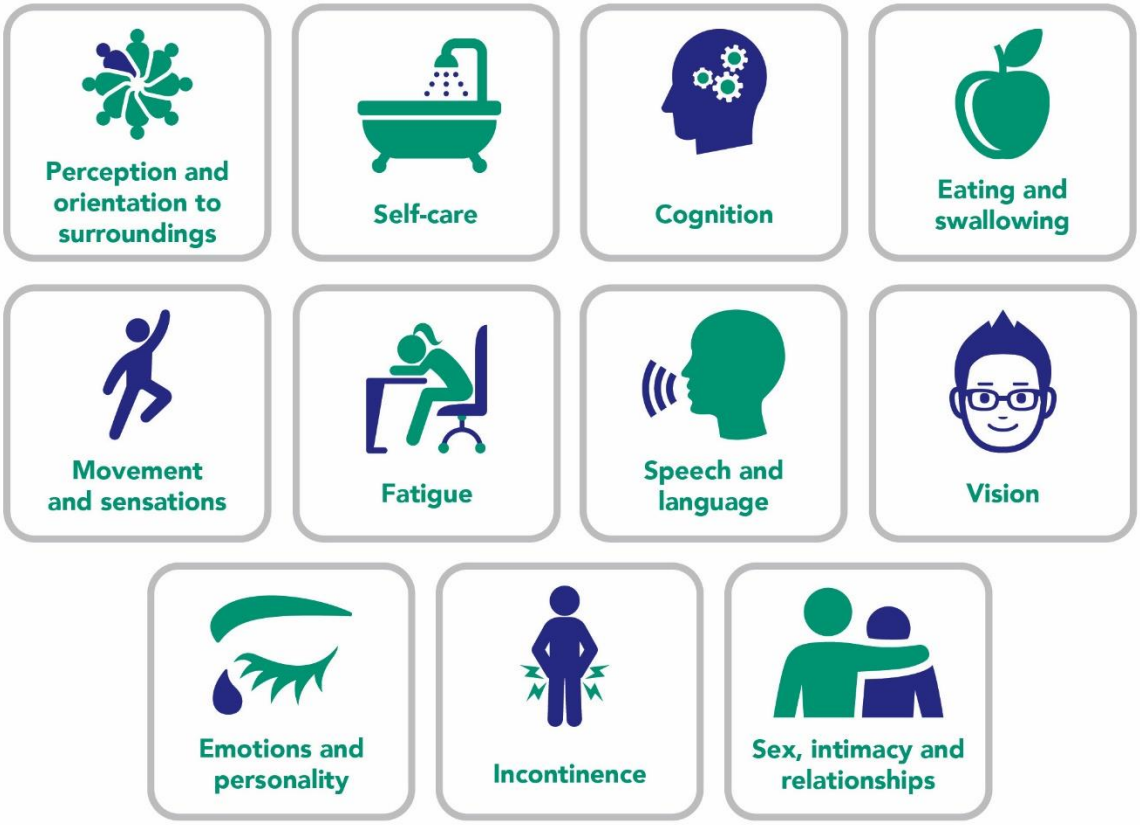
Ischaemic strokes are those caused by a blocked artery, and haemorrhagic strokes (intracerebral haemorrhage and subarachnoid haemorrhage) are caused by a burst artery (Figure 1). Undetermined strokes are assigned to strokes where routine imaging to determine the type of stroke has either not been completed or was inconclusive to make a diagnosis of the stroke type.

Figure 1 Types of stroke



Every stroke is different depending on what part of the brain is affected and the severity of the disruption to blood flow. What is common among all strokes is the devastation it can cause the survivor, their carer and family. Following a stroke, survivors may experience impaired function in a variety of areas (Figure 2).

Figure 2 Examples of impaired function following stroke



1.1.2 Risk factors for stroke

Some risk factors for stroke are modifiable (i.e. can be changed or controlled), and others are not.

While stroke can affect individuals of any age, the risk of stroke increases with age, and the change in stroke risk with age varies by sex. On average, men are at greater risk of stroke than women, but there are times in a woman's life where the risk is elevated compared to men, such as around pregnancy, after giving birth, and post-menopause.

Importantly, more than 80% of strokes can be prevented[2] and primary stroke prevention remains the most effective means of reducing the impact of stroke in Australia. Key modifiable risk factors for stroke include:

- high blood pressure
- abnormal blood lipids (e.g. raised cholesterol levels)
- overweight and obesity
- type 2 diabetes
- alcohol consumption
- physical inactivity
- smoking
- diet
- atrial fibrillation

High blood pressure, also known as hypertension, is the leading modifiable risk factor for stroke and the most preventable cause of stroke worldwide.[3] Importantly, while high blood pressure can be controlled through health promoting environments, lifestyle modifications and the use of antihypertensive medications, more than two thirds of those with high blood pressure do not have adequate control of their blood pressure.[4] A large proportion of those living with uncontrolled high blood pressure in Australia remain unaware (74%),[4] as they often do not experience symptoms. The only way to know if you are suffering from this 'silent killer' is to get your blood pressure checked regularly.

Stroke Foundation is a member of the National Hypertension Taskforce, alongside our partners at the Heart Foundation. This is a joint initiative of the Australian Cardiovascular Alliance and Hypertension Australia. Through implementation of their roadmap,[4] it aims to increase the number of Australians with their high blood pressure both treated and controlled effectively from the current 32% to 70% by 2030. In Australia, the proportion of people with controlled blood pressure is lagging behind other high-income countries like Canada (68%).[5] Achieving this target will make Australia a global leader in blood pressure management.

Their roadmap is built on three pillars to prevent, detect, and effectively treat high blood pressure, and has a number of key recommendations including a focus on team-based care, empowering the community to take charge of their health, and supporting screening and testing programs.

1.1.3 Recognition of stroke

It is critical that Australians understand the importance of phoning triple zero (000) immediately if they or someone else experience any of the signs of stroke.

Stroke Foundation recommends the F.A.S.T. test as an easy way to recognise the most common signs of stroke and remember that stroke is a medical emergency. Using the F.A.S.T. test involves asking these simple questions:

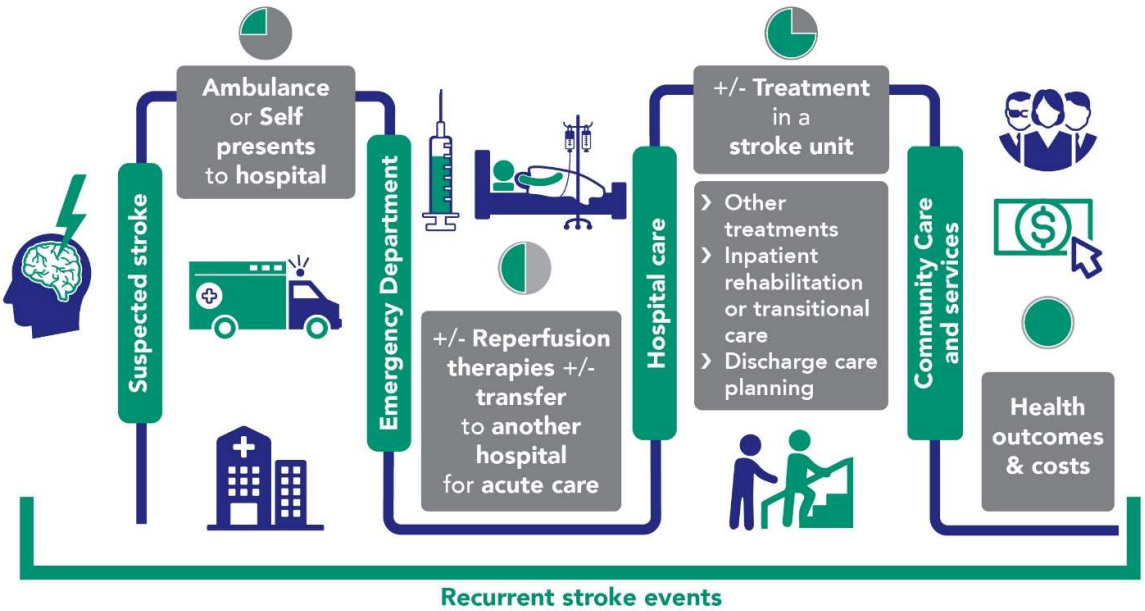
- **Face:** Check their face. Has their mouth drooped?
- **Arms:** Can they lift both arms?
- **Speech:** Is their speech slurred? Do they understand you?
- **Time:** Is critical. If you see any of these signs call 000 straight away.

Figure 3 Symptoms of stroke

1.1.4 Treatment and long-term care after stroke

Stroke is a medical emergency. Faster diagnosis and treatment can save lives and result in improved quality of life. When someone has a stroke, every minute counts. For most people who have a stroke, treatment will be provided through hospital care pathways (Figure 4).

Figure 4 Example of a typical patient care journey after stroke



Time Is Brain. When an acute stroke occurs, the best outcomes are achieved when treatment is provided as soon after the onset of symptoms as possible. Either a computerised tomography scan (CT scan) or magnetic resonance imaging (MRI) should be done urgently after a stroke, to determine the type of stroke (ischaemic or haemorrhagic). These brain scans may be repeated later to see how much of the brain has been affected by the stroke, or if a patient is getting worse.

For ischaemic strokes, treatment options include thrombolysis (clot-dissolving treatment) and endovascular thrombectomy (clot removal treatment), collectively known as reperfusion therapies.

During thrombolysis, a drug (recombinant tissue plasminogen activator) is administered intravenously. This treatment is more effective the earlier it is provided and is usually administered within 4.5 hours of the onset of stroke. Some patients with favourable brain imaging may be eligible for thrombolysis beyond this period of 4.5 hours after the onset of stroke.

Providing endovascular thrombectomy requires highly specialised teams that are present in comprehensive stroke centres. During this procedure, a small tube is fed from an artery in the leg up into the brain to physically remove the clot blocking blood supply to the brain. Patients with a blockage in the large arteries may be eligible for endovascular thrombectomy up to 24 hours after stroke onset, but the treatment is more effective the earlier it is provided.

For haemorrhagic strokes, treatment options may include drugs or transfusions of blood products to counteract the effects of blood thinners (for those on them), drugs to lower blood pressure or drugs to reduce spasms of the blood vessels and prevent seizures. If the area of bleeding is large, surgery may be performed to remove the blood and relieve pressure on the brain. Surgery may also be used to repair blood vessel problems, such as aneurysms or arteriovenous malformations, if they caused the stroke.

A stroke unit is a distinct ward in a hospital in which patients with stroke receive care from a specialised multidisciplinary team including medical, nursing and allied health professionals. Treatment in a stroke unit is proven to make the biggest difference to patient outcomes following stroke, both in hospital and after discharge.[6, 7] Patients treated in a dedicated stroke unit are more likely to be alive, independent, and living at home one year after stroke than if cared for in an alternative ward.[6, 7] The Australian Stroke Coalition (ASC), co-chaired by Stroke Foundation and the Australian and New Zealand Stroke Organisation (ANZSO), has developed and successfully piloted a voluntary system for certification of stroke units in Australian hospitals. This ASC Stroke Unit Certification Program is now an ongoing initiative, with the goal of certifying all centres providing stroke care in Australia by 2030.

Rehabilitation is a proactive, person-centred and goal-oriented process that should be provided by a specialised interdisciplinary team of health professionals throughout the care continuum after a stroke.[8] Rehabilitation should begin within 48 hours after hospital admission and have the ultimate aim of supporting the survivor of stroke to maximise their function and achieve the highest possible level of independence – physically, psychologically, socially and financially.[8]

1.1.5 30/60/90 National Stroke Targets

Australia has lagged behind other developed countries in the timely delivery of acute stroke treatments and the provision of treatment in a stroke unit.[9-12] We know that these interventions are sub-optimally utilised in Australia,[9, 13] and improving uptake of these interventions will improve outcomes after stroke:

- **For every 17 patients treated on a stroke unit, one death or dependent outcome is prevented.[6]**
- **For every ten patients treated with thrombolysis under three hours, one disabled outcome is prevented.[14]**
- **For every five patients treated with endovascular thrombectomy, one dependent outcome is prevented.**[15]

In addition, for every 15 minutes faster thrombolysis and endovascular thrombectomy is provided, the odds of death are lower (4% and 6%) and the odds of being discharged directly home post-stroke are higher (3% and 9%).[16, 17]

International experience has demonstrated that a clear focus on achieving performance benchmarks can greatly improve metrics and outcomes. For example, the Target Stroke program, established by the American

Heart Association in 2010, has delivered large and consistent improvements in timely access to thrombolysis and endovascular thrombectomy and subsequent reductions in stroke mortality and disability in participating hospitals.[10, 18]

Therefore, in 2023, national leaders in stroke agreed to bold new targets to ensure Australians have access to timely, world-leading stroke care. The 30/60/90 National Stroke Targets are a group of metrics designed to drive quality improvement activities in the areas of stroke unit access and time-critical emergency stroke treatments.

By 2030, the goal is to have:

- National median endovascular thrombectomy door to puncture time less than 30 minutes for transfers
- National median thrombolysis door to needle time less than 60 minutes
- National median door-in-door-out time for endovascular thrombectomy less than 60 minutes in metropolitan hospitals[e]
- National median endovascular thrombectomy door to puncture time in less than 90 minutes for primary presenters
- Certified stroke unit care provided to more than 90% of patients with primary stroke diagnosis.

These targets have been endorsed by state and territory governments, medical and nursing professional bodies and national stroke organisations, including Stroke Foundation. The establishment of these National Stroke Targets is the first step in a collaborative effort to support hospitals, stroke teams and governments to provide best-practice, time-critical stroke care for their patients and to reduce avoidable stroke-related deaths and disability. Local, state, and national initiatives to facilitate progress towards these goals will ensure they are implemented and embedded into practice.

1.2 Differences with prior Economic Impact of Stroke Reports

Differences in methods and data sources are the main reason why the results featured in this report may differ to those in the last Economic Impact of Stroke in Australia (2020). The methods for estimating the numbers of first-ever and recurrent stroke occurring in 2023 were developed in consultation with epidemiologists. In the previous report, recurrent strokes were omitted.[19] Rather than relying on information from the published literature, we analysed patient-level datasets to ascertain costs according to specific patient characteristics (such as age and type of stroke). This meant that we could determine the economic impact of stroke and estimate costs and benefits of the programs evaluated with greater precision.

[e] Where same-crew ambulance door-in-door-out transfer is possible. Regional services retrieving via road should aim for a door-in-door-out time of 75 minutes (hospitals requiring aero-retrieval service are not included in this target).

It is important to demonstrate the magnitude of the ongoing impact of stroke faced by many Australians. People who have had a stroke have ongoing healthcare needs and many people retire years earlier than expected due to stroke. This is why we estimated the economic and health impacts of stroke over a lifetime, and when estimating the costs and benefits of several programs. While costs related to the programs may be paid up-front, many benefits from these programs would only be realised beyond the short-term after stroke.

1.3 Structure of this report

In this report we demonstrate the enormous health and economic impacts of stroke in Australia using models that incorporate Australian Government resources and population statistics combined with best available data on stroke incidence, costs, and outcomes that were accessible to the project team.

Firstly, we provide estimates of the numbers of stroke occurring in Australia in 2023 (incidence). These are reported as first-ever and recurrent strokes, with breakdowns by age and stroke type. For each of these categories, a separate model was constructed with inputs (costs, disability, and mortality) specific to those categories in order to estimate costs in the short-term and long-term after stroke and the relevant health impact of stroke according to these patient characteristics.

Secondly, we estimated the economic and health impacts of stroke in Australia by aggregating the outputs of these separate models. Each model was also structured to be able to investigate impacts of different types of interventions (primary prevention, acute, secondary prevention and rehabilitation) on the overall costs and impacts of stroke in Australia.

Thirdly, using this model, we present the costs and benefits of national programs that aim to prevent or treat stroke compared with the existing system with no action.

2. Conceptual framework and scope of this report

To address the aims of this report we outline the methods undertaken in four linked stages (Figure 5).

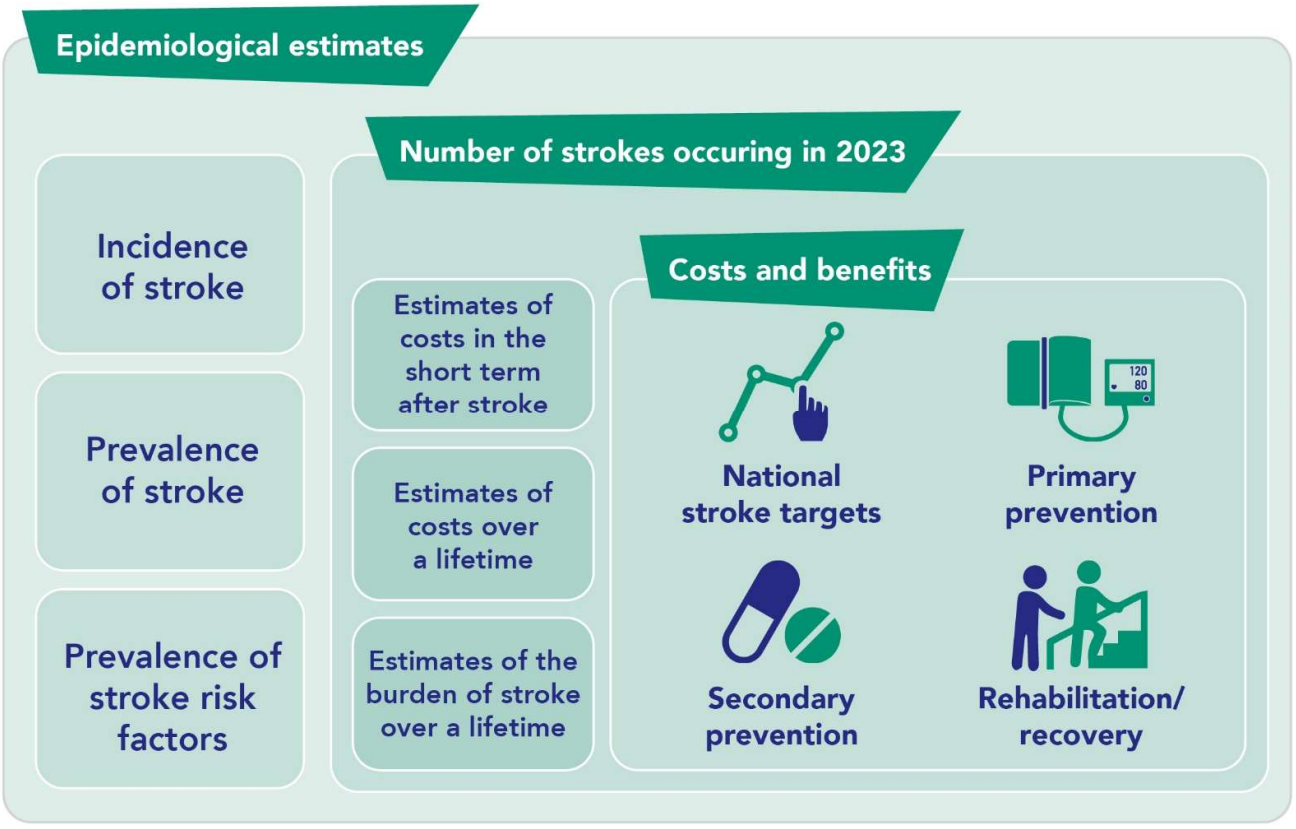
First stage: the number of first-ever and recurrent strokes occurring in the 2023 calendar year were estimated. The epidemiological estimates in the first stage of the project underpinned all subsequent outputs.

Second stage: costs in the short-term after stroke (defined as from stroke onset to three months post-stroke) were estimated according to age groups, type of stroke, treatments provided in hospital, first-ever or recurrent stroke status, and fatal or non-fatal stroke status.

Third stage: separate models were used to estimate the economic and health impact of stroke over a lifetime for several patient groups (based on patient characteristics including age groups and type of stroke).

Fourth stage: these models were used to estimate the costs and benefits of improving the provision of evidence-based strategies to prevent or treat stroke compared with the status quo.

Figure 5 Project overview



2.1 Epidemiological estimates

2.1.1 Estimating incidence of stroke

The base population for 2023 used in our models was obtained from the Australian Bureau of Statistics for males and females and different age groups. We then applied stroke incidence rates to estimate the stroke numbers. Data from several sources were used to estimate the number of first-ever and recurrent strokes, and the number of fatal and non-fatal events (Table 1). Age-specific rates of stroke incidence for states and territories obtained from multiple sources were applied to state and territory-specific populations in 2023 obtained from the Australian Bureau of Statistics (2023).

For further details on data sources and the methods, see the appendix (page 91).

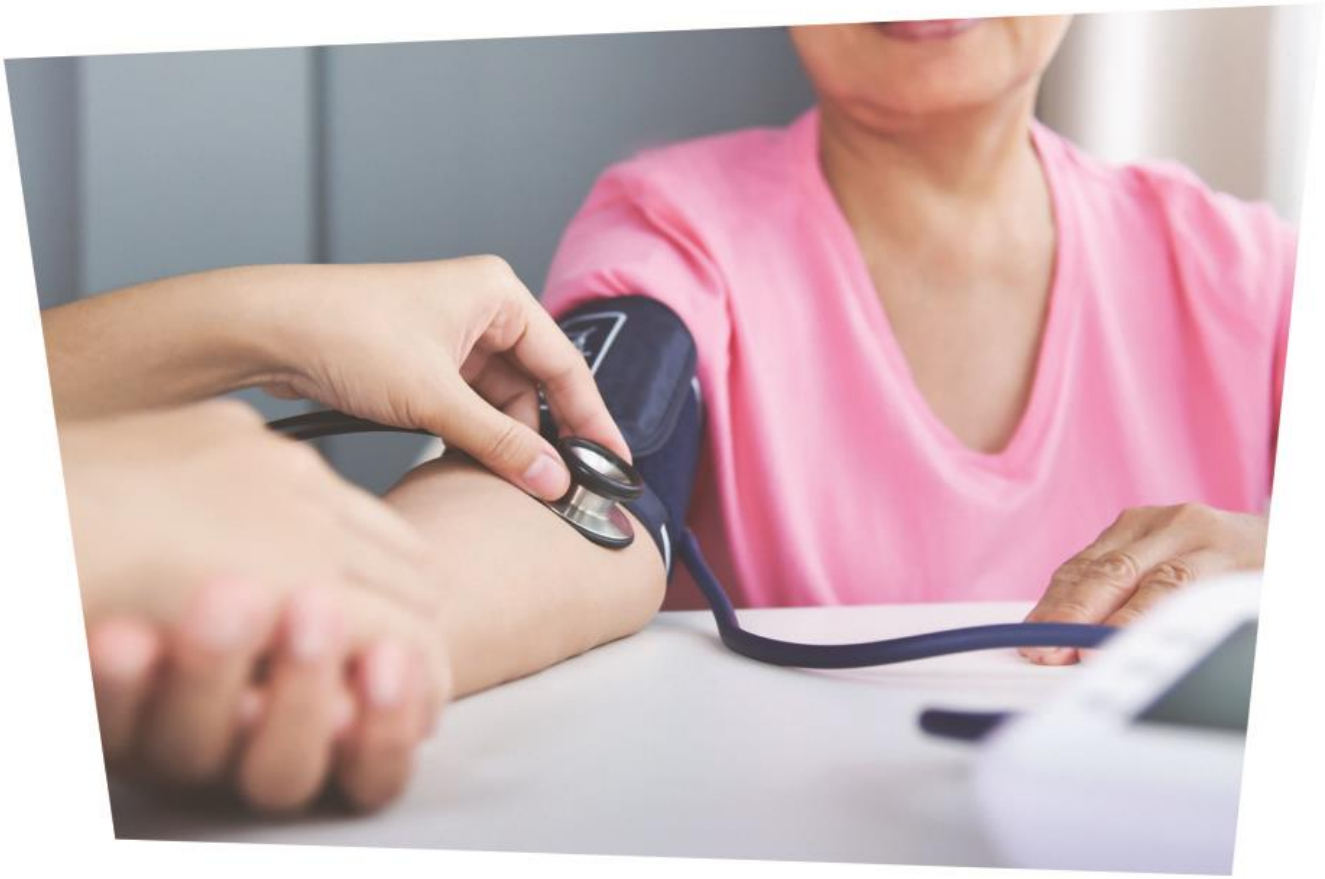
Table 1 Data sources for epidemiological estimates

Model input	Data source	Reference years
Incidence rates: Queensland, New South Wales, Victoria, Australian Capital Territory, Tasmania and South Australia	Australian Institute of Health and Welfare (2022)[20]	2018
Incidence rates: Western Australia	Balabanski et al (2023)[21] Additional analysis for 5-year age bands from 0 to 85+ years	2012-2015
Incidence rates: Northern Territory	Balabanski et al (2023)[21] Additional analysis for 5-year age bands from 0 to 85+ years and patients with Northern Territory postcodes in the South Australia and Northern Territory dataset.	2012-2015
Distribution of stroke subtypes (excluding subarachnoid haemorrhage)	Leyden et al (2017)[22]	2009-2010
Incidence of subarachnoid haemorrhage	The ACROSS Group (2000)[23]	1995-1998
Age-specific incidence rates over time	Youens et al (2023)[24]	2005-2017
Event to incidence rate ratios	Leyden et al (2017)[22]	2009-2010
28-day case fatality for ischaemic stroke, intracerebral haemorrhage and undetermined stroke	Australian Stroke Clinical Registry[9] Additional analysis.	2022
28-day case fatality for subarachnoid haemorrhage	Balabanski et al (2023)[21] Additional analysis for 5-year age bands from 0 to 85+ years	2012-2015
Proportion of fatal strokes that do not have a hospitalisation	Balabanski et al (2023)[21] Additional analysis.	2012-2015

2.1.2 Estimating prevalence of stroke and stroke risk factors

Age-and-sex-specific prevalence estimates for stroke were obtained from the 2018 Survey of Disability, Ageing and Carers.[25] Age- and sex-specific estimates for stroke risk factors were obtained from the 2022 National Health Survey.[26] Data on the total number of residents in Australia were obtained from the Australian Bureau of Statistics.[27] To estimate the number of people living with stroke or its risk factors, age-and-sex-specific prevalence estimates were applied to the number of residents in Australia in corresponding age and sex categories.

Different to other outputs featured in this report, the prevalence estimates are derived completely from extrapolation of information from Australian government sources. These estimates are not linked to the economic and health impacts estimated in other sections of the report.



2.2 Estimates of costs

Costs were estimated in the short-term after stroke (stroke onset to three months post-stroke) and over a lifetime after stroke (Table 2).

Costs in the short-term after stroke were estimated by extrapolating cost estimates obtained from analysis of patient-level data to the numbers of stroke estimated for the 2023 calendar year. This is described in further detail in section 2.3 and in the appendix (page 92). Costs in the long-term after stroke were estimated using a Markov model. This is described in further detail in following sections of the report.

Table 2 Estimated costs and data sources

	Analysis of patient-level data	Published literature
Road ambulance services (ST, L)	✓	✓
Air ambulance services (ST)		✓
Emergency department (ST, L)	✓	
Acute admission (ST, L)	✓	
Inpatient rehabilitation (ST, L)	✓	
Palliative care (ST, L)	✓	
Other subacute / non-acute care (ST, L)	✓	
Aged care (ST)		
Residential aged care	✓	✓
Transitional care	✓	✓
Home care	✓	✓
Outpatient services (ST, L)	✓	
Prescription medications (ST, L)	✓	
Productivity impacts (L)		
Employment	✓	✓
Household production		✓
Informal care (L)	✓	✓

ST: costs estimated in the short-term, L: costs estimated over a lifetime

2.3 Estimates of costs in the short-term after stroke

In the short-term after stroke (the first three months after stroke), costs were estimated by extrapolating data obtained from analyses of several datasets related to the Australian Stroke Clinical Registry (Table 3). The datasets used are described in further detail in the appendix (page 91). Costs included were based on a concept of a typical patient journey after stroke (Figure 6), whereby patients with suspected stroke arrive at hospital by ambulance to the emergency department, have subsequent hospital admissions (acute and subacute), and receive healthcare services including rehabilitation following discharge (including management in the community by medical and allied health professionals in primary care, and as part of aged care).

Average costs were obtained directly from analysis of patient-level data and were summarised for first-ever and recurrent strokes, by age, stroke type, fatal stroke status, and treatment provided during the acute admission following stroke. Where costs could not be obtained directly from analysis of the patient-level data, the number of times a service was used was estimated and unit prices were applied with basic assumptions. Air ambulance costs were obtained completely from personal communication with clinical experts and the published literature.

The average costs were applied to the numbers of strokes estimated for the 2023 calendar year to estimate the short-term economic impact. Costs were expressed in 2023 Australian dollars. Where relevant, the estimated costs were converted to the 2023 equivalent using the Total Health Price Index.[28]

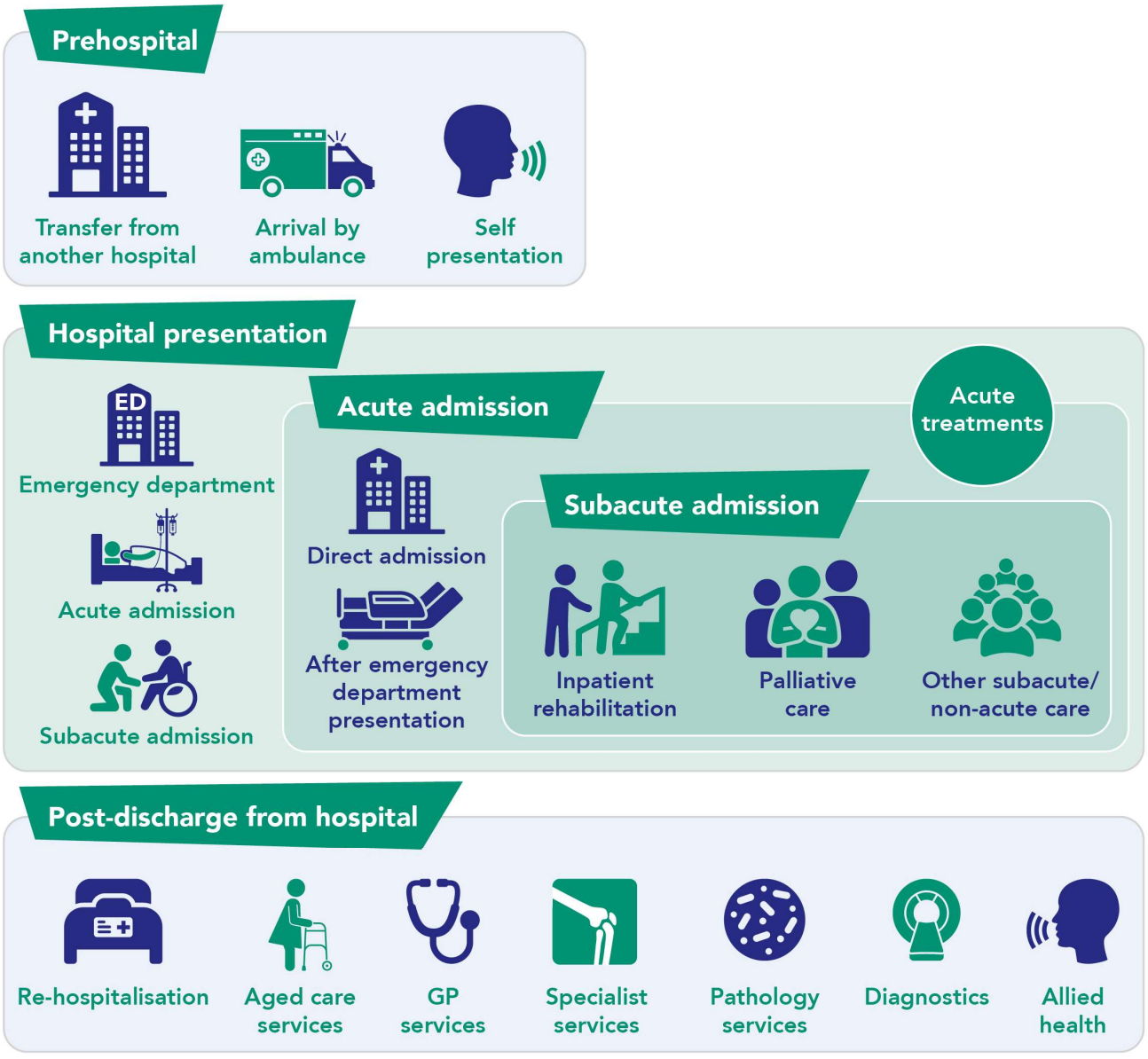
Table 3 Data sources for estimates of costs in the short-term after stroke

Model input	Detail and data source	Reference years
Ambulance services	Proportions of ambulance arrival from by age and stroke type. Data source: the AuSCR	2022
Emergency department	Emergency department costs by age and stroke type and fatal stroke status. Data source: the AuSCR Victorian data linkage.	2018-2019
Acute admission	Acute admission costs by first-ever and recurrent strokes, and by age, stroke type and fatal stroke status and treatment provided. Data source: the AuSCR Victorian data linkage.	2018-2019
Subacute admission	Subacute care costs by age and stroke type, fatal stroke status and treatment provided. Data source: the AuSCR Victorian data linkage. Proportions receiving subacute care by age, stroke type, treatment and fatal stroke status. Data source: the AuSCR and the AuSCR Victorian data linkage.	2018-2019 2022
Outpatient services	Costs of outpatient services (general practitioner, specialist, other including allied health and pathology services) by age and stroke type. Data source: the PRECISE data linkage.	2012-2018
Medications	Costs of dispensed medications by age and stroke type. Data source: the PRECISE data linkage.	2012-2018
Aged care	Proportions discharged to aged care and transitional care by age, stroke type and fatal stroke status and treatment provided. Data source: the AuSCR Proportions using home care by age. Data source: the PRECISE data linkage. Duration (days) provided aged care, transitional care and home care. Data source: the PRECISE data linkage.	2022 2012-2018

AuSCR: the Australian Stroke Clinical Registry.

PRECISE data linkage is a data linkage project using data from the AuSCR.[29] All datasets are described in further detail in the appendix (page 91). Data used for model inputs are available upon reasonable request from the research co-leads.

Figure 6 Components of care included in the economic modelling.



2.4 Modelling the lifetime economic and health impact of stroke

A Markov decision analytic model was used to estimate the costs associated with stroke and the disability adjusted life years (DALYs) associated with stroke over a lifetime. A DALY represents the loss of one year of life in full health and is the combination of years of life lost due to early death and years of remaining life lived with disability. A model was made for each stroke type (ischaemic stroke, intracerebral haemorrhage and undetermined stroke), age group and by first-ever or recurrent stroke reported in the epidemiological estimates using model inputs specific to those characteristics.

The model that was designed accounted for change in disability using data on **modified Rankin Scale (mRS)** health states and how it changes over time. The mRS is a 7-point scale that is a measure of functional dependence after stroke. Scores range from 0 (no symptoms) to 5 (severe disability), and deaths are categorised as mRS 6.[30] The model started at three months post-stroke with mRS distributions obtained from the Australian Stroke Clinical Registry follow-up surveys. Transitions between health states (in yearly cycles) were informed by data from published literature and mortality data from Australian Government sources (Table 4).

Mortality at 90 days and distributions of the mRS at three months post-stroke were obtained from the Australian Stroke Clinical Registry by age, stroke type and by first-ever or recurrent stroke status. Transitions between mRS health states (including death) from three months to five years post-stroke were informed by the findings from a population-based cohort study.[31] Due to the lack of published data on mRS transitions beyond five years post-stroke, the mRS health state at five years was considered to be stable, with only transitions from any mRS health state to death occurring thereafter. Patients with an mRS of 0 were assumed to have the same life expectancy as that of the general population obtained from Australian life tables.[32] Those with an mRS of 1-5 were assumed to have an increased relative risk of death compared to mRS 0 based on published data.[33] Within the first five years, where expected mortality in the general population was greater than that observed by Ganesh et al (2017) for older age groups,[31] the transitions to death were increased according to the relative risks reported in Shavelle et al (2019).[33]

Yearly costs were obtained from analysis of linked datasets and were applied according to mRS health states to estimate costs until the expected end of life (excluding costs incurred in the first three months after stroke). Costs were expressed in 2023 Australian dollars. Where relevant, the estimated costs were converted to the 2023 equivalent using the Total Health Price Index.[28] As per standard practices, discounting of 5% was applied to costs and outcomes incurred in future years.[34] Half cycle correction was used to assume that the transitions occur at the mid-point of a model cycle (not at the start or end of the cycle).

Disability weights for mRS health states[35] were applied to the years lived in mRS health states and were used to estimate years of life lived with disability until the expected end of life. Years of life lost due to stroke were estimated by comparing the estimated years of life lived to the life expectancy of the general population of

the equivalent age using Australian life tables.[32] The estimated years of life lost were combined with the estimated years of life lived with disability to estimate the DALYs associated with stroke over a lifetime.

Table 4 Data sources for Markov model structure

Model input	Detail and data source	Reference year
Deaths at 3 months post-stroke	Proportion of patients who died at 3 months post-stroke by first-ever and recurrent strokes, and by age and stroke type. Data source: the AuSCR.	2022
Modified Rankin Scale distributions at 3 months post-stroke	Distribution of modified Rankin Scale health states at 90 days post-stroke by first-ever and recurrent strokes, and by age and stroke type. Data source: the AuSCR.	2022
Modified Rankin Scale transitions between 3 months and 5 years post-stroke	Transitions between modified Rankin Scale health states between 3 months and 5 years post-stroke. Data source: Ganesh et al (2017)[31]	2002 – 2014
Risk of death from 5 years post-stroke	Risk of death by modified Rankin Scale. Data source: Shavelle et al (2019)[33]	Meta analysis 11 papers
	Risk of death in the general population. Data source: Australian Bureau of Statistics (2023)	2023

AuSCR: the Australian Stroke Clinical Registry. The AuSCR dataset is described in further detail in the appendix (page 91). Data used for model inputs are available upon reasonable request from the research co-leads.

2.5 Estimating the costs and benefits of programs

The costs and benefits of improving the provision of evidence-based strategies to prevent or treat stroke were calculated using the estimates of the number of strokes occurring per year, and the economic and health impact associated with the strokes. Benefits included DALYs avoided and cost savings from avoiding poor outcomes. Treatment effects of each therapy were assumed to be the same regardless of age, sex, stroke type, and pre-morbid history. No lead time (the lag time until an intervention results in a benefit) was assumed. The results only include the effects of patients treated in one calendar year.

The following programs were modelled separately: achieving 30/60/90 National Stroke Targets; reducing uncontrolled hypertension or high blood pressure to prevent first-ever strokes; improving use of medications for high blood pressure to prevent recurrent strokes; and improving access to community-based rehabilitation after stroke.

3. Incidence of stroke

The incidence of stroke refers to new occurrences of stroke within a specified period of time. For this report, the number of first-ever strokes, recurrent strokes, and fatal strokes were estimated for the 2023 calendar year. The estimates presented in this chapter of the report were prepared in collaboration with experts in stroke epidemiology and data linkage. Incidence rates according to age, that were specific to each state and

territory, were applied to the populations in each state and territory. Adjustments were made to account for current trends in incidence rates. For further details on data sources and the methods, see the appendix (page 91).

Precision of incidence estimates may be improved in the future with larger datasets with a longer study period. Larger datasets will permit smaller age groups to be investigated and give greater confidence in ascertaining whether a presentation for stroke was a first-ever or recurrent event. As much as possible, five-year or ten-year age groupings for the incidence rates were used to estimate the numbers of stroke occurring in 2023, but some age groups were combined where it was most pragmatic to do so (e.g. less than 65 years and 100 years and over). There was a non-uniform increase in the estimated numbers of stroke with age because of these age groupings, but also partly because of the underlying population structure of Australia.

Key findings

- In 2023, it was estimated that **45,785 people in Australia suffered a stroke**. Of these, 34,793 were a first-ever stroke and 10,992 were a recurrent stroke. With current trends in the incidence of stroke, by 2050 it was estimated that there would be almost 55,000 first-ever strokes and almost 17,000 recurrent strokes occurring each year.
- **The majority of strokes are ischaemic strokes.** Of the first-ever strokes, 81.2% were ischaemic strokes, 10.2% were intracerebral haemorrhages, 3.3% were undetermined strokes and 5.3% were subarachnoid haemorrhages. Of the recurrent strokes, 84.8% were ischaemic strokes, 11.5% were intracerebral haemorrhages, and 3.7% were undetermined strokes.
- Stroke can occur in people of all ages. It was estimated that **25% of those who suffered a first-ever stroke in 2023 were under the age of 65 years**, and 10% of those who suffered a recurrent stroke in 2023 were under the age of 65 years.
- **Over 14% of first-ever strokes, and 16% of recurrent strokes resulted in a death within 28 days of stroke.** In general, intracerebral haemorrhages more often resulted in deaths within 28 days of stroke (over 31%) compared to ischaemic stroke (over 11%) and undetermined stroke (over 12%), highlighting the need for further developments in the prevention and treatment of intracerebral haemorrhage.

3.1 First-ever strokes

Of the estimated 45,785 people in Australia who experienced a stroke, **34,793 had a stroke for the first time in their lives** (Table 5, Figure 7). Of the first-ever strokes, 81.2% were ischaemic strokes, 10.2% were intracerebral haemorrhages, 3.3% were undetermined strokes and 5.3% were subarachnoid haemorrhages. Approximately 25% of first-ever strokes were in those aged under 65 years (Figure 8).

Table 5 Number of first-ever strokes in 2023

Age group	Ischaemic stroke	Intracerebral haemorrhage	Undetermined stroke	Subarachnoid haemorrhage	Total
<65 years	6,690	952	195	1,040	8,877
65-69 years	3,706	109	99	170	4,084
70-74 years	3,256	96	87	150	3,589
75-79 years	4,362	1,152	165	201	5,880
80-84 years	2,826	747	107	130	3,810
85-89 years	4,533	302	302	87	5,224
90-94 years	2,192	146	146	42	2,526
95-99 years	623	41	41	12	717
100 and over	75	5	5	1	86
All ages	**28,263**	**3,550**	**1,147**	**1,833**	**34,793**

Figure 7 Number of first-ever strokes in 2023

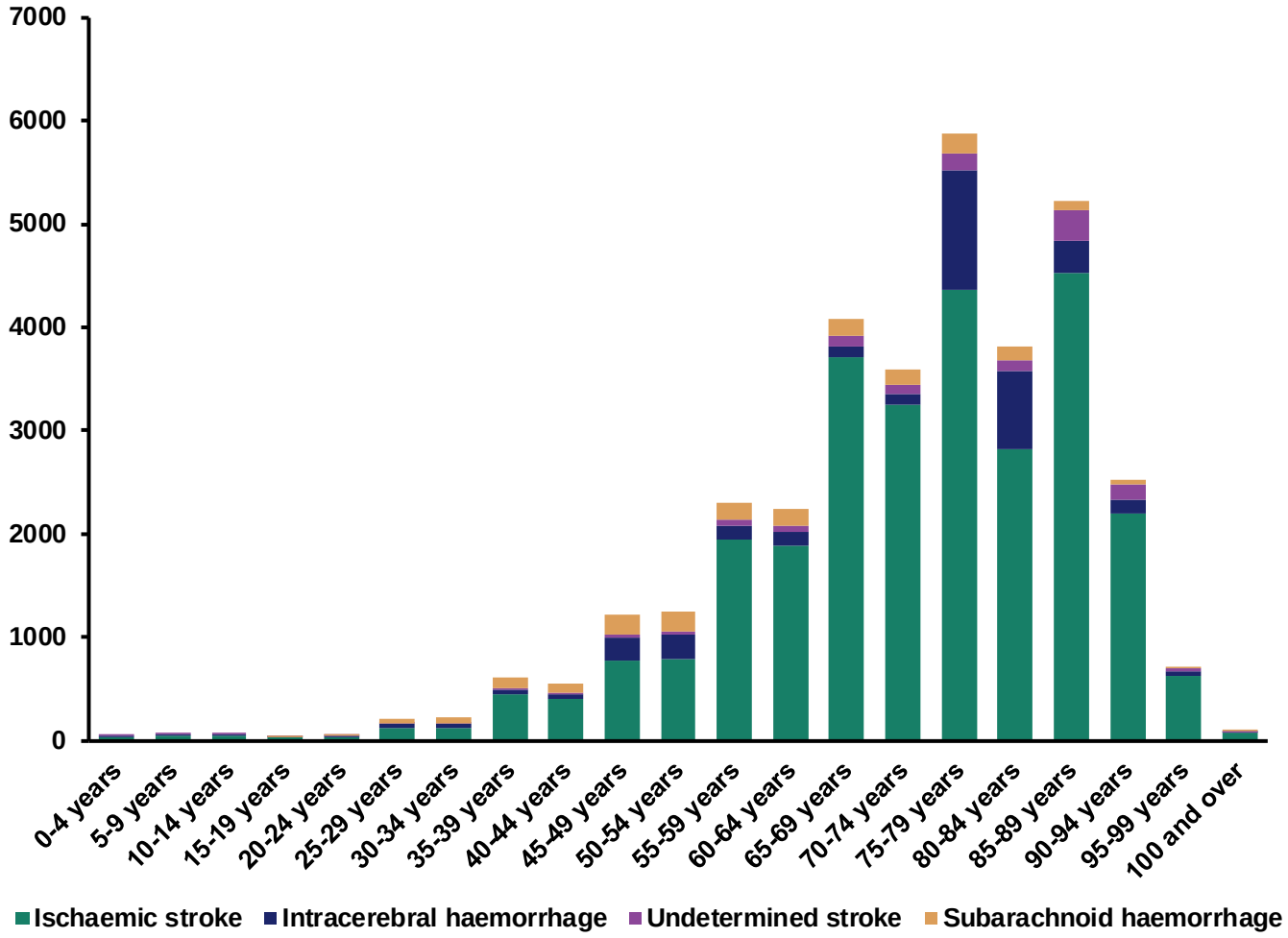
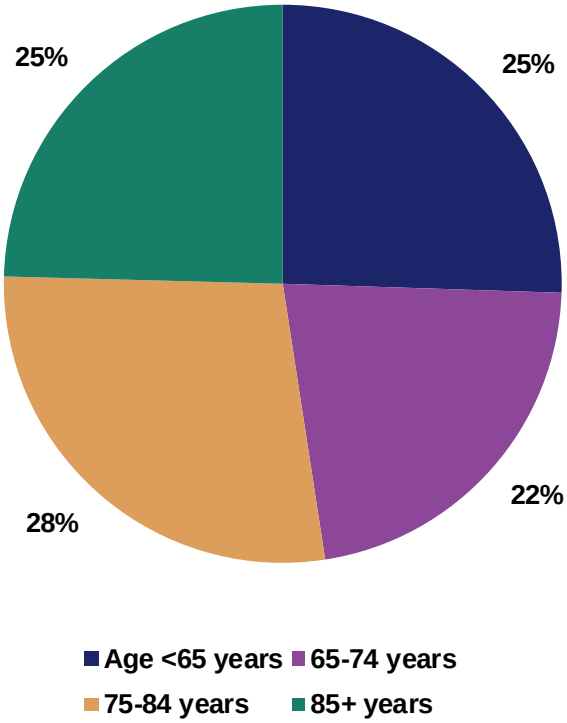


Figure 8. Age profile of first-ever strokes



Incidence of stroke has been increasing for those aged under 75 years in Australia since 2000,[24] but has been decreasing in those aged above 75 years (annual decrease of 1.66%). **The ageing population, prevalence of risk factors, and increasing population sizes in Australia, may explain why the absolute number of strokes occurring per year has not been declining.** With current trends in the incidence of stroke, and an increasing population, by 2050 it is estimated that there would be almost 55,000 first-ever strokes occurring each year.

The information used to produce these estimates were obtained from large, longitudinal datasets that included hospital records and death registries over several years, and where possible the information was applied specifically to the state or territory that the information came from. Having information from these datasets enabled accurate estimation of first-ever strokes occurring in Australia, particularly because the majority of patients with stroke are admitted to hospitals. It is important to note that these datasets would not identify non-admitted minor strokes that are more often seen in younger ages (incidentally diagnosed and treated by new services like the Young Stroke Service).[f] The incidence of these non-admitted minor strokes in younger ages remains poorly understood.

[f] https://www.youngstrokeservice.org.au/

3.2 Recurrent strokes

Of the estimated 45,785 people in Australia who suffered a stroke in 2023, **10,992 occurred in people who had a previous history of stroke** (Table 6, Figure 9). Of the recurrent strokes, 84.8% were ischaemic strokes, 11.5% were intracerebral haemorrhages, and 3.7% were undetermined strokes. Approximately, 10% of recurrent strokes were in those aged under 65 years (Figure 10). With current trends in the incidence of stroke,[24] by 2050 it is estimated that there will be almost 17,000 recurrent strokes occurring each year.

Recurrent subarachnoid haemorrhages may occur in rare circumstances, but the numbers were not estimated due to limitations with reliability of the data for this rare outcome. Recurrent subarachnoid haemorrhages are rare since the recurrence of subarachnoid haemorrhage is usually prevented with clipping of aneurysms after the first occurrence. In the ACROSS study, which was the source of data used for the subarachnoid haemorrhage incidence rates, only 4 out of 436 cases of subarachnoid haemorrhage were recurrent.[23]

Table 6 Number of recurrent strokes in 2023

Age group	Ischaemic stroke	Intracerebral haemorrhage	Undetermined stroke	Total
<65 years	989	127	28	1,144
65-69 years	1,059	31	28	1,118
70-74 years	930	27	25	982
75-79 years	1,999	528	75	2,602
80-84 years	1,295	342	49	1,686
85-89 years	1,865	124	124	2,113
90-94 years	902	60	60	1,022
95-99 years	256	17	17	290
100 and over	31	2	2	35
All ages	**9,326**	**1,258**	**408**	**10,992**

Figure 9. Number of recurrent strokes in 2023

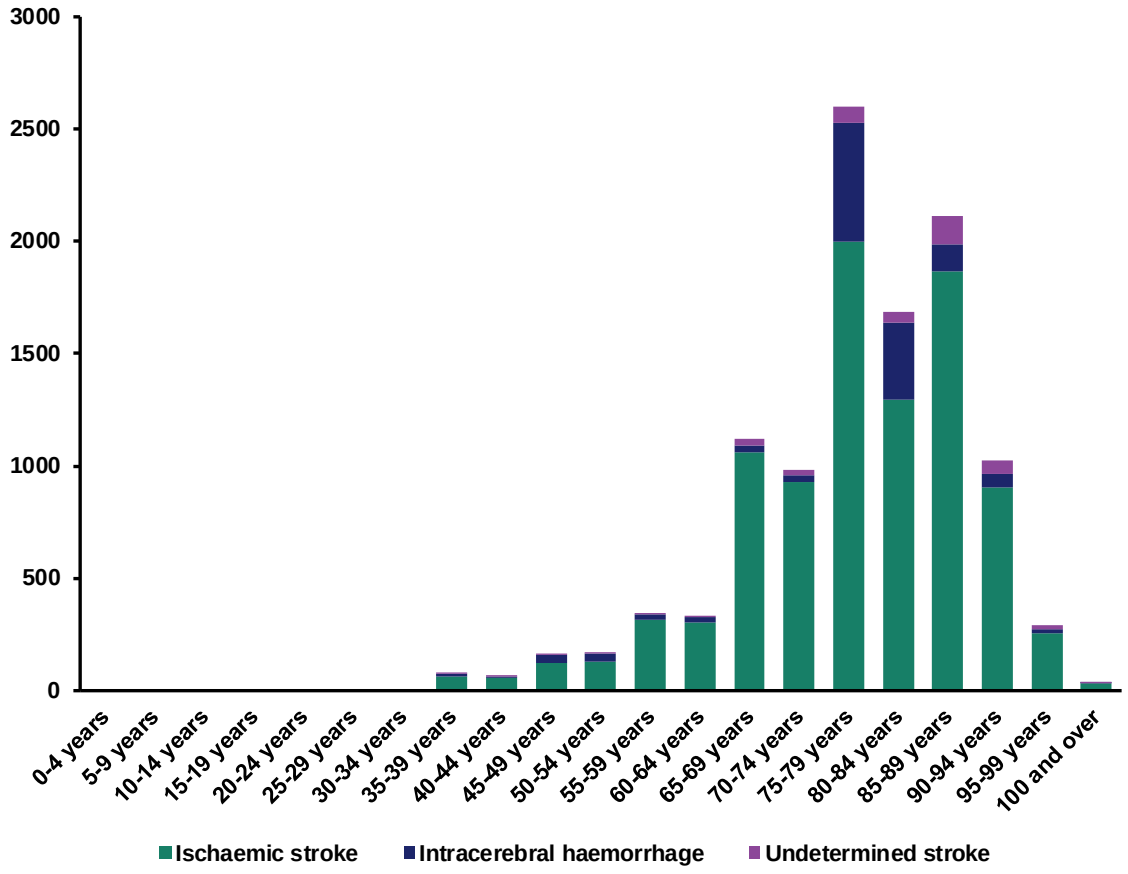
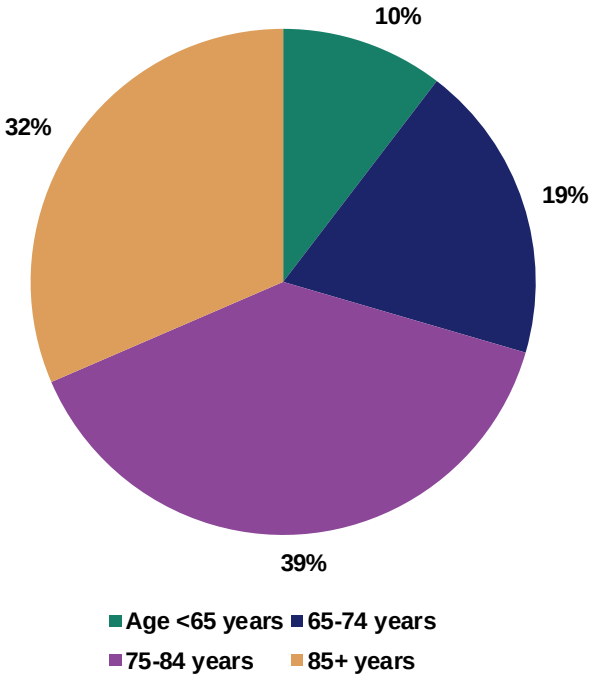


Figure 10. Age profile of recurrent strokes



3.3 Fatal first-ever strokes

Fatal strokes are typically classified as those that result in death within 28 days of stroke onset.

It was estimated that 4,924 of the 34,793 first-ever strokes were fatal (14.2%) in 2023 (Table 7). Fatal strokes were most commonly seen in those in older ages; of the 8,877 first-ever strokes occurring in people aged <65, it was estimated that 557 were fatal (6.3%), compared to approximately 26% in those older than 85 years old.

There was significant variation in the incidence of fatal strokes between stroke types. Fatal strokes were most common for those with first-ever intracerebral haemorrhage (31.0%), followed by first-ever subarachnoid haemorrhage (23.0%), first-ever undetermined stroke (14.6%) and first-ever ischaemic stroke (11.4%) (Figure 11).

Table 7 Number and proportion of fatal first-ever strokes in 2023

Age group	Ischaemic stroke Number (%)	Intracerebral haemorrhage Number (%)	Undetermined stroke Number (%)	Subarachnoid haemorrhage Number (%)	Total Number (%)
<65 years	248 (3.7%)	156 (16.4%)	7 (3.6%)	146 (14.0%)	557 (6.3%)
65-69 years	209 (5.6%)	21 (19.3%)	4 (4.0%)	40 (23.5%)	274 (6.7%)
70-74 years	229 (7.0%)	21 (21.9%)	4 (4.6%)	42 (28%)	296 (8.2%)
75-79 years	397 (9.1%)	374 (32.5%)	7 (4.2%)	64 (31.8%)	842 (14.3%)
80-84 years	338 (12%)	290 (38.8%)	5 (4.7%)	53 (40.8%)	686 (18%)
85-89 years	1106 (24.4%)	147 (48.7%)	86 (28.5%)	40 (46.0%)	1379 (26.4%)
90-94 years	535 (24.4%)	71 (48.6%)	42 (28.8%)	28 (66.7%)	676 (26.8%)
95-99 years	152 (24.4%)	20 (48.8%)	12 (29.3%)	8 (66.7%)	192 (26.8%)
100 and over	18 (24.0%)	2 (40.0%)	1 (20.0%)	1 (100%)	22 (25.6%)
All ages	3232 (11.4%)	1102 (31.0%)	168 (14.6%)	422 (23.0%)	4924 (14.2%)

Fatal stroke defined as a death within 28 days of stroke onset. % of all first-ever strokes

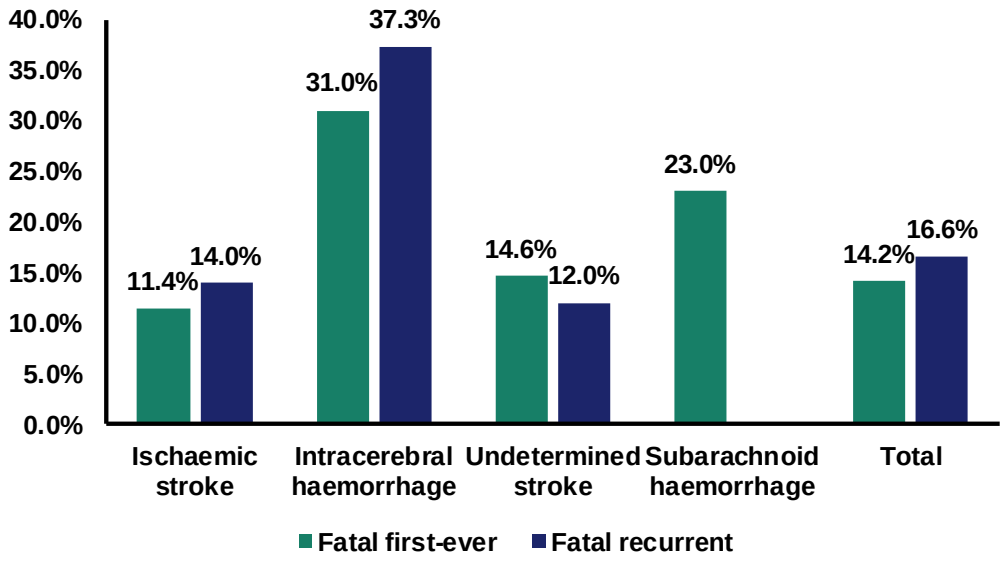
3.4 Fatal recurrent strokes

Excluding undetermined stroke, **recurrent strokes were more likely to result in death than first-ever strokes** (Figure 11).

It was estimated that 1,820 of the 10,992 recurrent strokes would be fatal (16.6%) (Table 8). Of the 1,144 recurrent strokes occurring in people aged under 65, it was estimated that 74 would be fatal (6.5%). Like with first-ever stroke, the proportion of strokes that were fatal increased with older age. Approximately 26% of those who had a recurrent stroke and were older than 85 years suffered a fatal stroke.

As a proportion of all occurrences of recurrent events, fatal strokes were most common for those with recurrent intracerebral haemorrhage (37.3%), followed by recurrent ischaemic stroke (14.0%) and recurrent undetermined stroke (12.0%)

Figure 11. Proportion of fatal strokes by stroke type



Denominator for these proportions are the number of first-ever and recurrent strokes occurring in 2023. The total number of fatal strokes: 6744. No fatal recurrent subarachnoid haemorrhages were estimated due to limited data.

Table 8 Number and proportion of fatal recurrent strokes in 2023

Age group	Ischaemic stroke Number (%)	Intracerebral haemorrhage Number (%)	Undetermined stroke Number (%)	Total Number (%)
<65 years	42 (4.2%)	28 (22%)	4 (14.3%)	74 (6.5%)
65-69 years	73 (6.9%)	5 (16.1%)	3 (10.7%)	81 (7.2%)
70-74 years	79 (8.5%)	8 (29.6%)	3 (12.0%)	90 (9.2%)
75-79 years	176 (8.8%)	167 (31.6%)	9 (12.0%)	352 (13.5%)
80-84 years	144 (11.1%)	162 (47.4%)	6 (12.2%)	312 (18.5%)
85-89 years	481 (25.8%)	61 (49.2%)	15 (12.1%)	557 (26.4%)
90-94 years	233 (25.8%)	29 (48.3%)	7 (11.7%)	269 (26.3%)
95-99 years	66 (25.8%)	8 (47.1%)	2 (11.8%)	76 (26.2%)
100 and over	8 (25.8%)	1 (50.0%)	0 (0%)	9 (25.7%)
All ages	1302 (14%)	469 (37.3%)	49 (12%)	1820 (16.6%)

Fatal stroke defined as a death within 28 days of stroke onset. % of all recurrent strokes

4. Prevalence of stroke and stroke risk factors

The estimates of prevalence presented in this chapter have been derived from extrapolation of information from government sources and have not been generated from the model like other outputs presented in the report. The prevalence estimates are not linked to the economic and health impacts estimated in the other sections of the report.

Key findings

- It is estimated that there were **440,481 people with a prior history of stroke living in Australia in 2023 (244,756 males and 195,725 females).**
- Many people in Australia also report having stroke risk factors such as hypertension (high blood pressure), diabetes, high cholesterol, smoking, physical inactivity and being overweight.
    - High blood pressure was common, affecting 24% of males and 22% of females.
    - Almost 7.5 million males (69%) and over 6.5 million females (59%) living in Australia were overweight or obese.
- Transient ischaemic stroke is an indication that someone may be at high risk of stroke. According to data from the Australian Institute of Health and Welfare, there are almost **20,000 presentations to hospital related to transient ischaemic attack in Australia each year.**

4.1 Prevalence of stroke

Stroke prevalence in Australia that was estimated using data from the 2018 Survey of Disability, Ageing and Carers,[25] was reported by the Australian Institute of Health and Welfare.[36] The Survey of Disability, Ageing and Carers included Australian residents aged under 65 years, or people of all ages with disability or long-term health conditions. History of stroke (excluding transient ischaemic attack) was self-reported by survey respondents. When applying these prevalence estimates to the Australian population in 2023**, it was estimated that there were 440,481 stroke survivors (Table 9). Of these, 244,756 were males and 195,725 were females.**

Table 9 Estimated number of people with stroke by age and sex in 2023

Age group (years)	Number of people in '000s			Age group	Prevalence from SDAC, 2018	
	Male	Female	Total		Male	Female
15-44	11.1	10.9	22.0	15-44	0.2%	0.2%
45-54	14.6	16.7	31.3	45-54	0.9%	1.0%
55-64	29.7	31.1	60.8	55-64	2.0%	2.0%
65-74	76.3	38.8	115.1	65-74	6.4%	3.0%
75-84	77.3	56.8	134.1	75-84	10.8%	7.1%
≥ 85	35.8	41.5	77.3	≥ 85	16.0%	12.3%
Total	244.8	195.7	440.5			

SDAC: Survey of Disability, Ageing and Carers

4.2 Prevalence of stroke risk factors

There are many modifiable stroke risk factors. In the INTERSTROKE study,[2] it was estimated that **10 modifiable risk factors accounted for over 80% of the risk of stroke**. It is important to know how prevalent these risk factors are in the population to inform initiatives to prevent stroke.

The most reliable data source identified for the prevalence of several risk factors was the 2022 National Health Survey.[26] The National Health Survey included all residents in Australia of all ages living in private dwellings in urban and rural areas, but excluded very remote parts of Australia and discrete Aboriginal and Torres Strait Islander Communities. High blood pressure and overweight/obesity were determined from measurement (Table 10). Other risk factors were self-reported.

Table 10 National Health Survey variables

Prevalence estimate	Definition used in the National Health Survey[26]
High blood pressure	measured blood pressure of ≥140/90 mmHg by the survey team.
Diabetes mellitus	self-report diagnosis of type 1 or type 2 diabetes mellitus, or diabetes mellitus of unknown type. These estimates include individuals who reported they had diabetes mellitus but that was not current at the time of interview.
High cholesterol	self-reported high cholesterol levels.
Current daily smoking	self-reported current daily smoking.
Physical inactivity	self-reported zero minutes of physical activity in the past week.
Overweight	measured body mass index (BMI) of 25 kg/m^2.

The prevalence rates of these risk factors were applied to the Australian population in 2023. The most common risk factor of stroke among people aged 18 years or older in Australia was overweight/obesity (Table 11). Almost 14 million people were estimated to be overweight/obese (69% of males and 59% of females). The next most common risk factor was hypertension, with almost 5 million people estimated to have a measured blood pressure above 140/90 mmHg (24% of males and 22% of females). Overall, the prevalence of diabetes, high cholesterol, smoking and physical inactivity was between 6% and 13%. Apart from smoking, the prevalence generally increased with age.

Table 11 Estimated number of people with risk factors for stroke in 2023

	Population	Hypertension	Diabetes	High cholesterol	Smoking	Physical inactivity	Overweight / obesity
Male				**Estimates in '000s**			
15-44	5533.2	729.4 (13%)	94.2 (2%)	111.7 (2%)	619.8 (11%)	395.2 (7%)	3354.8 (61%)
45-54	1625.4	479 (29%)	98.8 (6%)	153.3 (9%)	249.3 (15%)	138 (8%)	1266.1 (78%)
55-64	1487.1	503.1 (34%)	175.2 (12%)	309.4 (21%)	258.7 (17%)	195.2 (13%)	1162 (78%)
65-74	1191.5	474.9 (40%)	203.3 (17%)	276.8 (23%)	117.4 (10%)	185.4 (16%)	969.9 (81%)
75+	939.1	396.8 (42%)	194.3 (21%)	257.2 (27%)	35.4 (4%)	252.7 (27%)	696.5 (74%)
Total	10776.4	2583.2 (24%)	765.8 (7%)	1108.5 (10%)	1280.5 (12%)	1166.5 (11%)	7449.2 (69%)
Female				**Estimates in '000s**			
15-44	5441.5	526 (10%)	72.5 (1%)	82.6 (2%)	416.8 (8%)	479.3 (9%)	2679.7 (49%)
45-54	1671.5	410.3 (25%)	86.7 (5%)	134.6 (8%)	194.3 (12%)	219.6 (13%)	1125.3 (67%)
55-64	1555.0	474 (30%)	163 (10%)	266.6 (17%)	186.3 (12%)	209.9 (13%)	1080.8 (70%)
65-74	1292.8	495.2 (38%)	135.4 (10%)	318.9 (25%)	101.5 (8%)	248.6 (19%)	896.5 (69%)
75+	1136.8	500.6 (44%)	196 (17%)	348.4 (31%)	21.5 (2%)	337.8 (30%)	746.4 (66%)
Total	11097.5	2406.1 (22%)	653.7 (6%)	1151.1 (10%)	920.4 (8%)	1495.3 (13%)	6528.7 (59%)

Note: Hypertension is defined as blood pressure of >140/90 mmHg, and overweight defined as having a body mass index of ≥25 kg/m2 (includes obesity). Other risk factors are self-reported. * The proportion is calculated using those aged 18 years and over.

Another important risk factor for stroke is atrial fibrillation. Atrial fibrillation is a condition that results in an irregular heartbeat. Those with atrial fibrillation have a greater likelihood of forming blood clots in the heart because the blood that pools in the heart is not ejected efficiently. These can cause ischaemic strokes when the blood clots travel into the brain from the heart. Approximately 30% of patients with stroke have a prior history of atrial fibrillation.[37] Proportions of hospitalisations due to stroke with an additional diagnosis of atrial fibrillation between 2001 and 2018 have been between 14% and 16%.[38]

In previous editions of this report, the prevalence of atrial fibrillation was estimated for an Australian population using findings from a study by Ball et al (2015).[39] In the study by Ball et al, [39] **it was estimated**

that 4.36 million Australians over the age of 55 years would have atrial fibrillation in 2023. There is evidence from the Australian Institute of Health and Welfare (2020) that atrial fibrillation also affects those in younger age groups: of the 72,542 hospitalisations primarily due to atrial fibrillation in 2018, over 3,000 were in those aged under 55 years.[38] Between 2014 and 2020, rates of hospital presentations for atrial fibrillation have been stable.[40]

4.3 Transient ischaemic attack

Transient ischaemic attacks are often a sign that someone is at high risk of ischaemic stroke. Patients with a transient ischaemic attack have similar risk factor profiles to people with stroke, and almost 5% of patients with a transient ischaemic attack will experience a stroke within ninety days, with over half of these occurring within two days.[41]

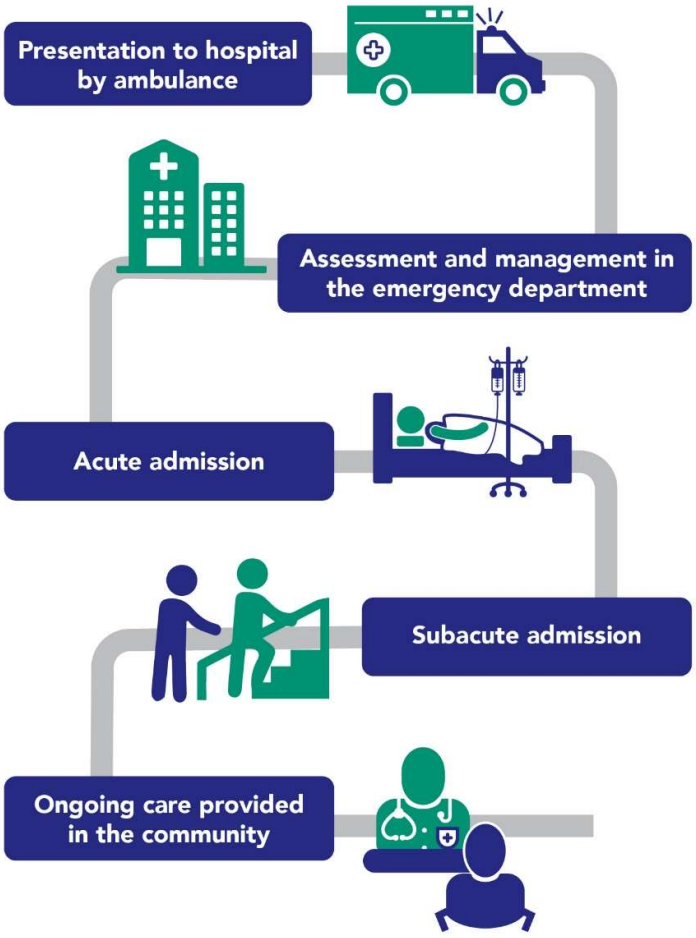
Not all patients with transient ischaemic attack present to hospital.[42] Since people with transient ischaemic attack are often treated in the community by general practitioners or are misdiagnosed,[43] it is difficult to assess the prevalence of transient ischaemic attack (i.e. the number of people in Australia that have experienced a transient ischaemic attack).

The best indication of how common transient ischaemic attacks are in the Australian population comes from hospital data. According to the Australian Institute of Health and Welfare,[36] in the 2020-21 financial year there were **19,700 presentations to public hospital emergency departments for transient ischaemic attack**, with **13,000 of these resulting in a subsequent admission to hospital.** Among those who were admitted, costs of hospitalisations related to transient ischaemic attack are approximately $4,000 per person, which is substantially less than admissions for stroke.[44] Once discharged from hospital, these patients are likely to be managed by a general practitioner and/or receive follow-up care in a specialist clinic.

5. Cost impacts

After the onset of stroke, a typical patient pathway through the healthcare system may be as follows (Figure 12):

Figure 12 Typical patient pathway after stroke



Like with any modelling, assumptions are made to simplify complex concepts or scenarios. We used a model that represents this typical pathway of treatment and management after the onset of stroke to estimate short-term costs (from stroke onset to three months post-stroke) according to a number of important patient characteristics (e.g. age and stroke type).

While costs in the short-term after stroke may receive the most attention because of the proximity to the stroke, and because of the importance of early treatment in hospital and subsequent rehabilitation, there are still important economic impacts long after stroke. Ongoing support at home, and from healthcare services, is essential for further recovery and to minimise risks of a recurrent stroke. Healthcare services post-stroke are typically coordinated by general practitioners and specialists, and where necessary will involve allied health professionals such as physiotherapists, occupational therapists, speech pathologists and psychologists.

Returning to work and participation in other social and community groups may be additional areas of focus for patients who had a stroke. Due to impairments following stroke, driving may be impacted and some may no longer be able to undertake the same tasks they did prior to stroke. Lost income after stroke, lost productivity at home, and greater need for informal care are costs to society following stroke that are important to quantify even though they may not be as obvious as healthcare costs.

In this chapter of the report, healthcare costs, productivity losses and costs related to informal care are estimated over a lifetime for people who had a stroke in 2023. Short-term and long-term costs are presented separately. For further details on data sources and the methods, see the appendix (page 91 and page 96).

Key findings

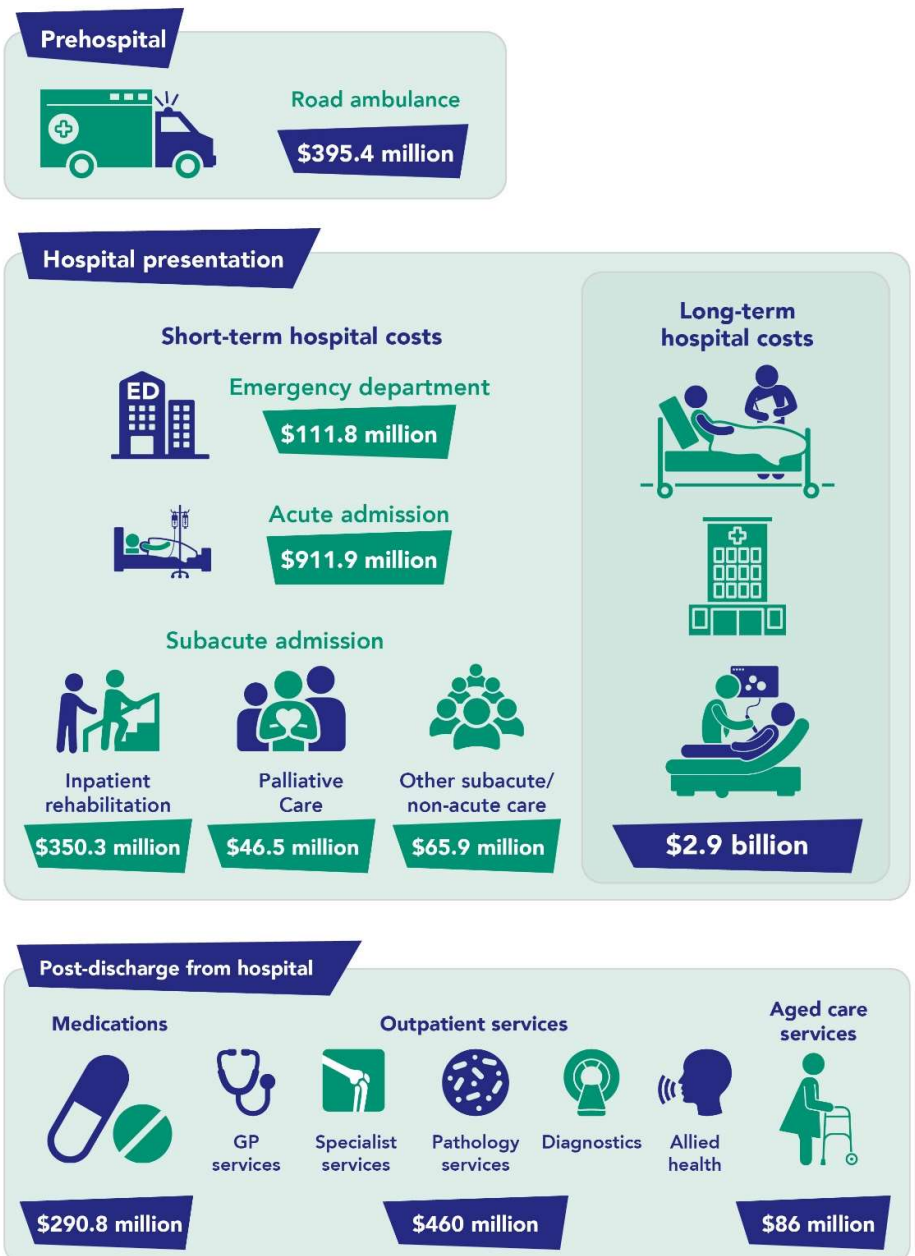
- **Costs associated with strokes occurring in 2023 were over $15.7 billion over a lifetime; over $350,000 per person.**
- Immediately after stroke, patients are mainly managed through the hospital system. Total costs incurred in the **short-term after stroke were over $1.2 billion for first-ever strokes,** and over **$400 million for recurrent strokes**. On average, short-term costs related to first-ever strokes were $38,729 per person, which was greater than those related to recurrent stroke ($36,621 per recurrent event).
- Total short-term costs of stroke were greater for ischaemic stroke than intracerebral haemorrhages. However, when the analyses were focused on first-ever events, intracerebral haemorrhages were more costly in the short-term at $43,082 than ischaemic stroke ($36,611).
- Costs related to patient transfer to hospital were **$54 million for road ambulance** and at least **$17 million for air ambulances.**
- The total costs for people experiencing a stroke in 2023 **after the first three months for the rest of their life were estimated to be over $14 billion.** The costs included almost:
    - $4 billion in healthcare costs (approximately one quarter of these costs were related to hospital services);
    - almost $3 billion from employment impacts;
    - over $3 billion from household impacts; and
    - almost $4 billion in costs related to informal care.
- For each person who experienced a stroke in 2023, the costs of stroke after the first three months for the rest of their life were over $320,000, with $89,592 in healthcare costs, $66,464 in costs related to employment, $76,775 in costs related to household productivity, and $88,059 in costs of informal care.

- Average costs per person were greatest for ischaemic stroke ($325,231), followed by intracerebral haemorrhage ($306,213) and undetermined stroke ($261,470).

- In the three to twelve months after stroke, more than $475 million in ongoing hospital and outpatient services and use of medications were incurred for first-ever strokes ($155 million for recurrent strokes). Between three months and five years post-stroke, there was an estimated total cost of over $1.5 billion for first-ever strokes and $473 million for recurrent strokes.

See below for description of healthcare costs associated with strokes that occurred in 2023 (please refer to Table 14, 15 and 18 for more details).

Costs of stroke presented in Figure 6 components of care included in the economic modelling



5.1 Costs over a lifetime after stroke

Costs associated with strokes occurring in 2023 were more than $15.7 billion over a lifetime (Table 12), with over $7.7 billion of these costs incurred in the first 12 months after stroke and $1.6 billion of these costs incurred in the first three months after a stroke (short-term costs). This was estimated to be almost $350,000 per person over a lifetime, including $66,464 in employment impacts, $76,775 in household productivity losses and $88,059 in costs related to informal care (Figure 13).

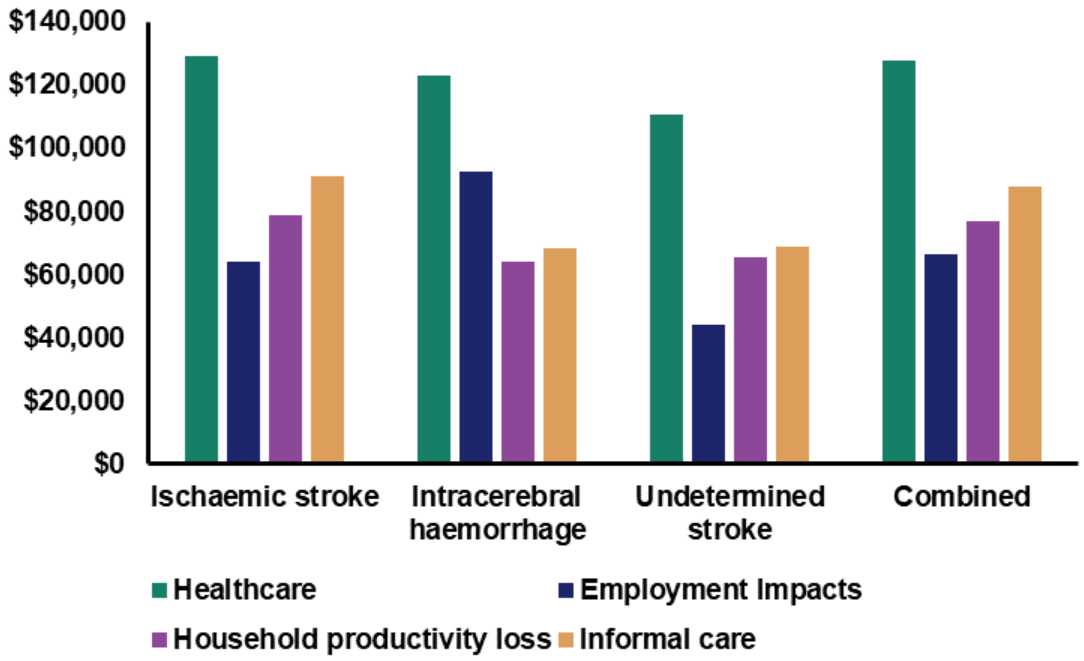
Costs related to the National Disability Insurance Scheme (NDIS) were not estimated using the model developed for this report but are publicly available in NDIS dashboards. Currently, the costs of managing stroke through the NDIS total over $1.3 billion per year.[45] This funded care for 9,609 patients with a primary disability from stroke between July 2023 and June 2024 (approximately $143,000 per person).

Costs of subarachnoid haemorrhage were not estimated in this report, but these may be substantial, particularly in the short-term after stroke since there is high mortality after subarachnoid haemorrhage and surgical procedures are provided in the acute setting.[46]

Table 12 Costs over a lifetime by stroke type for strokes occurring in 2023

	Ischaemic stroke	Intracerebral haemorrhage	Undetermined stroke	Combined
Total				
Short-term healthcare	$1,432,586,413	$203,546,376	$43,205,147	$1,679,337,937
Long-term	$12,226,083,012	$1,472,824,028	$407,535,628	$14,106,442,668
Healthcare	$3,419,941,414	$389,343,684	$129,217,158	$3,938,502,256
Employment Impacts	$2,407,736,804	$444,868,757	$69,163,172	$2,921,768,733
Household productivity loss	$2,964,174,204	$308,727,386	$102,169,227	$3,375,070,818
Informal care	$3,434,230,590	$329,884,201	$106,986,070	$3,871,100,861
Lifetime	**$13,658,669,425**	**$1,676,370,405**	**$450,740,775**	**$15,785,780,605**
Average				
Short-term healthcare	$38,109	$42,319	$27,720	$38,201
Long-term	$325,231	$306,213	$261,470	$320,890
Healthcare	$90,975	$80,948	$82,904	$89,592
Employment Impacts	$64,049	$92,492	$44,374	$66,464
Household productivity loss	$78,851	$64,187	$65,551	$76,775
Informal care	$91,355	$68,586	$68,641	$88,059
Lifetime	**$363,340**	**$348,532**	**$289,190**	**$359,091**

Figure 13. Average lifetime costs for strokes occurring in 2023



Costs related to healthcare services were estimated to be $2.3 billion at one year, $3.7 billion at five years and $5.6 billion over a lifetime (Table 13). Over a lifetime, costs related to healthcare services were greater than $127,000 per person.

Table 13 Healthcare costs over a lifetime related to strokes occurring in 2023

	Ischaemic stroke	Intracerebral haemorrhage	Undetermined stroke	Combined
Total				
to 3 months	$1,432,586,413	$203,546,376	$43,205,147	$1,679,337,937
to 1 year	$1,988,597,419	$260,008,907	$62,457,923	$2,311,064,250
to 5 years	$3,228,941,507	$396,303,940	$109,816,503	$3,735,061,950
to end of life	**$4,852,527,828**	**$592,890,061**	**$172,422,305**	**$5,617,840,194**
Average				
to 3 months	$38,109	$42,319	$27,720	$38,201
to 1 year	$52,900	$54,058	$40,072	$52,571
to 5 years	$85,894	$82,395	$70,457	$84,964
to end of life	**$129,084**	**$123,267**	**$110,624**	**$127,793**

In the following sections, the details of how we derived these total costs are provided, including the healthcare expenditure within 12 months, five years, and the rest of life.

5.2 Short-term healthcare costs

Costs in this section of the report relate to costs incurred in the first three months after the onset of stroke, unless otherwise stated. Total costs incurred in the short-term after stroke were over $1.6 billion, with $1.2 billion for first-ever strokes (Table 14), and over $400 million for recurrent strokes (Table 15). The largest contribution of costs was the acute admission, followed by costs related to inpatient rehabilitation and the emergency department. These costs are described in further detail in the following sections of the report.

Table 14 Short-term total costs for first-ever strokes occurring in 2023

	Ischaemic stroke	Intracerebral haemorrhage	Undetermined stroke	Combined
Road ambulance	$34,540,126	$4,610,411	$1,400,279	$40,550,816
Emergency department	$72,743,977	$8,945,472	$2,518,076	$84,207,524
Acute admission	$593,597,615	$90,269,654	$16,900,917	$700,768,186
Inpatient rehabilitation	$229,510,929	$35,229,969	$1,536,211	$266,277,110
Palliative care	$30,629,369	$2,770,389	$1,916,942	$35,316,700
Other subacute / non-acute care	$38,981,043	$7,708,355	$2,064,908	$48,754,306
Outpatient services				
General practitioner	$8,074,655	$762,040	$320,531	$9,157,226
Specialist	$14,942,004	$1,824,097	$539,908	$17,306,009
Other*	$2,936,889	$296,615	$117,052	$3,350,556
Total outpatient services	$25,953,547	$2,882,753	$977,492	$29,813,791
Prescription medications	$8,783,594	$525,286	$354,700	$9,663,580
Total excluding aged care	**$1,034,740,200**	**$152,942,288**	**$27,669,525**	**$1,215,352,014**
Aged care				
Residential aged care	$12,481,619	$2,099,120	$1,203,367	$15,784,106
Transitional care	$3,112,744	$371,747	$25,633	$3,510,125
Home care	$36,914,238	$3,268,177	$1,824,649	$42,007,064
Total aged care	$52,508,601	$5,739,045	$3,053,649	$61,301,295
Total including aged care	**$1,087,248,801**	**$158,681,333**	**$30,723,174**	**$1,276,653,309**

* including allied health and pathology

Costs incurred from stroke onset to three months post-stroke have been included. Aged care costs estimated in this report relate to those who commenced aged care in this period of time and include the provision of aged care services that are provided for a longer duration than three months.

Table 15 Short-term total costs for recurrent strokes occurring in 2023

	Ischaemic stroke	Intracerebral haemorrhage	Undetermined stroke	Combined
Road ambulance	$11,699,129	$1,652,980	$507,830	$13,859,939
Emergency department	$23,643,425	$2,999,027	$922,094	$27,564,546
Acute admission	$181,518,251	$22,467,461	$7,112,213	$211,097,924
Inpatient rehabilitation	$72,825,965	$10,693,788	$516,268	$84,036,021
Palliative care	$9,590,639	$801,573	$762,176	$11,154,388
Other subacute / non-acute care	$13,624,634	$2,690,745	$790,704	$17,106,083
Outpatient services				
General practitioner	$2,631,416	$260,452	$120,149	$3,012,017
Specialist	$4,998,659	$655,182	$206,264	$5,860,105
Other*	$974,272	$101,575	$41,886	$1,117,732
Total outpatient services	$8,604,347	$1,017,210	$368,298	$9,989,854
Prescription medications	$2,902,905	$183,207	$132,427	$3,218,539
Total excluding aged care	**$324,409,295**	**$42,505,990**	**$11,112,008**	**$378,027,293**
Aged care				
Residential aged care	$5,288,264	$898,511	$524,115	$6,710,890
Transitional care	$1,065,318	$120,401	$12,952	$1,198,670
Home care	$14,574,735	$1,340,142	$832,899	$16,747,775
Total aged care	$20,928,317	$2,359,053	$1,369,965	$24,657,335
Total including aged care	**$345,337,612**	**$44,865,043**	**$12,481,973**	**$402,684,628**

* including allied health and pathology

Costs incurred from stroke onset to three months post-stroke have been included. Aged care costs estimated in this report relate to those who commenced aged care in this period of time and include the provision of aged care services that are provided for a longer duration than three months.

A focus of this report is to illustrate the economic impacts of stroke by age and stroke type, given there are often differing needs according to these characteristics. While total costs provide an indication of how much funding may be required to treat and manage stroke, averages are more meaningful when assessing typical person-level needs after stroke. For example, since there are more ischaemic strokes than intracerebral haemorrhages, total costs of ischaemic stroke were far greater than for intracerebral haemorrhage. However, costs per person for first-ever intracerebral haemorrhages were $43,082, which is greater than those related to a first-ever ischaemic stroke ($36,611) (Figure 14, Table 16, Table 17).

Short-term costs related to first-ever intracerebral haemorrhage were particularly high for those aged under 65 years relative to other groups. For example, average costs of healthcare in the first three months ranged from $43,000 in the youngest age groups to $30,000 in the oldest age groups for ischaemic stroke, and from $70,000 in the youngest age groups to $25,000 in the oldest age groups for intracerebral haemorrhage. Efforts to improve primary prevention and acute treatments in those with intracerebral haemorrhage may be particularly important to reduce the costs associated with stroke. On average, costs of first-ever strokes ($38,729) were estimated to be greater than those of recurrent stroke ($36,621). Greater detail on age-specific costs for first-ever strokes and recurrent strokes are shown separately in the supplementary results (Supplementary Table 7, Supplementary Table 8, Supplementary Table 9).

Figure 14 Short-term average costs for strokes occurring in 2023

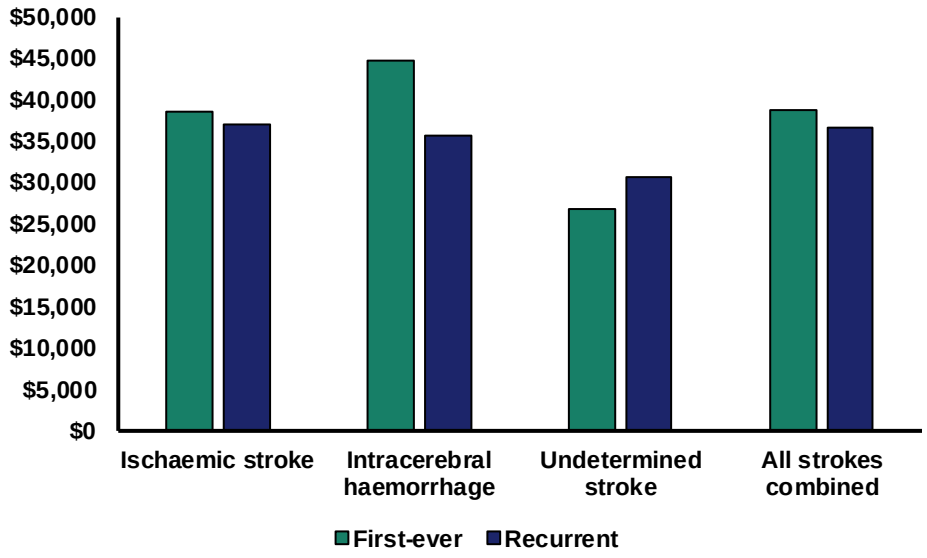


Table 16 Short-term average costs for first-ever strokes occurring in 2023

Age group	Ischaemic stroke	Intracerebral haemorrhage	Undetermined stroke
<65 years	$43,032	$70,503	$19,645
65-69 years	$37,675	$49,519	$44,653
70-74 years	$38,038	$49,837	$45,113
75-79 years	$39,319	$35,944	$25,967
80-84 years	$39,514	$34,141	$26,656
85+ years	$34,036	$29,285	$22,993
All ages	**$38,467**	**$44,697**	**$26,745**

Table 17 Short-term average costs for recurrent strokes occurring in 2023

Age group	Ischaemic stroke	Intracerebral haemorrhage	Undetermined stroke
<65 years	$38,800	$60,955	$22,316
65-69 years	$39,600	$48,606	$39,097
70-74 years	$39,986	$43,623	$39,545
75-79 years	$38,367	$35,226	$29,292
80-84 years	$38,643	$30,640	$29,882
85+ years	$33,087	$26,070	$29,840
All ages	**$37,024**	**$35,617**	**$30,451**

5.2.1 Ambulance Services

Typically, patients with stroke arrive to hospital using road ambulance services. In 2023, these costs were estimated to be over $54 million ($1,681 per transfer). For patients with stroke who first present to a hospital in a regional or rural area, transfers to other hospitals may be arranged where relevant, including transfers by air ambulances to hospitals in metropolitan areas for acute treatments.

Costs of air ambulance transfers were estimated separately and do not affect other outputs from the modelling in this report. In Victoria, New South Wales, and Tasmania, these costs were estimated by

extrapolating data from Ambulance Victoria (obtained for a stroke cohort) and populations within these states and territories. We estimated there would be 494 air ambulance transports per year in these states, with 49 of these being by fixed wing (10%), costing a total of $19,012,658. No air ambulance transfers were estimated for the Australian Capital Territory due to the close proximity of populations by road to around-the-clock endovascular thrombectomy services in Canberra.

The cost of air ambulance transfers related to stroke in other states and territories (Queensland, Northern Territory, Western Australia and South Australia) was estimated using data from the Royal Flying Doctor Service.[47-50] Based on flight distances, we assumed that there were 227 rotary wing transports, and 683 fixed wing transports provided by the Royal Flying Doctor Service per year ($6,896,734 for rotary wing aircraft and $10,172,056 for fixed wing aircraft). Further details of calculations are provided in the appendix (page 92).

In total, air ambulance transfers were estimated to cost $36,081,448. This is likely to be an under-estimate since only services related to aeromedical transfers to hospital were estimated and there are often costs related to transferring patients back to their residence. Costs related to other providers of air ambulance transport were not estimated in this report due to limited data.

5.2.2 Emergency department, acute admissions and subacute Care

After arriving to hospital, patients with stroke are usually assessed in the emergency department. Scans and tests are provided in order to determine the type of stroke and the most appropriate course of treatment after stroke (such as thrombolysis and endovascular thrombectomy). Patients may then be admitted to hospital and receive treatment in a stroke unit (a dedicated ward for the treatment of stroke with healthcare professionals who have expertise in caring for patients with stroke). Patients may then receive subacute care, including palliative care or rehabilitation as an inpatient.

Costs related to providing care in an emergency department and during the acute admission for stroke totalled over $1 billion, making up over 60% of total short-term costs after a stroke (Figure 15, Figure 16). While in hospital, 11% of patients incurred costs related to treatment in an intensive care unit during their acute admission (data not shown). Those who received treatment in an intensive care unit had hospital costs exceeding $43,000 per person (with over $17,000 related to the intensive care unit alone).

Costs related to inpatient rehabilitation were also substantial at over $350 million or almost one quarter of total costs incurred in the short-term after stroke. Costs related to palliative care, other subacute care and non-acute care were relatively small compared to other hospital costs, making up approximately 7% of total short-term costs. Inputs related to these costs were obtained from the Australian Stroke Clinical Registry dataset on patients admitted to stroke in 2018 linked to Victorian hospital administrative datasets (inflated to the 2023 equivalent).

While there are differences in acute stroke care systems between states and territories, the model inputs we used were similar to the costs reported for almost 4,000 patients admitted from 22 hospitals in Queensland between 2009 and 2013.[44] The median cost of an acute episode was $11,006 for intracerebral haemorrhage and $10,214 for ischaemic stroke in Queensland, and patients treated in a stroke unit had a greater median total cost when compared to those who were not ($9,388 vs $5,151), as did patients with ischaemic stroke who were provided thrombolysis when compared to those who were not ($12,425 vs $9,886). In the Victorian dataset analysed for this report, average costs related to a patient treated with thrombolysis were approximately $15,000 for non-fatal ischaemic strokes and $11,000 for fatal ischaemic strokes. The costs related to a hospital admission for a patient provided endovascular thrombectomy that we obtained from analysis of the Victorian dataset were approximately $27,000 greater than those treated with thrombolysis. These costs aligned with those reported in 2016 Australian dollars in which Arora et al (2018) estimated costs of the procedure alone were over $18,000 (not including costs of admission).[51]

Figure 15. Distribution of short-term costs after first-ever stroke

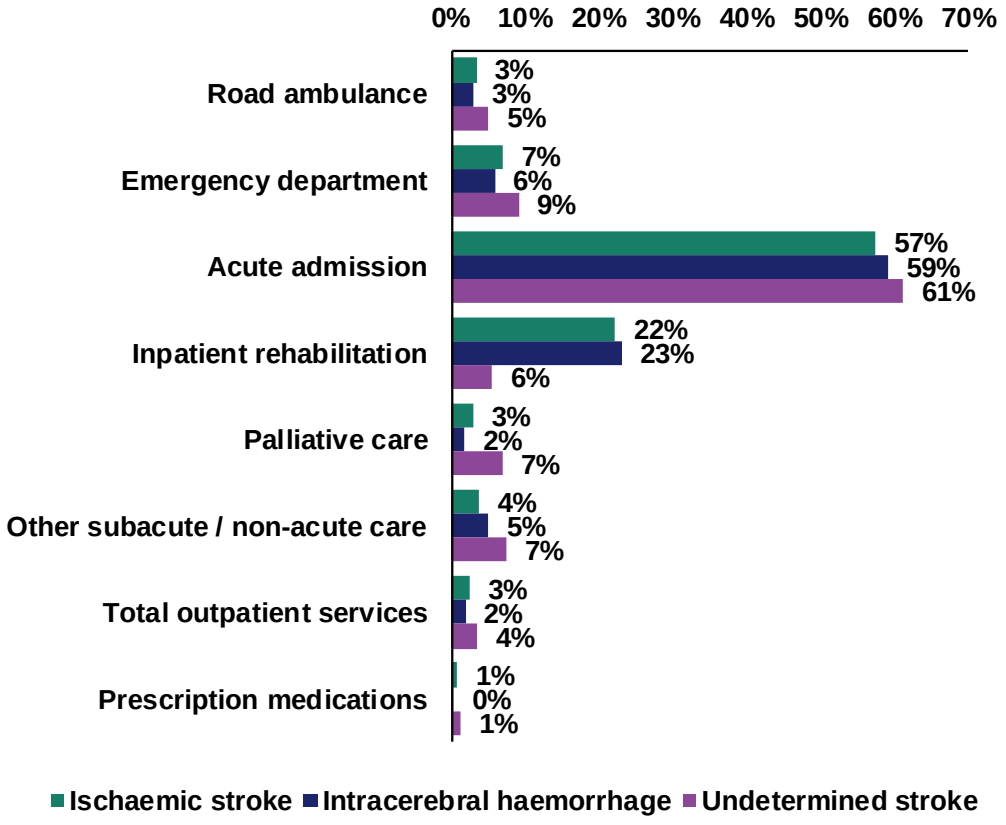
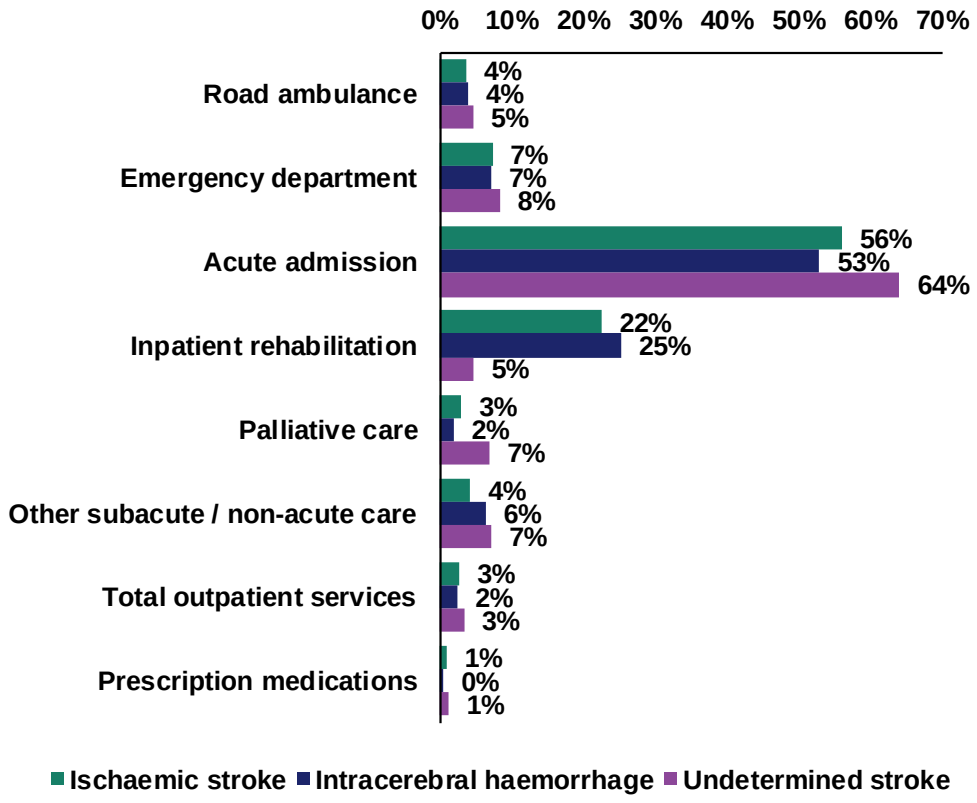


Figure 16. Distribution of short-term costs after recurrent stroke



5.2.3 Outpatient care

Following discharge from hospital, outpatient services (e.g. those related to general practitioners, specialists and allied health professionals) are accessed by patients with stroke to reduce their risk of recurrent strokes and for further rehabilitation. **These costs were relatively small compared to other costs, making up 2% of total short-term costs (over $39 million for first-ever and recurrent strokes combined**). Secondary prevention medications dispensed through the **Pharmaceutical Benefits Schedule cost over $12 million in the short-term after stroke**. Given our datasets relied on data from government-held administrative datasets, the costs related to outpatient services included in this report are limited to those provided with funding from the Australian Government. Privately purchased goods and services (e.g. rehabilitation accessed without a Medicare claim, or co-payments) and state-funded community health services have not been estimated.

5.2.4 Aged care services

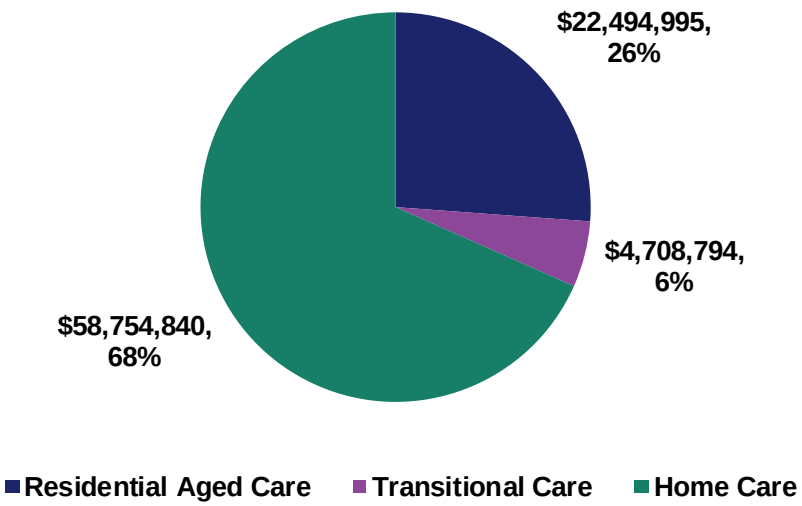
Residential aged care is generally provided to older people who can no longer live at home due to disabilities, while in-home aged care services are provided to older people who need assistance in order to continue living at home. There are three major types of aged care: residential aged care (accommodation in an aged care facility with constant care for those who can no longer live at home); transitional care services (temporary

care arrangements in aged care facilities or at home to support patients living at home); and home care (some support with activities of daily living from aged care services to live independently at home).

Costs of aged care were estimated to be over $85 million after stroke, **with home care costing $58 million, residential aged care costing $22 million** and **transitional care costing almost $5 million** (Figure 17). Per person, $6,475 was spent on aged care services after a stroke ($2,204 on residential aged care, $238 on transitional care services, and $4,033 on home care).

While aged care services may commence in the short-term after stroke, residential aged care and home care are provided for more than two years post-stroke for many patients (data not shown). Costs of aged care were only based on daily service fees[52] ($61.96 for residential aged care and transitional care services, and $27.45 for home care) and only new entries into residential aged care after stroke were costed due to limitations with the data. Therefore, costs related to residential aged care after a stroke are likely to be considerably higher than those presented in this report. Furthermore, costs related to aids, equipment and home modifications were not estimated. These may be provided through home care packages but also paid out of pocket. While some of these items may be expensive, these costs are likely to be relatively small compared to other costs. As reported in a trial of rehabilitation,[53] fewer than 5% of patients with stroke in Australia reported these types of costs. In the North East Melbourne Stroke Incidence Study, out of pocket costs which included aids, equipment and home modifications were 3.2% of total first year costs.[54] Annual costs over 10 years were 1.29% of total costs for people who had an ischaemic stroke, and 3.22% for those who had an intracerebral haemorrhage.[55]

Figure 17. Costs of aged care services after stroke



5.3 Long-term costs

Beyond the first three months, total costs for people with stroke in 2023 were estimated to be over $14 billion. The majority of these costs were incurred by ischaemic strokes (over $12 billion) (Table 18). The costs included almost $4 billion in healthcare costs, with approximately three quarters of these costs related to hospital services. Costs related to lost productivity were greater than the costs related to healthcare, at an estimate of over $6 billion. Although we assumed employment impacts were only incurred for those of typical working ages (18 to 67 years), almost $3 billion was lost due to employment impacts, and over $3 billion was lost due to household productivity impacts. Costs of informal care provided over a lifetime were almost $4 billion. These costs are described in further detail in the following sections of the report.

Table 18 Long-term costs for first-ever and recurrent strokes combined

	Ischaemic stroke	Intracerebral haemorrhage	Undetermined stroke	Combined
Healthcare	$3,419,941,414	$389,343,684	$129,217,158	$3,938,502,256
Road ambulance	$295,125,345	$33,375,220	$12,511,828	$341,012,393
Hospital	$2,508,336,957	$297,404,284	$93,631,444	$2,899,372,685
Outpatient services	$366,182,755	$39,578,823	$14,411,380	$420,172,958
Medications	$250,296,357	$18,985,358	$8,662,505	$277,944,221
Productivity				
Employment	$2,407,736,804	$444,868,757	$69,163,172	$2,921,768,733
Household	$2,964,174,204	$308,727,386	$102,169,227	$3,375,070,818
Informal care	$3,434,230,590	$329,884,201	$106,986,070	$3,871,100,861
Total	**$12,226,083,012**	**$1,472,824,028**	**$407,535,628**	**$14,106,442,668**

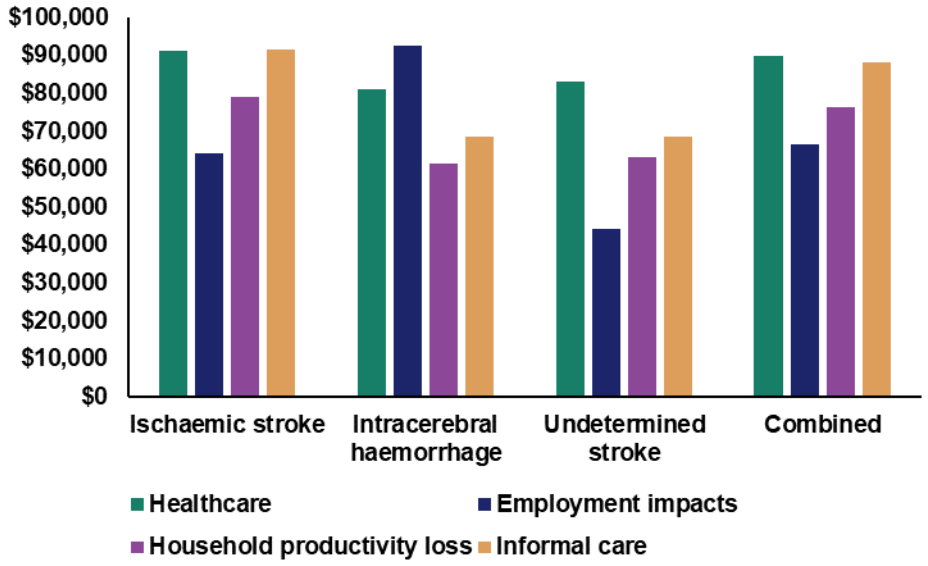
Among those who experienced a stroke in 2023, costs beyond the first three months were estimated to be over $320,000 per person (Table 19), with $89,592 in healthcare costs, $66,464 in costs related to employment, $76,398 in costs related to household productivity, and $88,059 in costs of informal care (Figure 18). Average costs were greatest for ischaemic stroke ($325,231), followed by intracerebral haemorrhage ($306,213) and undetermined stroke ($261,470). On average, the costs of healthcare were greater than costs related to employment for those with ischaemic stroke and undetermined stroke. However, for those with intracerebral haemorrhage, the average costs related to employment ($92,492) were estimated to be greater than costs of healthcare ($80,948). Equivalent costs for first-ever strokes and recurrent strokes are shown separately in the supplementary results (Supplementary Table 10 – Supplementary Table 13).

Table 19 Long-term costs per person for first-ever and recurrent strokes combined

	Ischaemic stroke	Intracerebral haemorrhage	Undetermined stroke	Combined
Healthcare	$90,975	$80,948	$82,904	$89,592
Road ambulance	$7,851	$6,939	$8,027	$7,757
Hospital	$66,725	$61,833	$60,073	$65,954
Outpatient services	$9,741	$8,229	$9,246	$9,558
Medications	$6,658	$3,947	$5,558	$6,323
Productivity				
Employment*	$64,049	$92,492	$44,374	$66,464
Household	$78,858	$61,498	$63,047	$76,398
Informal care	$91,355	$68,586	$68,641	$88,059
Total long-term costs	**$325,231**	**$306,213**	**$261,470**	**$320,890**

* Averages here include all strokes as a denominator (whereas productivity costs were only estimated for those in the typical working ages of 18-67 years).

Figure 18 Long-term costs per person for first-ever and recurrent strokes combined



Overall costs are comparable to a recent study conducted by Tan et al (2022), in which lifetime costs were modelled for 13,555 cases of stroke among those aged 18–64 years in Australia. Annual costs were applied according to the mRS in a Markov model with transitions in mRS determined by the risk of stroke recurrence. The societal costs estimated for this cohort was $2 billion over 5 years ($149,180 per person). Over 30 years, the societal costs were $3.4 billion ($249,780 per person). The healthcare costs for the under 65 years groups that were estimated using our model were within the ranges in economic modelling of younger adults in Australia,[56] but costs related to productivity losses estimated using our model were considerably higher than in this other study.

5.3.1 Healthcare costs

In the three to twelve months after stroke, an estimated total cost of over $475 million in ongoing hospital and outpatient services, and medications were incurred for first-ever strokes and over $155 million for recurrent strokes (Table 20). Between three months and five years post-stroke, there was an estimated total cost of over $1.5 billion for first-ever strokes and $473 million for recurrent strokes. Costs of healthcare between three months post-stroke until the end of life was over $3.1 billion for first-ever strokes and $789 million for recurrent strokes.

Average costs were greatest for younger age groups, with healthcare costs per person in the 3-12 months post-stroke being $16,272 for those aged under 35 years and $11,759 for those aged 85 and over. Between three months and five years after stroke, an additional $60,000 to $20,000 in healthcare costs per person was estimated, with younger age groups incurring greater costs than older age groups.

Equivalent costs according to stroke type and age are shown separately in the supplementary results (Supplementary Table 14 - Supplementary Table 19).

Table 20 Healthcare costs beyond the first 3 months after stroke

Age group	Total	Average
	3 – 12 months post-stroke	
<65 years	$143,722,222	$15,996
65-69 years	$80,657,143	$16,028
70-74 years	$69,345,926	$15,682
75-79 years	$123,234,964	$14,880
80-84 years	$75,877,049	$14,142
85+ years	$138,889,007	$11,698
All ages	**$631,726,312**	**$14,370**
	3 months – 5 years post-stroke	
<65 years	$535,526,198	$59,602
65-69 years	$295,313,931	$58,682
70-74 years	$253,149,271	$57,247
75-79 years	$432,669,768	$52,242
80-84 years	$238,563,957	$44,462
85+ years	$300,500,887	$25,309
All ages	**$2,055,724,013**	**$46,763**
	3 months post-stroke – end of life	
<65 years	$1,492,714,292	$166,134
65-69 years	$632,344,653	$125,654
70-74 years	$477,042,985	$107,879
75-79 years	$686,963,351	$82,946
80-84 years	$317,154,854	$59,109
85+ years	$332,282,121	$27,986
All ages	**$3,938,502,256**	**$89,592**

5.3.2 Productivity impacts

Patients with stroke are often above the age of retirement, with over 75% of strokes occurring in 2023 in those aged over 65 years. While those in this older cohort are less likely to have paid employment than younger cohorts, they still participate in important activities at home and in the community (e.g. as carers and as volunteer workers). Stroke can lead to significant impairments which may limit a person's participation in these activities. In this report, the impact on these activities were estimated as household productivity losses.

Substantial welfare payments and lost taxation opportunities associated with stroke were estimated previously[19] and may be relevant for certain life stages. However, we were unable to identify appropriate inputs to fit our model structure, so these were not estimated in this report.

It was also not possible to include employment impacts of caregivers (e.g. as done in an economic evaluation of speech and language therapy[57]) because representative data on workforce participation for carers, and data on the number and type of carers for patients with stroke, are needed to support estimates of employment impacts for caregivers. These are areas requiring further research.

Employment impacts

A new Australian productivity measure, the productivity-adjusted life year (PALY)[58] was used to estimate the impacts related to employment over the remaining working lifetime (assumed to be 18 to 67 years of age). Retirement age was assumed to be 67 years in line with the 2023 Australian pension age. The PALY is calculated by multiplying the years of life lived with a productivity index which ranges between 0 (no productivity) and 1.0 (full productivity), meaning one PALY is equal to one year of full productivity. The PALYs estimated in this report were based on missed days from work due to illness (absenteeism), reduced efficiency or productivity while at work due to illness (presenteeism), early retirement or workforce drop-out due to illness (workforce participation), as well as premature mortality.

Over 29,000 PALYs were lost in the patients who had a stroke in 2023 (Table 21), with over two years of full productivity lost per person. Per person who suffered a stroke aged 18-67, there were costs of $206,055 related to employment impacts. The largest total number of PALYs were lost in the 45-49 year age group (6,100 PALYs). On average, the greatest average number of PALYs lost (7.806) and **greatest average cost of productivity loss ($775,277) were in the 25-29 year age group.** Equivalent costs for first-ever strokes and recurrent strokes are shown separately in the supplementary results (Supplementary Table 20, Supplementary Table 21).

Table 21 Long-term total employment impacts for all strokes occurring in 2023

Age group	Total PALYs lost*	Total cost of productivity loss	Average PALYs lost*	Average cost of productivity loss
0-19 years	268	$25,204,851	6.878	$647,147
20-24 years	318	$30,901,154	7.641	$743,125
25-29 years	1,282	$127,285,653	7.806	$775,277
30-34 years	1,279	$132,904,669	7.428	$772,098
35-39 years	4,038	$428,833,101	6.939	$736,846
40-44 years	3,251	$342,837,045	6.208	$654,631
45-49 years	6,100	$624,719,574	5.119	$524,321
50-54 years	4,580	$447,661,606	3.772	$368,630
55-59 years	5,633	$516,198,808	2.271	$208,088
60-64 years	2,132	$173,377,519	0.884	$71,876
65-69 years	91	$4,690,116	0.018	$932
All ages	29,681	$2,921,768,733	2.091	$206,055

* Only over the working lifetime (aged 18-67 years)

Household productivity impacts

Household production was defined as the hours of time spent performing domestic activities, childcare activities, adult care activities and voluntary work. The amount of household production lost was estimated using data from Australia's Time Use Survey published by the Australian Bureau of Statistics (2020-21)[59] using assumptions on hours lost according to age and level of disability.

The types of household productivity (domestic activities, childcare activities, adult care activities) were valued with the replacement cost method, whereby the costs of purchasing these services commercially were used. Hourly prices for the different types of activities were applied.[60] The hourly replacement cost of volunteer work was applied to the amount of time spent performing voluntary work.[61]

Total household productivity loss was estimated to be over $3 billion (Table 22). Over two thirds of the costs associated with household productivity were incurred by those with a first-ever stroke. Costs per person were greatest in the 65-69 year age group (Table 23), which likely indicates the greater household productivity in retirement age. On average, it was estimated that household productivity impacts would be greater for patients with recurrent stroke than those with a first-ever stroke of the equivalent age. For example, in the 65-69 year age group, the average cost was $89,623 for first-ever strokes, $110,702 for recurrent strokes, and $94,307 for first-ever strokes and recurrent strokes combined. Household productivity impacts were the lowest for those who were in the oldest groups, likely indicating reduced ability to perform household duties due to disability. For those who were 85 and over, the average cost was $57,236 for first-ever strokes, $58,378 for recurrent strokes, and $57,569 for first-ever strokes and recurrent strokes combined.

Table 22 Total household productivity impacts for strokes occurring in 2023

Age group	Combined Total cost	First-ever Total cost	Recurrent Total cost
<65 years	$734,816,919	$631,740,668	$103,076,251
65-69 years	$474,593,219	$350,793,651	$123,799,567
70-74 years	$385,110,633	$285,555,969	$99,554,664
75-79 years	$704,098,643	$462,656,103	$241,442,540
80-84 years	$392,919,610	$259,363,664	$133,555,946
85+ years	$683,531,795	$481,480,381	$202,051,413
All ages	**$3,375,070,818**	**$2,471,590,438**	**$903,480,380**

Table 23 Average household productivity impacts for strokes occurring in 2023

Age group	Combined Average cost	First-ever Average cost	Recurrent Average cost
<65 years	$81,783	$80,585	$89,975
65-69 years	$94,307	$89,623	$110,702
70-74 years	$87,089	$83,026	$101,310
75-79 years	$85,015	$81,466	$92,757
80-84 years	$73,230	$70,494	$79,200
85+ years	$57,569	$57,236	$58,378
All ages	**$76,775**	**$74,980**	**$82,157**

5.3.3 Informal caregiver impacts

An informal carer is defined as a person most closely involved in helping the person with stroke to live at home (such as a spouse or other member of the family but may be a friend or neighbour). Care provided by an informal carer is different to assistance provided through formal support services.

Informal caregivers may provide assistance with daily activities such as community tasks (e.g. banking and paying bills; errands such as posting letters or making appointments; transport to appointments or social occasions; shopping; and “check-ups”); domestic tasks (e.g. gardening; handyman tasks; grounds and home maintenance; housework such as laundry, cleaning, washing up; supervision of medication; supervision or assistance to walk outside); and personal care tasks (e.g. eating; grooming; bathing; dressing; toilet use; help with incontinence pads; moving from bed to chair or chair to chair; walking inside the house including stairs). The work of informal caregivers may be critical to someone with impairments after stroke so that they can continue living in private accommodation.

Total costs related to informal caregiver impacts were almost $4 billion (Table 24). Costs per person were greatest in lower age groups (Table 25), with those aged under 65 years incurring $159,860 on average and those aged 85 and over incurring $26,516 on average. This reflects the longer lifespan of younger patients with stroke relative to older counterparts, and ongoing support needs after stroke. For first-ever strokes, the average cost was $90,865 for first-ever strokes, $79,647 for recurrent strokes, and $88,059 for first-ever strokes and recurrent strokes combined.

Table 24 Total informal caregiver impacts for strokes occurring in 2023

Age group	Combined Total cost	First-ever Total cost	Recurrent Total cost
<65 years	$1,436,343,475	$1,254,017,339	$182,326,136
65-69 years	$616,933,779	$469,602,287	$147,331,492
70-74 years	$462,712,606	$352,168,033	$110,544,573
75-79 years	$716,433,332	$482,044,526	$234,388,806
80-84 years	$323,840,332	$216,452,983	$107,387,350
85+ years	$314,837,336	$220,939,937	$93,897,399
All ages	**$3,871,100,861**	**$2,995,225,104**	**$875,875,757**

Table 25 Average informal caregiver impacts for strokes occurring in 2023

Age group	Combined Total cost	First-ever Total cost	Recurrent Total cost
<65 years	$159,860	$159,964	$159,151
65-69 years	$122,592	$119,977	$131,744
70-74 years	$104,638	$102,394	$112,494
75-79 years	$86,504	$84,880	$90,048
80-84 years	$60,355	$58,831	$63,682
85+ years	$26,516	$26,264	$27,130
All ages	**$88,059**	**$90,865**	**$79,647**

6. Wellbeing impacts

The wellbeing impacts related to stroke estimated in this report included impacts on the quality of life and the length of life lived, expressed in disability adjusted life years (DALYs). DALYs are a commonly used summary measure of population health combining years of life lost due to early death and years of remaining life lived with disability. One DALY is the equivalent of the loss of one year of life in full health.

For our estimate of DALYs, we followed incident events in a calendar year, counting all premature mortality after stroke, and we did not adjust disability for other pre-existing comorbidities. While disability and mortality in survivors of stroke may not be due to the stroke itself, it was important to take this approach to demonstrate the impacts on wellbeing after stroke over the same time horizon as the costs of stroke, and because the economic impacts and health benefits of programs modelled would be underestimated by looking only in the short-term.

Different to previous research conducted, and to be consistent with the estimates of costs, we took the approach of estimating death and disability associated with stroke over a lifetime for strokes occurring in 2023. In the Australian Burden of Disease Study,[55] estimates of disability associated with stroke were adjusted for comorbidity and were applied to prevalent strokes (all patients living with stroke) at a particular point in time. The years of life lost (YLL) estimated in the Australian Burden of Disease Study were also more conservative because they were based on fatal strokes only. The approach taken for this report was also different to the prevalence approach taken in previous reports commissioned by Stroke Foundation.[19] Previously, all prevalent strokes were included for estimates of years of life lived with disability (YLD) and it was assumed that there would be no asymptomatic strokes. Subsequently, disability weights were applied according to the expected numbers of people with stroke and their expected level of disability to calculate YLD, and YLL was calculated based on life expectancy at the time of death due to stroke (i.e. fatal stroke).

According to the Australian Burden of Disease study,[62] the total number of DALYs due to stroke have reduced by 52.8% since 2013. **While stroke remains one of the leading causes of premature death and disability, it has gone from the third greatest contributor of DALYs in 2003, to now the fourteenth greatest contributor in 2023. This remarkable decline is a testament to the several developments in acute stroke care since the early 2000s.**

Key findings

- Premature death and disability due to a condition are often expressed in disability adjusted life years (DALYs). Impairments from stroke can remain in the long-term after stroke. Over a lifetime after stroke, there were 215,251 DALYs associated with stroke (47,693 years of life lived with disability and 167,558 years of life lost).

- Ischaemic stroke contributed 85% of the total DALYs associated with stroke. Intracerebral haemorrhage contributed 8% of the total years of life lived with disability and 13% of the total years of life lost.
- On average, patients with intracerebral haemorrhage were estimated to have the worst outcome after stroke (5.5 DALYs for first-ever intracerebral haemorrhage and 5.4 DALYs for recurrent intracerebral haemorrhage). Unlike after intracerebral haemorrhage, those who had a first-ever ischaemic stroke had better outcomes than those who had a recurrent ischaemic stroke (4.8 DALYs for first-ever ischaemic stroke and 5.0 DALYs for recurrent ischaemic stroke).

In 2023, there were 215,251 DALYs associated with stroke over a lifetime (47,693 years of life lived with disability and 167,558 years of life lost) (Table 26). Ischaemic stroke contributed 85% of the total DALYs associated with stroke. Intracerebral haemorrhage contributed 8% of the total years of life lived with disability and 13% of the total years of life lost (Figure 19), indicating the greater mortality after intracerebral haemorrhage compared to other types of stroke. Approximately a third of all DALYs associated with stroke were in those aged under 65 years.

Figure 19. Total years of life lived with disability and years of life lost by stroke type

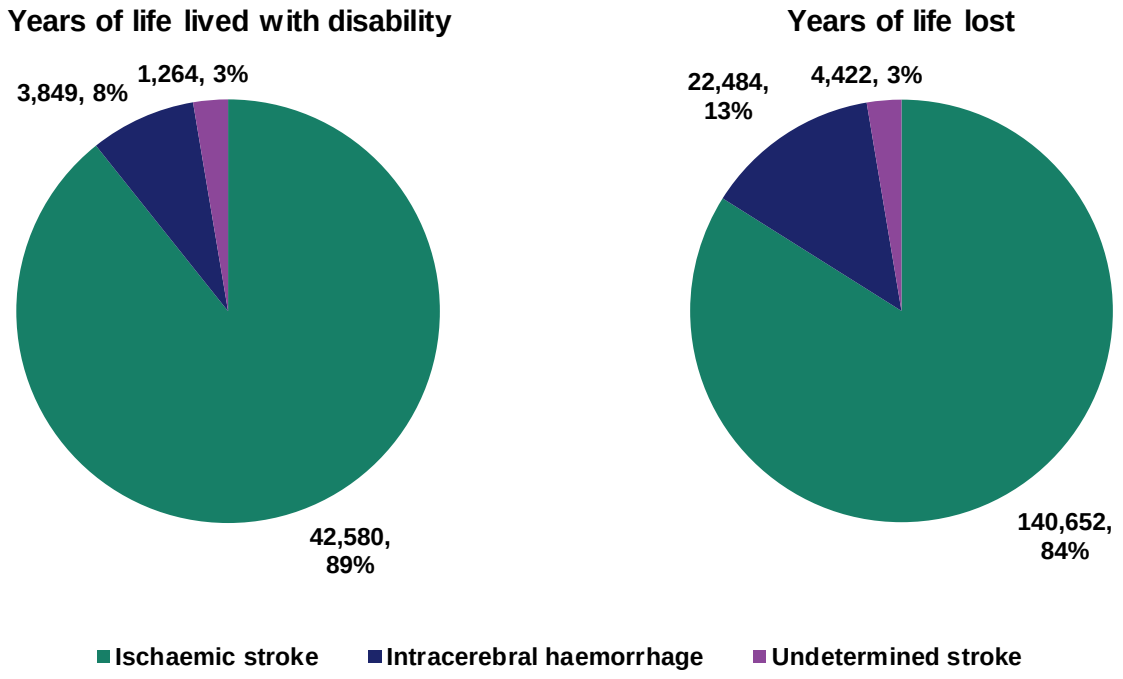
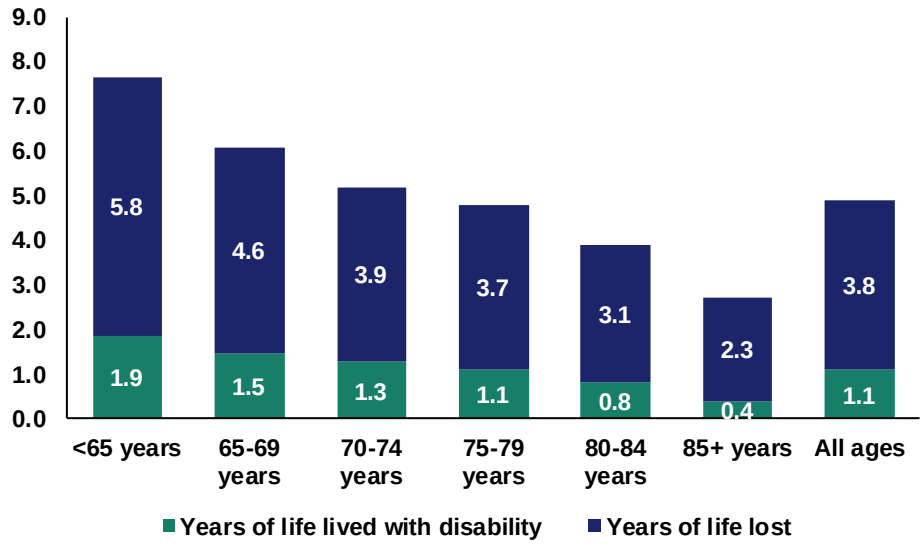


Table 26 Total years of life lived with disability and years of life lost after stroke

Age group	Ischaemic stroke	Intracerebral haemorrhage	Undetermined stroke	Total
		Years of life lived with disability		
<65 years	14,611	1,639	387	16,637
65-69 years	7,090	150	137	7,377
70-74 years	5,370	112	105	5,587
75-79 years	7,673	1,242	250	9,165
80-84 years	3,649	521	121	4,291
85+ years	4,188	184	263	4,635
All ages	42,580	3,849	1264	47,693
		Years of life lost		
<65 years	43,552	7,288	532	52,067
65-69 years	22,075	747	247	23,266
70-74 years	16,452	568	183	17,331
75-79 years	22,360	7,601	430	30,592
80-84 years	11,931	4,297	214	16,552
85+ years	24,281	1,986	564	27,751
All ages	140,652	22,484	2170	167,558
		Disability adjusted life years		
<65 years	58,163	8,927	919	68,704
65-69 years	29,165	897	384	30,643
70-74 years	21,822	680	288	22,918
75-79 years	30,033	8,843	680	39,757
80-84 years	15,580	4,818	335	20,843
85+ years	28,469	2,170	827	32,386
All ages	183,232	26,333	3434	215,251

On average after stroke a person was estimated to live the equivalent of 1.1 years of healthy life and have lost 3.8 years of life (Figure 20, Table 27). Those aged under 65 years were estimated to live the equivalent of 1.9 years of healthy life (e.g. lived 3.8 years of life at 50% of perfect health or 1.9 years of life in perfect health) and have 5.8 years of life lost on average. As expected, these estimates decreased with age, and those aged 85 and over were estimated to live the equivalent of 0.4 years of healthy life and have 2.3 years of life lost on average. On average, patients with intracerebral haemorrhage were estimated to have the worst outcome after stroke (5.5 DALYs for first-ever intracerebral haemorrhage and 5.4 DALYs for recurrent intracerebral haemorrhage). Unlike after intracerebral haemorrhage, those who had a first-ever ischaemic stroke had better outcomes than those who had a recurrent ischaemic stroke (4.8 DALYs for first-ever ischaemic stroke and 5.0 DALYs for recurrent ischaemic stroke).

Figure 20. Average years of life lived with disability and years of life lost by age



The outputs from our model related to life expectancy after stroke were similar to those reported in a recent study conducted in Australia and New Zealand by Peng et al[63] that involved 313,162 patients admitted with a coded diagnosis of stroke between 2008 and 2017. In this other study, the loss in life expectancy was estimated as the difference in the observed survival between the patients who had a stroke and the expected survival in the general population (matched on age, sex, year, and region). Similar to the outputs from our model, the greatest average years of life lost were observed for younger age groups (although a smaller proportion of life expectancy was lost). There were 5.0 years of life lost after ischaemic stroke, 7.4 after intracerebral haemorrhage, and 4.5 after undetermined stroke in the study conducted by Peng et al,[63] whereas we estimated 3.7 years of life lost after ischaemic stroke, over 4.7 after intracerebral haemorrhage, and over 2.8 years after undetermined stroke.

Table 27 Average years of life lived with disability and years of life lost after stroke

	Ischaemic stroke		Intracerebral haemorrhage		Undetermined stroke	
Age group	First-ever	Recurrent	First-ever	Recurrent	First-ever	Recurrent
Years of life lived with disability						
<65 years	1.9	2.0	1.5	1.6	1.7	1.7
65-69 years	1.4	1.7	1.1	1.1	1.0	1.4
70-74 years	1.2	1.5	0.9	1.0	0.9	1.2
75-79 years	1.2	1.3	0.7	0.8	1.0	1.1
80-84 years	0.8	1.0	0.5	0.5	0.7	0.9
85+ years	0.4	0.4	0.2	0.3	0.3	0.5
All ages	1.1	1.1	0.8	0.7	0.8	0.9
Years of life lost						
<65 years	5.6	6.3	6.6	7.9	5.3	6.7
65-69 years	4.3	5.6	5.1	6.2	3.0	5.2
70-74 years	3.7	4.8	4.4	5.5	2.3	4.3
75-79 years	3.3	4.1	4.4	4.8	2.2	3.5
80-84 years	2.7	3.2	3.8	4.2	1.8	2.8
85+ years	2.3	2.4	2.8	2.8	2.2	2.0
All ages	3.7	3.9	4.7	4.7	2.8	3.1
Disability adjusted life years						
<65 years	7.5	8.2	8.1	9.5	7.0	8.4
65-69 years	5.8	7.3	6.2	7.3	4.0	6.6
70-74 years	4.9	6.3	5.3	6.4	3.2	5.5
75-79 years	4.4	5.4	5.1	5.6	3.2	4.7
80-84 years	3.6	4.2	4.3	4.7	2.5	3.6
85+ years	2.7	2.8	3.1	3.1	2.5	2.5
All ages	4.8	5.0	5.5	5.4	3.5	3.9

7. Costs and benefits of programs to prevent stroke, save lives and enhanced recovery

The models used to estimate the cost and wellbeing impacts over a lifetime after stroke were also used to estimate the effects of improving the provision of evidence-based therapies compared to current standards of care. Four programs (each related to different types of treatment) were selected by Stroke Foundation for modelling. These are described in sequence in this chapter of the report. The economic impacts and health benefits of the programs selected for modelling were estimated over a lifetime to ensure consistency of outputs between chapters of this report, and because the economic impacts and health benefits would be underestimated by looking only at the short-term impacts after stroke since stroke has long-term impacts.

Key findings

- Substantial benefits are achievable from improving the provision of evidence-based therapies provided in hospital to the standards according to 30/60/90 National Stroke Targets, with 4,085 DALYs avoided. The additional costs of providing acute care ($24,274,708) were offset by savings from improving employment; improving household productivity; reducing informal care, with savings totalling over $26 million. Activities required to support the achievement of 30/60/90 National Stroke Targets were estimated to cost almost $4 million. This cost included Stroke Unit Certification and additional employment of Stroke Care Coordinators in hospitals as recommended by the Australian Stroke Coalition.
- The potential benefits from the prevention of stroke are also substantial. High blood pressure (also known as hypertension) is the number one risk factor for stroke. When estimating the effects of reducing uncontrolled blood pressure according to targets for 2030 set by the National Hypertension Taskforce, it was estimated that 838 first-ever strokes and the 4,061 DALYs associated with these strokes would be avoided. Expected savings from preventing these strokes were over $315 million.
- Modest benefits were expected from improving the use of antihypertensive medications for preventing recurrent stroke. In 2023, 130 recurrent stroke events could be prevented, and savings of over $9 million could be achieved from further improving adherence to these medications, with a relatively small additional cost to provide medications.
- Supporting recovery and rehabilitation after stroke to reduce impairments from stroke were also estimated. In a scenario where additional patients were able to access outpatient rehabilitation services, it was estimated that 3,296 DALYs could be avoided. The total additional therapist costs of providing rehabilitation (over $4 million), and an additional $9 million in healthcare costs over a lifetime were offset with large savings from improved productivity and reduced informal caregiver burden. An overall saving of over $118 million was estimated.

7.1 Estimating effects of achieving National Stroke Targets

The costs and benefits of achieving the 30/60/90 National Stroke Targets were modelled for the Australian population who had a stroke in 2023. A scenario where the National Stroke Targets were achieved was compared to a scenario with current performance related to these targets observed in the Australian Stroke Clinical Registry (Table 28). Further details of the Australian Stroke Clinical Registry are provided in the appendix (page 91). While data from the National Stroke Audit[13] may be more representative than data from the Australian Stroke Clinical Registry, it was not used because of limitations with the availability of data on treatment with endovascular thrombectomy and outcomes after discharge from hospital. Data from the Australian Stroke Clinical Registry is likely to be an overestimation of current provision of evidence-based treatments. Therefore, it is likely that the health and economic impacts from improving provision of treatments have been underestimated.

Table 28 National Stroke Targets compared to current performance

Target	Current performance	Improvement in treatment
Median endovascular clot retrieval door to puncture time <30mins for transfers	40 minutes	10 minutes saved per person treated
Median thrombolysis door to needle time <60mins	74 minutes	14 minutes saved per person treated
Median door in door out time for endovascular clot retrieval <60mins (for transfers)	124 minutes	64 minutes saved per person treated
Median endovascular clot retrieval door to puncture time <90mins for primary presenters	115 minutes	25 minutes saved per person treated
Certified stroke unit care provided to >90% of patients with primary stroke diagnosis	75%	15% greater proportion treated

Treatment effects

The numbers of patients treated with thrombolysis and endovascular thrombectomy were based on the estimated numbers of ischaemic stroke events and the proportions of patients with ischaemic stroke that were treated with thrombolysis and endovascular thrombectomy as observed in the Australian Stroke Clinical Registry. For the provision of reperfusion therapies, the time savings from achieving the 30/60/90 National Stroke Targets were applied per person treated. For each minute of treatment time saved with thrombolysis, 1.8 additional days of healthy life were applied (0.0049 DALYs avoided).[64] For each minute of treatment time saved with endovascular clot retrieval, 4.2 additional days of healthy life were applied (0.0115 DALYs avoided).[65] As observed in the Australian Stroke Clinical Registry we assumed that 45% of patients receiving endovascular thrombectomy were transferred, and that the remaining 55% of patients were primary

presenters.[9] Unlike in the previous edition of this report,[19] additional proportions of patients receiving reperfusion therapies were not modelled.

The additional number of patients treated in certified stroke units was estimated by improving the proportions of patients treated in a stroke unit (by age, stroke type, fatal stroke status and recurrent stroke status) as observed in the Australian Stroke Clinical Registry to 90%. A 25% reduced risk of death or dependency was applied to the additional numbers of patients treated,[6] redistributing mRS scores from mRS>2 (death or dependency) to mRS 0-2 (independent) at 90 days post-stroke.

Costs included

Costs included were those related to shifting from care on a general ward to care on a stroke unit. For the additional numbers of patients treated in a stroke unit, the acute hospital cost differences between treatment in a stroke unit and treatment in a general ward were applied (from analysis of data from the Australian Stroke Clinical Registry linked to Victorian hospital administrative databases). Since the 30/60/90 National Stroke Targets do not include additional treatment with reperfusion therapies, no costs specifically related to achieving the targets related to thrombolysis and endovascular thrombectomy were applied. However, we assumed that reducing time to treatment would be attributed to two major activities required to achieve the National Stroke Targets: Stroke Unit Certification and the employment of Stroke Care Coordinators in hospitals (who are required to implement and coordinate use of pathways and processes leading to timely care of patients with acute stroke).

Cost and wellbeing impacts

With achievement of the 30/60/90 National Stroke Targets, over 4000 DALYs were estimated to be avoided (Table 29).

Over half of the DALYs avoided were from the additional numbers of patients treated in a stroke unit. There were 207 DALYs avoided from over 40,000 minutes saved from faster provision of thrombolysis, and there were 1788 DALYs avoided from over 155,000 minutes saved from faster provision of endovascular thrombectomy.

Over $26 million in savings were estimated over a lifetime after a stroke with the improvements in provision of acute care (Table 30). There were marginal increases in costs related to healthcare services over a lifetime after stroke. These costs of healthcare services were offset by over $23 million in savings from reducing employment impacts; almost $20 million in savings from improving household productivity; and over $7 million in savings from reduced informal care.

Table 29 Improvements in outcomes from achieving National Stroke Targets in 2023

Target	Number of minutes saved	DALYs avoided
Median endovascular clot retrieval door to puncture time <30mins for transfers	14,956	172
Median thrombolysis door to needle time <60mins	41,869	206
Median door in door out time for endovascular clot retrieval <60mins	95,717	1,101
Median endovascular clot retrieval door to puncture time <90mins for primary presenters	44,807	516
Certified stroke unit care provided to >90% of patients with primary stroke diagnosis	N/A	2,090
Total	197,349	4,086

These are lifetime impacts expected for the strokes that occur in any one year.

Table 30 Economic impacts of achieving National Stroke Targets in 2023

	Before	After	Change
Healthcare	$5,617,840,194	$5,642,114,902	$24,274,708
Road ambulance	$395,423,148	$396,420,858	$997,710
Hospital	$4,319,795,084	$4,340,990,887	$21,195,803
Outpatient services	$459,976,603	$462,629,623	$2,653,020
Medications	$290,826,340	$292,550,157	$1,723,817
Aged care	$151,819,019	$149,523,377	-$2,295,642
Productivity			
Employment	$2,921,768,733	$2,898,530,265	-$23,238,468
Household productivity	$3,375,070,818	$3,355,261,628	-$19,809,190
Informal care	$3,871,100,861	$3,863,800,602	-$7,300,258
Total	$15,785,780,605	$15,759,707,397	-$26,073,208

These are lifetime economic impacts expected for the strokes that occur in any one year.

Activities required to support achievement of National Stroke Targets

The cost savings estimated outweighed the costs of major activities required to achieve the 30/60/90 National Stroke Targets (total cost of $3,868,590).

Stroke Unit Certification, which is required to increase access to certified stroke unit care in Australian hospitals, is an established national priority, with evidence of effectiveness from similar programs internationally. Australian hospitals with acute stroke services expected to complete the Australian Stroke Coalition Stroke Unit Certification process were estimated using data from the National Stroke Audit.[66] It was assumed that 93 hospitals (admitting over 75 patients with stroke per year) would require Stroke Unit Certification, with 74 hospitals yet to complete the certification process. A $4,000 cost of the certification process (based on a cost recovery model) was applied per hospital. A $2,000 cost of re-certification every

four years was also applied to 10% of sites that are predicted to require two attempts for the certification process. Assistance with ward rounds in the style of the Victorian Telestroke Inpatient Service are expected to be required for small and medium-sized regional hospitals (34 hospitals in inner regional and outer regional hospitals admitting fewer than 150 patients each per year).

Estimated cost was $296,000 for new certifications, $20,000 for re-certification (10% of all eligible hospitals), and $1,670,114 for additional telemedicine support.

The additional employment of **Stroke Care Coordinators** (or a clinical nurse consultant) required at hospitals treating patients with stroke were estimated using data obtained from the 2021 and 2023 National Stroke Audit Organisational Survey comprising 121 hospitals,[13, 66] and from a national survey whereby non-medical clinical leads in stroke coordinator roles[g] recorded their working arrangements.[67] Utilising different categories of admission volume, we estimated that for 18 hospitals in Australia without a stroke care coordinator or a clinical nurse consultant role, an additional 11.1 full time equivalent (FTE) would be required. In addition, we assumed one 0.5 FTE National Stroke Targets Coordinator would be required to coordinate this initiative at a national level. These roles were priced at $86 per hour pro rata (2023 reference year). There were insufficient data to determine additional FTE required at hospitals with existing stroke care coordinator or clinical nurse consultant roles.

The estimated cost was $1,799,421 for additional Stroke Care Coordinators and $81,055 for a National Stroke Targets Coordinator.

[g] The coordinator role was defined as any “nonphysician in a formal or informally recognised clinical leadership position for stroke, with involvement in overseeing the clinical organisation for stroke services or providing support for ensuring the quality of stroke care delivered". Details of FTE are provided in the appendix.

7.2 Estimating effects of reducing uncontrolled hypertension – primary prevention

Hypertension (also called high blood pressure) is the number one risk factor for stroke and is the leading preventable cause of death in Australia. High blood pressure contributes to over 25,000 deaths annually from its attribution to various chronic conditions including stroke, heart disease, kidney disease, heart failure, atrial fibrillation and dementia.[68-70] Therefore, the prevention, detection and treatment of hypertension is critical to reducing premature death and disability, and its economic impact on individuals, employers, and government.

In this section of the report, we estimated the costs and benefits of preventing first-ever strokes (primary prevention) by modelling a reduction in the proportion of people with uncontrolled hypertension in Australia. A scenario in which National Hypertension Taskforce goals related to controlled hypertension were achieved[5] was compared to a scenario where the current proportions of people with controlled hypertension in Australia was unchanged. The National Hypertension Taskforce's goal is to increase the proportion of people with controlled hypertension from the current 32% to 70% by 2030.

Treatment effects

The numbers of first-ever ischaemic stroke and intracerebral haemorrhage that would be prevented in 2023 from improving current control of hypertension were estimated by using population attributable risks from the INTERSTROKE study.[2] Population attributable risks indicate the proportion of events that could be avoided if the risk factor was controlled. Almost 90% of the population attributable risks were related to 10 modifiable risk factors, with population attributable risks related to hypertension being 41.3% (31.1% to 52.3%) for ischaemic stroke, and 25.2% (5.9% to 64.6%) for intracerebral haemorrhage. These population attributable risks were assumed to apply for uncontrolled hypertension, using the following formula by Ezzati et al:[71]

The following calculation was used: $PAR = [P(E) \times (RR - 1)] / [P(E) \times (RR - 1) + 1]$, where PAR is the population attributable risk, P(E) is the prevalence of exposure to the risk factor in the population, and RR is the relative risk of disease associated with exposure to the risk factor.

The proportion of adults with hypertension in the general population was 56.1% in the INTERSTROKE study (average age 62 years),[2] similar to proportions of people of equivalent age in the general population in Australia: 44.3% for those aged 55-64 years and 53.2% for those aged 65-74 years.[72] Of those with hypertension, 68% were assumed to have uncontrolled hypertension (32% controlled hypertension).

Next, an adjusted population attributable risk with increased hypertension control was calculated after reducing the prevalence of uncontrolled hypertension to 30% (70% controlled hypertension). Lastly, the relative reduction in new strokes occurring in 2023 from the reduction of hypertension was calculated using the relative change in combined population attributable risks (from all 10 modifiable risk factors). This last step was undertaken because, in reality, individuals have more than one risk factor, and while approximately half of patients with stroke have high blood pressure, this is not always the direct cause of stroke. This is

consistent with the concept of 'absolute risk' whereby assessing the combined effect of risk factors is more likely to more accurately classify the risk of a cardiovascular event than looking at individual risk factors (e.g. considering blood pressure alone).

Costs included

Several broad system-level changes are required to improve control of hypertension in the Australian population. Therefore, no costs related to additional prevention, detection and treatment of hypertension were estimated in the modelling undertaken. Reduction in the economic impact of stroke estimated could be used to support major activities to achieve the goals of the National Hypertension Taskforce.[4] These include the following activities:

- Prevention: population-based strategies to improve diet, increase physical activity and maintain healthy body weight.
- Detection: improving screening in primary, secondary and tertiary care, with incentives for primary care; programs for monitoring blood pressure; education; and improving health literacy.
- Diagnosis and treatment including greater adoption of 24-hour blood pressure monitoring and implementation of single pill combination therapy as first-line treatment of hypertension.

Cost and wellbeing impacts

From improving control of hypertension from 32% to 70%, it was estimated that there would be 838 fewer strokes in 2023, corresponding to over 4,000 DALYs avoided (Table 31). The lifetime costs associated with the 838 first-ever strokes prevented were over $315 million (Table 32). There were savings of over $112 million in healthcare costs, with the majority of those costs related to hospital services (over $86 million). There were over $64 million in savings from reducing employment impacts; over $62 million in savings from improving household productivity; and over $76 million in savings from reduced informal care.

Table 31 Improvements in outcomes from the prevention of first-ever stroke by meeting National Hypertension Taskforce targets in 2023

	Before	After	Change
First-ever stroke events	32,963	32,125	-838
Years of life lived with disability	36,165	35,247	-919
Years of life lost	123,973	120,831	-3,142
Disability adjusted life years	160,139	156,078	-4,061

These are lifetime impacts expected for the strokes prevented that would have occurred in any one year.

Table 32 Economic impacts from the prevention of first-ever stroke by meeting National Hypertension Taskforce targets in 2023

	Before	After	Change
Healthcare	$4,425,791,479	$4,313,346,642	-$112,444,837
Road ambulance	$308,762,015	$300,904,203	-$7,857,813
Hospital	$3,405,050,500	$3,318,582,961	-$86,467,539
Outpatient services	$368,227,092	$358,860,023	-$9,367,069
Medications	$233,696,271	$227,748,012	-$5,948,258
Aged care	$110,055,601	$107,251,443	-$2,804,158
Productivity			
Employment	$2,552,699,633	$2,488,079,611	-$64,620,022
Household productivity	$2,471,590,438	$2,408,768,861	-$62,821,576
Informal care	$2,995,225,104	$2,919,120,983	-$76,104,121
Total	$12,445,306,653	$12,129,316,097	-$315,990,556

These are lifetime economic impacts expected for the strokes prevented that would have occurred in any one year.

Significant cost savings could be achieved with the prevention of first-ever strokes from improving the control of hypertension. Importantly, this is just one of many conditions that would be prevented if the goal of the National Hypertension Taskforce was reached. Therefore, our estimates are conservative in terms of the potential overall impact. The economic modelling undertaken assumes that improved blood pressure control is achieved without impacting other risk factors. In reality, interventions that are provided to improve control of hypertension will have collateral effects on the management of other risk factors. For example, medications to lower blood pressure also prevent the onset of heart disease.

7.3 Estimating effects of improving use of antihypertensive medications – secondary prevention

Following a stroke, one of the main healthcare goals is to prevent the onset of a recurrent stroke (secondary prevention). There are several evidence-based therapies to reduce the risk of recurrent stroke. In The Australian and New Zealand Clinical Guidelines for Stroke Management,[73] there is a strong recommendation to initiate or intensify blood pressure lowering with medications in patients with stroke and high blood pressure. Additionally, there is a weak recommendation to continue or initiate blood pressure lowering with medication for patients with stroke who have blood pressure within acceptable ranges. Despite these recommendations, there are data from the Australian Stroke Clinical Registry that one in five patients with stroke depart hospital without these medications.[9] Similarly, in the community-setting post-stroke, 20% discontinue their antihypertensive medication within one year.[74]

In this section of the report, we estimated the costs and benefits of preventing recurrent strokes occurring in 2023 by improving the provision of antihypertensive medications after stroke in Australia. A scenario with increased proportions of patients dispensed and continuing antihypertensive medications was compared to that of current antihypertensive treatment observed in studies of stroke in Australia.

Treatment effects

Proportions of patients dispensed and continuing to use antihypertensive medication in the first year after stroke observed by Dalli et al[74] (Table 33) were improved by a relative 10% increase up to a maximum proportion of 95%. For example, for patients with ischaemic stroke aged 75-84 years, the proportion dispensed antihypertensive medications was increased from 92.20% to 95% and the proportion continuing to use antihypertensive medications was increased from 75.47% to 83.02%.

Table 33 Proportion of patients dispensed and continuing to use antihypertensive medications

Age	Ischaemic stroke		Intracerebral haemorrhage		Undetermined stroke	
	Dispensed	Continued	Dispensed	Continued	Dispensed	Continued
<65 years	75.41%	70.59%	72.09%	65.21%	65.45%	68.33%
65-74 years	88.64%	76.18%	87.16%	75.06%	83.58%	77.38%
75-84 years	92.20%	75.47%	91.68%	72.48%	90.80%	76.65%
85+ years	91.83%	74.26%	86.39%	69.09%	83.33%	74.74%

Source: Additional analysis undertaken in the PRECISE dataset[74]

Fatal first-ever strokes were excluded from these analyses to ensure estimates of medication use and continuation better reflected the population of patients alive and eligible to receive therapy. A 29% reduced risk of recurrent stroke was applied to the additional numbers of patients with first-ever stroke prescribed antihypertensive medications.[75] In order to model the effect of improving treatment in a calendar year, the risk reduction was adjusted by the proportion of patients with a recurrent stroke who had a stroke in the previous twelve months (Table 34).

Table 34 Proportion of patients with a recurrent stroke that had a stroke admission in the prior 12 months.

Age group	Ischaemic stroke	Intracerebral haemorrhage	Undetermined stroke
<65 years	42.35%	35.48%	52.38%
65-74 years	41.63%	53.33%	52.38%
75-84 years	41.19%	42.62%	52.38%
85+ years	39.01%	31.82%	52.38%

Source: Additional analysis undertaken using the AuSCR Victorian data linkage

Costs included

Costs of additional patients dispensed and continuing to use antihypertensive medications over twelve months after stroke ($462.71) were included.[76] This cost reflected typical antihypertensive treatment with an angiotensin-converting enzyme inhibitor and a diuretic, and two general practitioner visits to renew prescriptions.

There are many possible strategies to improve the provision of antihypertensive medications for the secondary prevention of stroke. While specific strategies were not costed in this report, the following may warrant investment with the savings estimated from the prevention of recurrent stroke. These include:

- Implementation of processes at discharge from hospital after stroke to ensure appropriate provision of medications.
- Better follow-up of patients after discharge from hospital, continued focus on improving adherence to medications through primary care by improving the provision of coordinated care and health promotion activities.
- Encouraging self-management strategies and education following stroke, achieved with low cost, scalable, digital solutions.

Costs and benefits

With improvement in the proportion of patients dispensed and continuing to use antihypertensive medications after a first-ever stroke, it was estimated that 130 recurrent strokes would be prevented per year, resulting in 179 DALYs avoided (Table 35). The costs of providing additional numbers of patients with antihypertensive medications over one-year were estimated to be almost $1.4 million. These costs were offset by savings in healthcare costs and savings from improving productivity and reduced informal care. The total cost savings resulting from the prevention of recurrent strokes were estimated to be close to $9 million over a lifetime (Table 36). This is likely to underestimate the impact of improving the provision of blood pressure lowering medications after stroke since these medications can reduce the risk of other cardiovascular diseases.

Table 35 Use of antihypertensive medications for prevention of recurrent stroke and its effect on health outcomes among stroke survivors in 2023

Target	Before	After	Change
Recurrent stroke events	4,522	4,392	-130
Years of life lived with disability	4,796	4,765	-31
Years of life lost	18,036	17,887	-149
Disability adjusted life years	22,831	22,652	-179

These are lifetime impacts expected for the strokes prevented that would have occurred in any one year.

Table 36 Use of antihypertensive medications for prevention of recurrent stroke and its economic impacts among stroke survivors in 2023

Target	Before	After	Change
Additional antihypertensive medications	-	$1,380,112	$1,380,112
Healthcare	$494,392,872	$489,221,850	-$5,171,022
Road ambulance	$35,981,829	$35,733,092	-$248,737
Hospital	$379,341,988	$375,091,318	-$4,250,671
Outpatient services	$38,239,522	$38,103,017	-$136,505
Medications	$23,809,851	$23,769,238	-$40,613
Aged care	$17,019,682	$16,525,185	-$494,497
Productivity			
Employment	$153,531,923	$152,829,909	-$702,014
Household productivity	$364,871,019	$363,071,883	-$1,799,136
Informal care	$373,437,460	$370,811,577	-$2,625,882
Total	$1,386,233,274	$1,377,315,331	-$8,917,943

These are lifetime economic impacts expected for the strokes prevented that would have occurred in any one year.

7.4 Estimating effects of improving access to community-based rehabilitation after stroke

After a stroke, the aim of rehabilitation is to regain function and achieve the greatest possible level of independence. There are many different pathways to receiving rehabilitation following stroke that include inpatient and community-based services.[77] Of those accessing rehabilitation after discharge from acute hospital following a stroke in Australia, 71% of patients access inpatient rehabilitation facilities, 15% access outpatient or community rehabilitation centres, 11% receive therapy at home and 2% receive therapy in other settings.[78] Up to half of the patients initially accessing inpatient rehabilitation receive subsequent rehabilitation elsewhere.[77] Access to rehabilitation can be influenced by patient and service factors. The types and amount of therapy offered are generally dependent on the various types of impairments experienced by a patient (e.g. motor, sensory, cognitive, and communication), severity of the impairments, person-centred goals to regain function, preferences for learning compensatory techniques, as well as available support and resources.

In this section of the report, the costs and benefits of improving the provision of community-based rehabilitation (i.e., where rehabilitation therapy sessions are provided in public hospital outpatient clinic, private clinic, or day rehabilitation centre) were estimated for patients with stroke. A scenario where a greater proportion of patients with stroke in 2023 were provided community-based rehabilitation was compared to current access based on the proportions of patients referred directly to community-based rehabilitation after discharge from acute hospital following a stroke. The amount of therapy provided in community-based rehabilitation was also increased to a level expected to result in improved outcomes for motor impairments based on a systematic review with a meta-analysis of randomised trials.[79] The proportion of patients accessing inpatient rehabilitation was not changed and we did not consider alternate programs such as early supported discharge services or telerehabilitation provided to people in their homes.

Rehabilitation programs are not being optimised to provide the recommended amount of therapy as described in the Australian and New Zealand Clinical Guidelines for Stroke Management.[35] Therefore, we have included this modelling in this report to support priority setting for augmentation of rehabilitation services that could be provided in the community in order to add to the evidence base and to inform policy decisions. We present costs and benefits that may be possible with improvements to only one of many settings for rehabilitation after stroke. We acknowledge that this is challenging to model because of the available evidence on the effectiveness of therapies for various impairments, and because implementing additional rehabilitation therapy may be difficult due to the limited capacity of the rehabilitation services that are currently available.

Eligible population

We considered two groups of patients who could benefit from community-based rehabilitation, with numbers of patients estimated using data from the 2023 Acute Stroke Services Audit Report[13]:

1) Patients who currently receive community-based rehabilitation (based on data on referral destination); and
2) Patients after acute stroke who were identified as having ongoing rehabilitation needs but did not receive a referral for rehabilitation.

Treatment effects

Effects of therapy were applied to both groups of patients. The effect of therapy was based on an improvement in activities of daily living observed in analysis 4.1.1 in the systematic review by Clark et al (2021).[80] This treatment effect was applied in our model by redistributing the number of patients expected to have dependence (mRS 2-4) to no dependence (mRS 0-1) by 90 days post-stroke.

Costs included

To achieve these treatment effects, we assumed that 12 additional hours would be provided for those already accessing rehabilitation (group 1), and 17 hours would be provided for those who were identified as having ongoing rehabilitation needs but not referred to rehabilitation (group 2). The additional amount of therapy was based on the average number of hours of therapy provided in community rehabilitation settings[77] and an additional 240% of therapy required to improve motor activity after stroke.[79] Since patients receiving community rehabilitation are provided with 5 hours of therapy on average, this was increased to 17 hours of therapy for patients (12 additional hours for group 1 and 17 additional hours for group 2). The average hourly price of allied health professionals ($72.29, including on-costs and allowances) was applied to each hour of therapy to estimate costs. Additional administration time and infrastructure costs were not estimated.

Costs and benefits

With improvement in the provision of community rehabilitation after stroke, it was estimated that over 3000 DALYs could be avoided (Table 37). The additional cost of providing rehabilitation was over $4 million, and an additional $13 million in healthcare costs over a lifetime were estimated (Table 38). These costs were offset with large savings from improved productivity and reduced informal care, resulting in an estimated saving of over $118 million over a lifetime.

Table 37 Improvements in acute stroke care from improving rehabilitation after stroke in 2023

	Before	After	Change
Years of life lived with disability	95,384	94,439	-945
Years of life lost	335,112	332,764	-2,348
Disability adjusted life years	430,498	427,202	-3,296

These are lifetime impacts expected for the strokes that occur in any one year.

Table 38 Economic impacts from improving rehabilitation after stroke in 2023

	Before	After	Change
Additional therapy costs	-	$4,027,910	$4,027,910
Healthcare	$11,235,680,388	$11,248,918,650	$13,238,262
Road ambulance	$790,846,296	$790,865,327	$19,031
Hospital	$8,639,590,168	$8,648,037,111	$8,446,943
Outpatient services	$919,953,206	$922,739,503	$2,786,297
Medications	$581,652,682	$583,638,671	$1,985,989
Aged care	$303,638,036	$303,638,036	-
Productivity			
Employment	$5,843,537,466	$5,802,907,729	-$40,629,737
Household productivity	$6,750,141,636	$6,697,449,102	-$52,692,534
Informal care	$7,742,201,722	$7,699,933,820	-$42,267,902
Total	$31,571,561,210	$31,453,237,212	-$118,323,998

These are lifetime economic impacts expected for the strokes that occur in any one year.

The results from this analysis reflect possible costs and benefits from improving one component of rehabilitation. We intended to model people who are discharged home with no rehabilitation, who would have been eligible to receive community rehabilitation. Indeed, there are other cohorts of survivors with rehabilitation needs who miss out such as those who go directly from acute hospital to residential aged care. In order to attain the health benefits and the subsequent economic benefits, the amount of additional therapy to improve motor activity would require a skilled therapy team, and motivated and health literate patients who would also undertake unsupervised training outside of formal therapy sessions. Due to limitations with the data available and being unable to model combined effects of rehabilitation for all types of impairments experienced by patients after stroke (e.g. motor, sensory, cognitive, communication), only the potential effects of improving rehabilitation to improve motor activity were estimated.

Strategies to improve the provision of rehabilitation after stroke to achieve these outcomes are needed. This may include training of clinicians and systems to encourage self-management that would see rehabilitation outcomes maximised. These strategies were not costed for this report, but they may warrant investment with the savings estimated from improving the provision of rehabilitation following a stroke. The findings provide evidence to support priority setting for rehabilitation, which is needed by almost all people experiencing stroke, and is often insufficient or inaccessible within the context of Australia at present.

8. Summary

Overall, the total costs of stroke over a lifetime for the 2023 Australian population was over $15 billion. If we do not instigate more prevention interventions and given current population growth trends, it is estimated that by 2050 there could be 72,000 extra strokes per year.

In this report, we provide comprehensive insights into the cost and economic impacts related to stroke in Australia. The costs estimated include those related to healthcare services and productivity that are borne by society, the patients with stroke, their carers and families, and the government as a funder of healthcare and welfare services. While the healthcare costs in the short-term after stroke may be the most noticeable, there are ongoing costs related to healthcare needs and impairments that persist well into the future. Therefore, we estimated healthcare costs in the short-term after a stroke, and costs until the end of life after a stroke in order to illustrate these impacts. There are also many important messages within this report illustrating the potential benefits from investment in reducing treatment gaps and improving prevention.

We demonstrated that the potential benefits of achieving the 30/60/90 National Stroke Targets (improving the provision of acute treatment) could be achieved with relatively low costs related to Stroke Unit Certification and the additional employment of Stroke Care Coordinators in hospitals. Other improvements to the healthcare system that are already underway will further facilitate the achievement of the 30/60/90 National Stroke Targets. One example is the work undertaken by the Australian Stroke Alliance,[h] which aims to improve access to pre-hospital stroke care by air and road ambulances equipped with light-weight brain scanners. Stroke telemedicine services (such as the Victorian Stroke Telemedicine Service)[i] in Australia will also be pivotal in facilitating the high-quality systems of acute stroke care required to achieve the 30/60/90 National Stroke Targets and providing better access and care in rural and regional Australia.

The potential benefits from achieving targets for the control of blood pressure according to the National Hypertension Taskforce Roadmap were estimated. The potential benefits from preventing recurrent strokes by improving provision of antihypertensive medications following a stroke were also estimated. Since the benefits estimated from controlling blood pressure in Australia were limited to those related to stroke, the impacts have been underestimated. High blood pressure is also a major risk factor for other conditions such as heart disease, kidney disease and dementia. Therefore, improving blood pressure management will also reduce the incidence of these conditions. The funding of activities required to improve control of blood pressure can be justified by the large potential cost savings that were estimated.

[h] https://austrokealliance.org.au/
[i] https://www.ambulance.vic.gov.au/about-us/our-services/victorian-stroke-telemedicine/

There are many different pathways to receiving rehabilitation following stroke that include inpatient and community-based services. Access to effective and affordable rehabilitation services is influenced by policy, system and patient factors. Health insurance and personal funds may be stretched especially when survivors of stroke are unable to work. Better systems for long-term stroke care and clearer pathways that are appropriately supported by a combination of NDIS, aged care and self-funded services are needed.[81] Because there is currently insufficient evidence, we provide this modelling to support priority setting for rehabilitation services that could be provided in the community after stroke. This is the tip of the iceberg, and better-quality evidence will help inform the modelling of benefits of other rehabilitation options in the future.

A strength of the analyses presented in this report, was that many inputs for the modelling were obtained from analysis of patient-level data, rather than taking the information from published literature. This enabled estimates of the number of strokes occurring per year and the health and economic impacts related to stroke. We have provided detailed information by different age groups and stroke types when estimating the short or longer-term impacts of stroke. The Advisory Committee provided additional context or other sources of information to improve the representativeness of the model. As more contemporary data are integrated, estimated costs will be more accurate.

Limitations include the sources of data that were available to use as model inputs and their ability to be generalised at a national level. For example, many of our estimates were derived from datasets obtained from linkages of the Australian Stroke Clinical Registry with hospital administrative data within one or two Australian states (Victoria and Queensland). However, while the patterns of resource use and treatment pathways may differ in other jurisdictions of Australia, the patient-level clinical costing attribution approaches in hospitals were based on nationally agreed methods.

The data presented in this report clearly illustrate that with improved prevention, early recognition and treatment of stroke, many adverse consequences could be avoided and consequently could reduce the societal economic impact of stroke.

9. References

1. Saver JL. Time is brain--quantified. Stroke 2006;37:263-266.

2. O'Donnell MJ, Chin SL, Rangarajan S, et al. Global and regional effects of potentially modifiable risk factors associated with acute stroke in 32 countries (INTERSTROKE): a case-control study. Lancet 2016;388:761-775.

3. GBD 2019 Stroke Collaborators. Global, regional, and national burden of stroke and its risk factors, 1990-2019: a systematic analysis for the Global Burden of Disease Study 2019. Lancet Neurol 2021;20:795-820.

4. Schutte AE, Bennett B, Chow CK, et al. National Hypertension Taskforce of Australia: a roadmap to achieve 70% blood pressure control in Australia by 2030. Med J Aust 2024;221:126-134.

5. Schutte AE, Webster R, Jennings G, Schlaich MP. Uncontrolled blood pressure in Australia: a call to action. Med J Aust 2022;216:61-63.

6. Langhorne P, Ramachandra S. Organised inpatient (stroke unit) care for stroke: network meta-analysis. Cochrane Database Syst Rev 2020;4:Cd000197.

7. Stroke Unit Trialists' Collaboration. Organised inpatient (stroke unit) care for stroke. Cochrane Database Syst Rev 2013;2013:Cd000197.

8. Stroke Foundation. National Rehabilitation Stroke Services Framework 2022. Melbourne, Australia.

9. Cadilhac DA, Dalli LL, Morrison J, Paice K, Carter H, Campbell BCV, Cloud GC, Kilkenny MF, Faux S, Hill K, Donnan GA, Grimley R, Lannin NA, Stojanovski B, Cowans S, Middleton S, Dewey H; on behalf of the AuSCR Consortium. The Australian Stroke Clinical Registry Annual Report 2022. The Florey Institute of Neuroscience and Mental Health; December 2023, Report No. 15, 72 pages. doi.org/10.26188/24790896

10. Xian Y, Xu H, Smith EE, et al. Achieving More Rapid Door-to-Needle Times and Improved Outcomes in Acute Ischemic Stroke in a Nationwide Quality Improvement Intervention. Stroke 2022;53:1328-1338.

11. Sentinel Stroke National Audit Programme (SSNAP). National results, April 2021 – March 2022. https://www.strokeaudit.org/Results2/Clinical-audit/National-Results.aspx. Accessed 22 August 2024.

12. NHS National Services Scotland. Scottish Stroke Improvement Programme 2023: national report. https://www.publichealthscotland.scot/media/20499/ssip-june2023-english.pdf. Accessed 22 August 2024.

13. Stroke Foundation. National Stroke Audit Acute Services Report 2023. Melbourne, Australia.

14. Emberson J, Lees KR, Lyden P, et al. Effect of treatment delay, age, and stroke severity on the effects of intravenous thrombolysis with alteplase for acute ischaemic stroke: a meta-analysis of individual patient data from randomised trials. Lancet 2014;384:1929-1935.

15. Goyal M, Menon BK, van Zwam WH, et al. Endovascular thrombectomy after large-vessel ischaemic stroke: a meta-analysis of individual patient data from five randomised trials. Lancet 2016;387:1723-1731.

16. Saver JL, Fonarow GC, Smith EE, et al. Time to treatment with intravenous tissue plasminogen activator and outcome from acute ischemic stroke. Jama 2013;309:2480-2488.

17. Jahan R, Saver JL, Schwamm LH, et al. Association Between Time to Treatment With Endovascular Reperfusion Therapy and Outcomes in Patients With Acute Ischemic Stroke Treated in Clinical Practice. Jama 2019;322:252-263.

18. Man S, Solomon N, Mac Grory B, et al. Shorter Door-to-Needle Times Are Associated With Better Outcomes After Intravenous Thrombolytic Therapy and Endovascular Thrombectomy for Acute Ischemic Stroke. Circulation 2023;148:20-34.

19. Deloitte Access Economics. The economic impact of stroke in Australia, 2020. November 2020.

20. Australian Institute of Health and Welfare. (2022). Estimating the incidence of stroke and acute coronary syndrome using the National Integrated Health Services Information Analysis Asset. Canberra: AIHW. doi:10.25816/resc-1m16.

21. Balabanski AH, Nedkoff L, Brown A, et al. Incidence of Stroke in the Aboriginal and Non-Aboriginal Populations of Australia: A Data Linkage Study. Stroke 2023;54:2050-2058.

22. Leyden JM, Kleinig TJ, Newbury J, et al. Adelaide stroke incidence study: declining stroke rates but many preventable cardioembolic strokes. Stroke 2013;44:1226-1231.

23. The ACROSS group. Epidemiology of aneurysmal subarachnoid hemorrhage in Australia and New Zealand: incidence and case fatality from the Australasian Cooperative Research on Subarachnoid Hemorrhage Study (ACROSS). Stroke 2000;31:1843-1850.

24. Youens D, Katzenellenbogen J, Srinivasa Ragavan R, et al. Differing Definitions of First-Ever Stroke Influence Incidence Estimates More than Trends: A Study Using Linked Administrative Data. Neuroepidemiology 2023;57:423-432.

25. Australian Bureau of Statistics (2018), Disability, Ageing and Carers, Australia: Summary of Findings, ABS Website, accessed 22 August 2024.

26. Australian Bureau of Statistics (2022), National Health Survey, ABS Website, accessed 22 August 2024.

27. Australian Bureau of Statistics (September 2023), National, state and territory population, ABS Website, accessed 31 May 2024.

28. Australian Institute of Health and Welfare (2023) Health expenditure Australia 2021-22, AIHW, Australian Government, accessed 31 May 2024.

29. Andrew NE, Kim J, Cadilhac DA, et al. Protocol for evaluation of enhanced models of primary care in the management of stroke and other chronic disease (PRECISE): A data linkage healthcare evaluation study. Int J Popul Data Sci 2019;4:1097.

30. Saver JL, Chaisinanunkul N, Campbell BCV, et al. Standardized Nomenclature for Modified Rankin Scale Global Disability Outcomes: Consensus Recommendations From Stroke Therapy Academic Industry Roundtable XI. Stroke 2021;52:3054-3062.

31. Ganesh A, Luengo-Fernandez R, Wharton RM, et al. Time Course of Evolution of Disability and Cause-Specific Mortality After Ischemic Stroke: Implications for Trial Design. J Am Heart Assoc 2017;6.

32. Australian Bureau of Statistics (2020-2022), Life expectancy, ABS Website, accessed 4 June 2024.

33. Shavelle RM, Brooks JC, Strauss DJ, Turner-Stokes L. Life Expectancy after Stroke Based On Age, Sex, and Rankin Grade of Disability: A Synthesis. J Stroke Cerebrovasc Dis 2019;28:104450.

34. Manipis, K., Viney, R., De Abreu Lourenço, R., Ng, C., Yu, A., Meshcheriakova, E., de Feria Cardet, R., Carrello, J., Akanksha, A., Arora, S., Addo, R., Thomas, J., Cronin, P., Vigours, S., Vargas Parada, C., Norris, S., Kim, H., & Goodall, S. (2023). Health Technology Assessment methods: Economic Evaluation. Australian Health Technology Assessment Methods and Policy Review. Canberra: Australian Government, Department of Health and Aged Care.

35. Hong KS, Saver JL. Quantifying the value of stroke disability outcomes: WHO global burden of disease project disability weights for each level of the modified Rankin Scale. Stroke 2009;40:3828-3833.

36. Australian Institute of Health and Welfare (2024) Heart, stroke and vascular disease: Australian facts, AIHW, Australian Government, accessed 24 July 2024.

37. Kilkenny MF, Dalli LL, Kim J, et al. Factors Associated With 90-Day Readmission After Stroke or Transient Ischemic Attack: Linked Data From the Australian Stroke Clinical Registry. Stroke 2020;51:571-578.

38. Australian Institute of Health and Welfare (2020) Atrial fibrillation in Australia, AIHW, Australian Government, accessed 25 July 2024.
39. Ball J, Thompson DR, Ski CF, Carrington MJ, Gerber T, Stewart S. Estimating the current and future prevalence of atrial fibrillation in the Australian adult population. Med J Aust 2015;202:32-35.
40. Dawson LP, Ball J, Wilson A, et al. Population trends in the incidence and outcomes of atrial fibrillation presentations to emergency departments in Victoria, Australia. Heart Rhythm 2024;21:693-695.
41. Shahjouei S, Sadighi A, Chaudhary D, et al. A 5-Decade Analysis of Incidence Trends of Ischemic Stroke After Transient Ischemic Attack: A Systematic Review and Meta-analysis. JAMA Neurol 2021;78:77-87.
42. Gangadharan S, Tomari S, Levi CR, et al. Rural versus metropolitan comparison of processes of care in the community-based management of TIA and minor stroke in Australia (an analysis from the INSIST study). Aust J Rural Health 2023;31:274-284.
43. Tomari S, Magin P, Lasserson D, et al. The Characteristics of Patients With Possible Transient Ischemic Attack and Minor Stroke in the Hunter and Manning Valley Regions, Australia (the INSIST Study). Front Neurol 2020;11:383.
44. Kim J, Grimley R, Kilkenny MF, et al. Costs of acute hospitalisation for stroke and transient ischaemic attack in Australia. Health Inf Manag 2023;52:176-184.
45. National Disability Insurance Agency. Stroke dashboard, 30 June 2024. Accessed September 12, 2024.
46. Ojha M, Finnis ME, Heckelmann M, et al. Outcomes following grade V subarachnoid haemorrhage: A single-centre retrospective study. Anaesth Intensive Care 2020;48:289-296.
47. Schofield, Z., Gardiner, F.W., Bishop, L., Spring, B., Gale, L., and Quinlan, F. (2023). Best for the Bush in Focus: Heart, Stroke and Vascular Disease. Canberra, Royal Flying Doctor Service of Australia.
48. Gardiner FW, Bishop L, Dos Santos A, et al. Aeromedical Retrieval for Stroke in Australia. Cerebrovasc Dis 2020;49:334-340.
49. Muyambi K, Gardiner F, Sollid S, et al. Aeromedical retrieval services characteristics globally: a scoping review. Scand J Trauma Resusc Emerg Med 2022;30:71.
50. O'Connor TM, Hanks HA, Elcock MS, Turner RC, Veitch C. The medical and retrieval costs of road crashes in rural and remote northern Queensland, 2004-2007: findings from the Rural and Remote Road Safety Study. Med J Aust 2009;190:54-56.
51. Arora N, Makino K, Tilden D, Lobotesis K, Mitchell P, Gillespie J. Cost-effectiveness of mechanical thrombectomy for acute ischemic stroke: an Australian payer perspective. J Med Econ 2018;21:799-809.
52. My Aged Care 2024, My Aged Care website, Australian government, accessed 4 July 2024, <https://www.myagedcare.gov.au/>.
53. Gao L, Sheppard L, Wu O, et al. Economic evaluation of a phase III international randomised controlled trial of very early mobilisation after stroke (AVERT). BMJ Open 2019;9:e026230.
54. Dewey HM, Thrift AG, Mihalopoulos C, et al. Cost of stroke in Australia from a societal perspective: results from the North East Melbourne Stroke Incidence Study (NEMESIS). Stroke 2001;32:2409-2416.
55. Gloede TD, Halbach SM, Thrift AG, Dewey HM, Pfaff H, Cadilhac DA. Long-term costs of stroke using 10-year longitudinal data from the North East Melbourne Stroke Incidence Study. Stroke 2014;45:3389-3394.
56. Tan E, Gao L, Collier JM, et al. The economic and health burden of stroke among younger adults in Australia from a societal perspective. BMC Public Health 2022;22:218.
57. Kim J, Rose ML, Pierce JE, et al. High-Intensity Aphasia Therapy Is Cost-Effective in People With Poststroke Aphasia: Evidence From the COMPARE Trial. Stroke 2024;55:705-714.

58. Ademi Z, Ackerman IN, Zomer E, Liew D. Productivity-Adjusted Life-Years: A New Metric for Quantifying Disease Burden. Pharmacoeconomics 2021;39:271-273.

59. Australian Bureau of Statistics (2020-2021), How Australians Use Their Time, ABS Website, accessed 4 June 2024.

60. Australian Bureau of Statistics (August 2023), Employee earnings, ABS Website, accessed 5 June 2024.

61. Volunteering Victoria (2020). State of Volunteering in Victoria 2020. https://stateofvolunteering.org.au/. Accessed 4 June 2024.

62. Australian Institute of Health and Welfare (2023) Australian Burden of Disease Study 2023, AIHW, Australian Government, accessed 22 August 2024.

63. Peng Y, Ngo L, Hay K, Alghamry A, Colebourne K, Ranasinghe I. Long-Term Survival, Stroke Recurrence, and Life Expectancy After an Acute Stroke in Australia and New Zealand From 2008-2017: A Population-Wide Cohort Study. Stroke 2022;53:2538-2548.

64. Meretoja A, Keshtkaran M, Saver JL, et al. Stroke thrombolysis: save a minute, save a day. Stroke 2014;45:1053-1058.

65. Meretoja A, Keshtkaran M, Tatlisumak T, Donnan GA, Churilov L. Endovascular therapy for ischemic stroke: Save a minute-save a week. Neurology 2017;88:2123-2127.

66. Stroke Foundation. National Stroke Audit Acute Services Report 2021. Melbourne, Australia.

67. Purvis T, Middleton S, Alexandrov AW, et al. Understanding Coordinator Roles in Acute Stroke Care: A National Survey. J Stroke Cerebrovasc Dis 2021;30:106111.

68. Xu X, Islam SMS, Schlaich M, Jennings G, Schutte AE. The contribution of raised blood pressure to all-cause and cardiovascular deaths and disability-adjusted life-years (DALYs) in Australia: Analysis of global burden of disease study from 1990 to 2019. PLoS One 2024;19:e0297229.

69. Institute of Health Metrics and Evaluation. Global Burden of Disease. Deaths by Risk Factor in Australia. 2019. https://ourworldindata.org/grapher/number-of-deaths-by-risk-factor?country=~AUS. Accessed 22 August 2024.

70. GBD 2019 Risk Factors Collaborators. Global burden of 87 risk factors in 204 countries and territories, 1990-2019: a systematic analysis for the Global Burden of Disease Study 2019. Lancet 2020;396:1223-1249.

71. Ezzati M, Lopez AD, Rodgers A, Vander Hoorn S, Murray CJ. Selected major risk factors and global and regional burden of disease. Lancet 2002;360:1347-1360.

72. Australian Institute of Health and Welfare (2019) High blood pressure , AIHW, Australian Government, accessed 22 August 2024.

73. Stroke Foundation. The Australian and New Zealand Clinical Guidelines for Stroke Management. Melbourne, Australia.

74. Dalli LL, Kim J, Cadilhac DA, et al. Greater Adherence to Secondary Prevention Medications Improves Survival After Stroke or Transient Ischemic Attack: A Linked Registry Study. Stroke 2021;52:3569-3577.

75. Lakhan SE, Sapko MT. Blood pressure lowering treatment for preventing stroke recurrence: a systematic review and meta-analysis. Int Arch Med 2009;2:30.

76. Kim J, Andrew NE, Thrift AG, Bernhardt J, Lindley RI, Cadilhac DA. The potential health and economic impact of improving stroke care standards for Australia. Int J Stroke 2017;12:875-885.

77. Grimley RS, Rosbergen IC, Gustafsson L, et al. Dose and setting of rehabilitation received after stroke in Queensland, Australia: a prospective cohort study. Clin Rehabil 2020;34:812-823.

78. Lynch EA, Mackintosh S, Luker JA, Hillier SL. Access to rehabilitation for patients with stroke in Australia. Med J Aust 2019;210:21-26.

79. Schneider EJ, Lannin NA, Ada L, Schmidt J. Increasing the amount of usual rehabilitation improves activity after stroke: a systematic review. J Physiother 2016;62:182-187.

80. Clark B, Whitall J, Kwakkel G, Mehrholz J, Ewings S, Burridge J. The effect of time spent in rehabilitation on activity limitation and impairment after stroke. Cochrane Database Syst Rev 2021;10:Cd012612.

81. Trudinger, M. Do We Need a Better System for Long-Term Stroke Care?. Australian Physiotherapy Association. February 1, 2023. https://australian.physio/inmotion/do-we-need-better-system-long-term-stroke-care. Accessed 22 August 2024.

82. Huang H, Lai LT. Incidence and Case-Fatality of Aneurysmal Subarachnoid Hemorrhage in Australia, 2008-2018. World Neurosurg 2020;144:e438-e446.

83. Ambulance Victoria. Annual Report 2022-23. Melbourne, Australia.

84. Australian Human Resources Institute. HR Pulse Survey Report: Absence Management. 2016. Melbourne, Australia.

85. Medibank, KPMG Econtech. Sick at Work: The cost of presenteeism to your business and the economy. July 2011. Melbourne, Australia.

86. Kotseva K, Gerlier L, Sidelnikov E, et al. Patient and caregiver productivity loss and indirect costs associated with cardiovascular events in Europe. Eur J Prev Cardiol 2019;26:1150-1157.

87. Australian Bureau of Statistics (July 2024), Labour Force, Australia, ABS Website, accessed 22 August 2024.

88. Orman Z, Olaiya MT, Thrift AG, et al. Cost-Effectiveness of an Individualised Management Program after Stroke: A Trial-Based Economic Evaluation. Neuroepidemiology 2024;58:156-165.

89. Cain S, Churilov L, Collier JM, et al. Factors associated with paid employment 12 months after stroke in A Very Early Rehabilitation Trial (AVERT). Ann Phys Rehabil Med 2022;65:101565.

90. Dewey HM, Thrift AG, Mihalopoulos C, et al. Informal care for stroke survivors: results from the North East Melbourne Stroke Incidence Study (NEMESIS). Stroke 2002;33:1028-1033.

10. Appendix

Supplementary tables

Supplementary Table 1. Data sources for estimates of healthcare costs over a lifetime 96

Supplementary Table 2. Model inputs used to derive employment impacts 98

Supplementary Table 3. Household productivity hours lost per year per person 99

Supplementary Table 4. Hourly prices applied to hours of household productivity lost 100

Supplementary Table 5. Informal care costs per year according to the modified Rankin Scale (mRS)101

Supplementary Table 6. Data sources for estimates of the burden of stroke over a lifetime 101

Supplementary Table 7. Costs per person in the short-term after ischaemic stroke by age and stroke type 102

Supplementary Table 8. Costs per person in the short-term after intracerebral haemorrhage by age and stroke type 103

Supplementary Table 9. Costs per person in the short-term after undetermined stroke by age and stroke type 104

Supplementary Table 10. Total costs for first-ever strokes 105

Supplementary Table 11. Average costs for first-ever strokes 105

Supplementary Table 12. Total costs for recurrent strokes 106

Supplementary Table 13. Average costs for recurrent strokes 106

Supplementary Table 14. Total long-term healthcare costs for ischaemic stroke 107

Supplementary Table 15. Long-term average healthcare costs for ischaemic stroke 108

Supplementary Table 16. Total long-term healthcare costs for intracerebral haemorrhage..... 109

Supplementary Table 17. Long-term average healthcare costs for intracerebral haemorrhage..... 110

Supplementary Table 18. Total long-term healthcare costs for undetermined stroke 111

Supplementary Table 19. Long-term average healthcare costs for undetermined stroke 112

Supplementary Table 20. Long-term total employment impacts for first-ever strokes occurring in 2023 113

Supplementary Table 21. Long-term total employment impacts for recurrent strokes occurring in 2023 113

11.1 Incidence of stroke methods

The National Integrated Health Services Information (NIHSI) Analysis Asset informed estimates of first-ever stroke for Queensland, New South Wales, Victoria, the Australian Capital Territory, Tasmania and South Australia.[20] Data from Balabanski et al informed estimates of first-ever stroke for the Northern Territory and for Western Australia.[21]

The rates of first-ever stroke taken from these sources comprised a combination of all stroke types combined (i.e. ischaemic stroke, intracerebral haemorrhage, undetermined stroke and subarachnoid haemorrhage). The rates for each stroke type were not available from these datasets since these were administrative datasets and the available coding is not as reliable as a clinical diagnosis. Instead, data from Adelaide Stroke Incidence Study[22] were used to estimate the incidence of the ischaemic stroke, intracerebral haemorrhage and undetermined stroke. These types of stroke were diagnosed using clinical and imaging data and were available for most age categories. The age-specific distributions of ischaemic stroke, intracerebral haemorrhage and undetermined stroke observed in the Adelaide Stroke Incidence Study were applied to the number of incident strokes for each state and territory after removing the number of subarachnoid haemorrhages. Since subarachnoid haemorrhage was not observed in younger age groups in the Adelaide Stroke Incidence Study, data on incidence of subarachnoid haemorrhage from The ACROSS group[23] were used to estimate the incidence of subarachnoid haemorrhage. It was assumed that there was no change in the incidence over time as reported by Huang et al (2020).[82] The ACROSS group (2000) and Huang et al (2020) studies only included aneurysmal subarachnoid haemorrhage which comprised approximately 85% of all subarachnoid haemorrhage. Out of 436 events, only four were recurrent subarachnoid haemorrhage in the study by the ACROSS group.[23] Due to these negligible numbers, we did not attempt to estimate the number of recurrent subarachnoid haemorrhage events.

Since incidence rates may change over time and rates were unavailable for 2023, an adjustment for trends in age-specific rates was applied to estimate the equivalent age-specific rates for 2023. Annual percentage changes reported in three separate age bands (<55, 55-74, 75+) as published by Youens et al were used.[24]

The ratio of first-ever and recurrent strokes observed in the Adelaide Stroke Incidence Study were then used to estimate the total number of first-ever and recurrent stroke hospitalisations (excluding subarachnoid haemorrhage).[22]

Stroke case fatality by type of stroke and recurrent stroke status was determined using data from the Australian Stroke Clinical Registry.

The proportion of patients not hospitalised in the 28-day period prior to death from stroke was estimated using data from Balabanski et al (2023).[21] This was used to adjust the costs attributed to patients with fatal stroke.

11.2 Data sources for cost estimates

11.2.1 The Australian Stroke Clinical Registry

The AuSCR is a national clinical quality registry established in 2009 to monitor the quality of acute stroke care in consecutive admissions and obtain information on survival and patient-reported outcomes. While participation by hospitals is voluntary, the AuSCR has had high participation in several states since its inception. The data have been successfully linked in several different projects to enhance the information on patient care processes and treatments before stroke and after stroke. Therefore, it has provided a unique source of data that complements government data and has been heavily drawn upon for the outputs in this report.

Standardised data on consecutive patients admitted for stroke at participating hospitals are entered into the AuSCR. Data collected includes evidence-based therapies provided while in hospital, as well as important clinical and demographic patient information. These data have been used to inform improvements to the healthcare system. As recommended for national registries, an 'opt-out' model for patient inclusion is used, in addition to a waiver of consent for people who die while in hospital.

Of the 103 public hospitals and four private hospitals that completed the 2023 Stroke Foundation Organisational Survey, the AuSCR included ≥75% of hospitals in the Australian Capital Territory, Queensland, Tasmania and Victoria. In general, hospitals participating in the AuSCR in 2022 were larger hospitals admitting more patients with stroke, were more likely to routinely provide thrombolysis and more often have a dedicated stroke coordinators than the hospitals only participating in the Stroke Foundation Audits.[9]

At 90-180 days after admission for stroke, patients are contacted for a follow-up assessment. Data collected at this assessment includes the mRS, which is a standardised instrument for reporting disability after stroke which approximates post-stroke activity limitations. Over 60% of patients eligible for follow-up have their follow-up completed. Survival status is determined via annual data linkages with the National Death Index held by the Australian Institute of Health and Welfare.

11.2.2 The Australian Stroke Clinical Registry - Victorian data linkage

Data from AuSCR participants who were admitted for stroke in 2018 to hospitals in Victoria were linked to ambulance records held by Ambulance Victoria government-held hospital administrative datasets: the Victorian Emergency Minimum Dataset (VEMD), the Victorian Admitted Episodes Dataset (VAED) and the Victorian Cost Data Collection (VCDC). Data on hospital records were obtained for the five years prior to the hospital admission for stroke registered in the AuSCR and for the 12 months after hospital admission for stroke. The dataset included over 120,000 records (with approximately 48,000 records related to the stroke and those related to admissions after the stroke) for over 7,000 participants.

The VEMD contains data on emergency department presentations at Victorian public hospitals. Data used from the VEMD included dates of presentation and separation to determine time in relation to the hospital

admission for stroke registered in the AuSCR. Diagnosis codes (International Classification of Diseases, 10th Revision) were used to determine the primary diagnosis of hospital presentations.

The VAED contains data on admitted episode of care at Victorian hospitals, rehabilitation centres, extended care facilities and day procedure centres. Data used from the VEMD included dates of presentation and separation to determine time in relation to the hospital admission for stroke registered in the AuSCR. Diagnosis codes (International Classification of Diseases, 10th Revision) were used to determine the primary diagnosis of hospital presentations. Australian National Subacute and Non-Acute Patient Classification (AN-SNAP) Version 4 codes (which are related to provision of subacute care) were used to differentiate between acute hospital admissions and different types of subacute admissions (rehabilitation, palliative care and other subacute care).

The Victorian Cost Data Collection (VCDC) includes patient-level costs incurred while in hospital, including patient and non-patient services. Patient-level costing of presentations to hospital are conducted at Victorian hospitals and are reported to the VCDC and in turn to the Independent Health and Aged Care Pricing Authority to fund hospital services. In 2018-19, 96% of admitted acute episodes had cost data. Multiple imputation with chained equations were used to estimate costs for hospital presentations without cost data. Data on costs were missing for <2% of records related to the hospital records for the presentation related to stroke, and for <15% of records related to hospital presentations following the presentation related to stroke. Data were imputed based on the patients' age and the primary diagnosis code.

11.2.3 PRECISE Data Linkage

The PRECISE dataset had AuSCR registrants in Victoria and Queensland from 2012-2016 linked to government-held hospital administrative datasets, the Medicare Benefits Schedule (to determine outpatient services received), the Pharmaceutical Benefits Scheme (to determine medications received) and the National Aged Care Data Clearinghouse. Details of this study have been published elsewhere.[29]

11.3 Data analysis

11.3.1 Ambulance Services

Costs related to road ambulance services were estimated based on the proportions of patients arriving to hospital by ambulance from additional analysis of the 2022 AuSCR dataset.[9] Proportions of patients arriving to hospital by ambulance were summarised by age and stroke type. These proportions were applied to the number of stroke events expected in 2023 to estimate the number of patients arriving to hospital by ambulance. To estimate the cost of ambulance transports, this was multiplied by the unit price of road ambulance transports obtained from emergency medical services sources ($1,681). Costs related to air ambulance (rotary wing and fixed wing) services were estimated separately since information on these services was not available in the datasets we analysed.

Costs of aeromedical retrievals for stroke in Victoria were based on fees published by Ambulance Victoria. These were applied to the numbers of patients provided endovascular thrombectomy from the Victorian Stroke Telemedicine Service (provided in Victoria and Tasmania).[83] Costs were extrapolated to New South Wales based on populations in these states. No air ambulance transfers were estimated for the Australian Capital Territory due to the close proximity of populations by road to around-the-clock endovascular thrombectomy services in Canberra.

Costs of aeromedical retrievals for stroke in the Northern Territory, Queensland, South Australia and Western Australia were estimated using data from the Royal Flying Doctor Service. The number of air ambulance transports per annum was taken from the Royal Flying Doctor Service Best for the Bush report.[47] Over a five year period between 1 January 2017 and 31 December 2021, there were 4,548 transports for cerebrovascular disease, giving an estimated 910 air ambulance transports for cerebrovascular disease per annum. Due to limited data, costs related to other air ambulance service providers in these states and territories were not estimated.

The proportions of RFDS services that were by rotary wing and fixed wing were estimated using published data on flight distances, with the median flight distance 290.8 km (IQR 211 km, 500 km).[48] Given that fixed wing aeromedical retrieval is preferred over rotary wing for distances beyond 200 km,[49] and 75% of flight distances were greater than 211 km, it was assumed that assumed that 75% of transfers were by fixed wing.

Costs of rotary wing and fixed wing per hour for RFDS services were obtained from O'Connor et al.[50] For rotary wing aircraft, the estimated cost was $5,164/engine hour, with an additional staff cost of $2,600. For fixed wing aircraft, the estimated cost was $2,400/engine hour, with an additional staff cost of $1,800. Hourly costs were multiplied by the average transfer time of 4 hours reported by Gardiner et al (2020).[48]

11.3.2 Emergency department

Costs related to the emergency department were obtained from patient-level analysis of a dataset that had the AuSCR registrants from 2018 linked to the Victorian Emergency Minimum Dataset (VEMD) and the Victorian Cost Data Collection (VCDC). The VCDC includes patient-level costs incurred while in hospital, including patient and non-patient services. Costs specific to emergency department presentations (determined from the VEMD and VCDC) in the first three months following the onset of stroke were analysed.

Data from the AuSCR were used to determine age, stroke type, fatal stroke status, treatment (treatment in a stroke unit and the provision of reperfusion therapies) and first-ever stroke status. Costs were stratified according to these AuSCR data.

11.3.3 Acute admissions

Costs related to the acute admissions were obtained from patient-level analysis of a dataset that had the AuSCR registrants from 2018 linked to the Victorian Admitted Episodes Dataset (VAED) and the VCDC. The VCDC includes patient-level costs incurred while in hospital, including patient services (e.g. care received) and non-patient services (e.g. maintenance). Costs specific to acute hospital admissions (determined from

the VAED and VCDC) in the first three months following the onset of stroke were analysed. Several different categories of costs are available within these datasets (such as medical, nursing, allied health, surgical and intensive care units). Acute hospital admissions were differentiated from subacute hospital admissions by identifying the hospital admission records without Australian National Subacute and Non-Acute Patient Classification (AN-SNAP) Version 4 codes (which are related to provision of subacute care).

Data from the AuSCR were used to determine first or recurrent stroke, age, stroke type, fatal stroke status, and treatment provided in hospital (treatment in a stroke unit and the provision of reperfusion therapies). Costs were stratified according to these AuSCR data. Proportions of patients in different treatment pathways were determined according to first-ever or recurrent stroke, age, stroke type and fatal stroke status.

11.3.4 Subacute care

Costs related to the subacute and non-acute admissions were obtained from patient-level analysis of a dataset that had the AuSCR registrants from 2018 linked to the VAED and VCDC. The VCDC includes patient-level costs incurred while in hospital, patient services (e.g. care received) and non-patient services (e.g. maintenance). Costs specific to hospital admissions (from the VAED) in the first three months following the onset of stroke were analysed. Subacute and non-acute admissions were identified using AN-SNAP Version 4 codes (which are related to the provision of subacute care). These hospital admissions were further categorised into rehabilitation, palliative care and other subacute care.

Data from the AuSCR were used to determine age, stroke type, fatal stroke status, treatment (treatment in a stroke unit and the provision of reperfusion therapies) and first-ever stroke status. Costs were stratified according to these AuSCR data.

Proportions of patients discharged to inpatient rehabilitation were obtained from the AuSCR. Proportions of patients discharged to the other types of subacute care were obtained from the AuSCR data linkage.

11.3.5 Outpatient care

Costs related to outpatient care were obtained from patient-level analysis of the PRECISE dataset.[29] This dataset had AuSCR registrants in Victoria and Queensland from 2012-2016 linked to a range of government-held administrative datasets (up to 2018). This includes the Medicare Benefits Schedule (MBS), state government-held hospital data, the Pharmaceutical Benefits Scheme (PBS) and the National Aged Care Data Clearinghouse (NACDC).

The MBS services that were included were those related to rehabilitation, general practitioner and specialist services, chronic disease management, treatments for sequelae of stroke and secondary prevention management. These costs were categorised into general practitioner, specialist and other (including allied health and pathology services) according to codes specific to the specialty of the MBS provider. Costs related to outpatient care in the first three months following stroke were estimated using the fee charged or the schedule fee of MBS services (whichever was greater). Since the MBS includes only government-subsidised medical services, this does not include privately funded healthcare services outside of this scope.

Data from the AuSCR were used to determine age, stroke type and fatal stroke status. Costs were stratified according to these AuSCR data.

11.3.6 Medications

Costs related to medications were obtained from patient-level analysis of PBS data from the PRECISE dataset,[29] as described above. The medications that were included were those deemed to be most relevant for post-stroke care (antihypertensive medications, antithrombotic medications, lipid-lowering medications, pain management, antidepressants and treatments for muscle spasticity). Costs related to medications in the first three months following stroke were estimated using the patient contribution costs, the benefit amount, and the closing the gap payment. Since the PBS includes only the medications subsidised by the Australian Commonwealth government, any medications supplied without a prescription, and medications that are either privately purchased, or funded under other specialty schemes were not included.

Data from the AuSCR were used to determine age, stroke type and fatal stroke status. Costs were stratified according to these AuSCR data.

11.3.7 Aged care services

Using person-level costing data from the NACDC, we estimated the costs of three types of aged care services: residential aged care, transitional care services, and home care packages.

For residential aged care, only costs related to new residential aged care admissions following stroke were included. Proportions of patients discharged to residential aged care for the first time after stroke were obtained from additional analysis of the 2022 AuSCR data.[9] In the AuSCR, patients discharged back to residential aged care are categorised as being discharged to ‘usual residence’ along with people returning to private residences. Proportions of patients provided transitional care services after stroke were also obtained from the AuSCR. Proportions of patients accessing home care after stroke and were obtained from analysis of the PRECISE dataset.[29]

These proportions were applied to the number of stroke events expected in 2023 to estimate the number of patients provided aged care services. The number of days that these services were received following stroke was also obtained from the PRECISE dataset[29] and were multiplied by the daily fee of these services to estimate the cost of these services. Other costs related to residential aged care (means tested fees, accommodation costs, and other service fees) were not estimated. All data were summarised by age using data from the AuSCR.

Although, the duration that patients receiving aged care services typically exceeds three months, since these services were commenced in the first three months, these were reported alongside the short-term costs.

11.4 Estimating long-term costs and outcomes

11.4.1 Estimating healthcare costs

Analysis of data related to the AuSCR were used to determine costs of ongoing health service use according to mRS health states. The datasets analysed are described in further detail in the appendix (page 91). Costs related to hospital services, outpatient services and medication prescription were obtained directly from analysis of these datasets according to mRS. Costs related to ambulance services were estimated by applying the unit price of road ambulance transports to the average number of ambulance transports obtained from analysis of the AuSCR Victorian data linkage.

Transitions between mRS health states between three to 12 months after stroke and from one to five years after stroke were not differentiated by age group. Due to limited data on transitions beyond five years after stroke, we assumed that patients expected disability would be stable at five years. Those with no disability were then assumed to have the same mortality as the general population, and those with disability (mRS 1-5) were assumed to have a greater mortality than the general population. The accuracy of our models would be improved with more specific data on transitions between mRS health states. Likewise, the costs we used as model inputs to produce our estimates were substantially lower in the 3-15 month period after stroke than in just the first three months after stroke. Longer-term costs according to mRS would improve precision of the model, particularly for our lifetime estimates of costs associated with stroke.

Supplementary Table 1. Data sources for estimates of healthcare costs over a lifetime

Model input	Detail and data source	Reference year
Costs of ambulance services	The average number of ambulance services per year by modified Rankin Scale and stroke type. Data source: the AuSCR Victorian data linkage.	2018-2019
Costs of hospital services (emergency department, acute admissions, subacute admissions)	Annual cost of hospital services by modified Rankin Scale and stroke type. Data source: the AuSCR Victorian data linkage.	2018-2019
Costs of outpatient services	Annual cost of outpatient services by modified Rankin Scale and stroke type Data source: the PRECISE data linkage.	2012-2018
Costs of medications	Annual cost of medications by modified Rankin Scale and stroke type Data source: the PRECISE data linkage.	2012-2018

AuSCR: the Australian Stroke Clinical Registry.

The datasets are described in further detail in the appendix (page 91). Data used for model inputs are available upon reasonable request from the research co-leads.

11.4.2 Estimating employment impacts

A new Australian productivity measure, the productivity-adjusted life year (PALY)[58] was used to estimate the impacts related to employment over the remaining working lifetime (assumed to be 18 to 67 years of age). Retirement age was assumed to be 67 years in line with the 2023 Australian pension age. The PALY is calculated by multiplying the years of life lived with a productivity index which ranges between 0 (no productivity) and 1.0 (full productivity), meaning one PALY is equal to one year of full productivity. The PALYs estimated in this report were based on missed days from work due to illness (absenteeism), reduced efficiency or productivity while at work due to illness (presenteeism), early retirement or workforce drop-out due to illness (workforce participation), as well as premature mortality.

The average number of working days per year for a full-time worker (*which were assumed to be 240 days given that full time workers have 4 weeks of annual leave and therefore work 48 weeks per year, 5 days per week*) were adjusted for absenteeism and presenteeism data from the published literature. Absenteeism and presenteeism estimates for those without stroke were obtained from studies on the Australian general population. In general, Australians lose 8.8 days per person per year due to absenteeism (obtained from the Australian Human Research Institute survey[84]), and 6.5 days per person per year due to presenteeism (obtained from a report by Medibank Australia[85]), totalling 15.3 days lost days of work per person per year.

Absenteeism and presenteeism associated with stroke were sourced from a study conducted in seven European countries since no equivalent data were available for Australia.[86] Stroke survivors were reported to have 34 absent days per person related to the index hospitalisation for stroke and subsequent sick leave (before returning to work), as well as an additional 13 absent days for the remainder of the year (after returning to work). We assumed that ongoing absenteeism beyond the first year was also 13 days. In addition, stroke survivors lose 9 days per person per year due to presenteeism. In line with this study, we assumed 56 days were lost per person for the year of the stroke event, and 22 days lost per person for each year thereafter. Therefore, the productivity indices were estimated to be 0.77 [(240-56)/240] in the year of incident stroke, and 0.91 [(240-22)/240] in the years following. The productivity index in those without stroke was estimated to be 0.94 [240-15.3)/240].

These productivity indices were adjusted for the proportion of the population working full time. To estimate the proportion of condition-specific full time workers, age group and sex-specific workforce participation rates in those with and without stroke were calculated. Age- and sex-specific labour force rates for the general population were drawn from the Australian Bureau of Statistics,[87] and assumed to reflect those without stroke. The proportion of stroke survivors who returned to the workforce was obtained from a secondary analysis of a dataset used for the economic evaluation of a community-based intervention for patients with stroke conducted in Victoria, Australia.[88] These estimates were applied to the general population workforce participation rates to obtain workforce participation in those following a stroke. To obtain the proportion of full time workers, the estimated condition-specific workforce participation rates were adjusted by the average

hours worked per week in each age group and sex (assuming 40 hours of work per week reflects full time work).[87]

To estimate the productivity impacts related to stroke, first we modelled the years of life lived and productivity for the working-age population who had stroke. The same cohort was then modelled again with the assumption that they did not have stroke, with relevant changes made to mortality rates, workforce participation and productivity indices to reflect this assumption. The difference in PALYs between the two modelled scenarios was multiplied with average age group and sex-specific earnings for full time employment[60] to estimate the total productivity cost related to employment using a human capital approach.

The productivity indices were only applied to people with stroke with mRS score of 0-2. It was assumed that those with mRS score of 3-5 would not return to work, and therefore their productivity would be zero. As observed in the A Very Early Rehabilitation Trial (AVERT), the odds of people with stroke with mRS of 3 or more by 12 months returning to work was 94% lower than those with an mRS of 0.[89]

Supplementary Table 2. Model inputs used to derive employment impacts

Model input	Without stroke	First year after stroke	Subsequent years after stroke	Source
Productivity index*	0.94	0.77	0.91	Calculated
Absenteeism (absent/missed days from work)	8.8	47	13	Australian Human Resources Institute (2016)[84] Kotseva et al (2019)[86]
Presenteeism (unproductive days while at work)	6.5	9	9	Medibank Australia (2011)[85] Kotseva et al (2019)[86]
Workforce participation	Age group and sex-specific	Adjusted for return to work data following a stroke (by age group and sex)	Adjusted for return to work data following a stroke (by age group and sex)	Australian Bureau of Statistics (2024)[87] Orman et al (2024)[88]
Average hours worked per week	Age group and sex-specific	Age group and sex-specific	Age group and sex-specific	Australian Bureau of Statistics (2024)[87]
Average annual earnings	Age group and sex-specific	Age group and sex-specific	Age group and sex-specific	Australian Bureau of Statistics (2023)[60]

* Productivity indices were calculated from absenteeism and presenteeism data, and then adjusted for proportion of full time workers (estimated from age group and sex-specific workforce participation and average hours worked per week data).

11.4.3 Estimating household productivity impacts

Household production was defined as the hours of time spent performing domestic activities, child care activities, adult care activities and voluntary work. The amount of household production lost was estimated using data from Australia's Time Use Survey published by the Australian Bureau of Statistics.[59]

Average time spent per day by disability status was used to estimate hours of lost productivity over a year. Patients with no disability (mRS 0 and mRS 1) were assumed to have household productivity unaffected and were estimated to have the average household productivity of the population without disability. Patients with slight and moderate disability (mRS 2 and mRS 3) were assumed to have household productivity reduced from the average household productivity of the population without disability to the average household productivity of the population with disability. Those with moderately severe disability and severe disability (mRS 4 and mRS 5) were assumed to have no household productivity. Therefore, the average household productivity of the population without disability was assumed to be lost for these groups, as for those who died.

The types of household productivity (domestic activities, child care activities, adult care activities) were valued with the replacement cost method, whereby the cost of purchasing these services commercially were used. Hourly rates for the different types of household productivity were applied.[60] The hourly replacement cost of volunteer work was applied to the amount of time spent performing voluntary work (Volunteering Victoria, 2020).[61]

Supplementary Table 3. Household productivity hours lost per year per person

	Domestic activities Hours lost		Child care activities Hours lost		Adult care activities Hours lost		Voluntary work Hours lost	
	Age <65 years	**Age 65+ years**	**Age <65 years**	**Age 65+ years**	**Age <65 years**	**Age 65+ years**	**Age <65 years**	**Age 65+ years**
mRS 0	0	0	0	0	0	0	0	0
mRS 1	0	0	0	0	0	0	0	0
mRS 2	0	183	146	73	0	37	0	30
mRS 3	0	183	146	73	0	37	0	30
mRS 4	846	1430	329	103	18	55	12	49
mRS 5	846	1430	329	103	18	55	12	49
mRS 6	846	1430	329	103	18	55	12	49

mRS: modified Rankin Scale

Supplementary Table 4. Hourly prices applied to hours of household productivity lost

Category	Unit Price	Source
Domestic activities	$29.1 (Community and personal service workers)	Australian Bureau of Statistics (August 2023)
Child care activities	$25.6 (Carers and Aides)	Australian Bureau of Statistics (August 2023)
Adult care activities	$25.6 (Carers and Aides)	Australian Bureau of Statistics (August 2023)
Voluntary work		Volunteering Victoria (2020)
Age 15-24 years	$18.19	
Age 25-34 years	$50.11	
Age 35-44 years	$48.15	
Age 45-54 years	$41.15	
Age 55-64 years	$51.46	
Age 65+ years	$36.11	

Reference year 2020, inflated to 2023 equivalent using the ratio: 103.9 / 98.1

11.4.4 Estimating informal caregiver impacts

Informal care costs according to mRS were obtained from a secondary analysis of a dataset used for the economic evaluation of a community-based intervention for patients with stroke conducted in Victoria, Australia (Orman et al, 2024). Patients were eligible for this study if they were discharged to the community after stroke, and have relatively good outcomes compared to the average patient who suffers a stroke. Nevertheless, the informal care hours were greater than those reported by Dewey et al (7 hours of care community task, 6 hours domestic tasks and 4 hours personal tasks).[90]

In this study, an informal carer was defined as a person most closely involved in helping the person with stroke to live independently at home (such as a spouse or other member of the family but may be a friend or neighbour). Hours of help received for daily activities were obtained for community tasks (banking and paying bills; errands such as posting letters or making appointments; transport to appointments or social occasions; shopping; “check ups”), domestic tasks (gardening; handyman tasks; grounds and home maintenance; housework such as laundry, cleaning, washing up; supervision of medication; supervision or assistance to walk outside) and personal care tasks (eating; grooming; bathing; dressing; toilet use; help with incontinence pads; moving from bed to chair or chair to chair; walking inside the house including stairs). Assistance provided by a formal support service was not included.

Supplementary Table 5. Informal care costs per year according to the modified Rankin Scale (mRS)

	mRS 0	mRS 1	mRS 2	mRS 3	mRS 4	mRS 5
% requiring informal care	13.26%	24.90%	40.10%	69.05%	100%	100%
Informal care hours per week (of those requiring informal care)	14.9	18.1	19.9	21.0	48.8	71.0
Informal care hours per week (all included)	1.9	5.6	9.9	13.4	27.8	47.9
Informal care cost per year (of those requiring informal care)	$18,603	$28,211	$26,560	$30,857	$45,371	$117,115
Informal care cost per year (all included)	$3,178	$9,085	$16,123	$21,928	$45,371	$78,103

Reference year 2021, inflated to 2023 equivalent using the ratio: 103.9 / 100

Source: Orman et al (2024)[88]

11.4.5 Estimating disability adjusted life years

Disability weights for mRS health states were obtained from Hong et al.[35] These disability weights were applied according to the years of life lived in mRS states to estimate the years of life lived with disability (YLD). Years of life lost (YLL) were estimated by comparing the estimated years of life lived generated by the Markov model with the life expectancy of the general population of the equivalent age at the age of stroke. DALYs (YLD + YLL) associated with stroke over a lifetime were estimated by combining the estimated YLD with the estimated YLL following stroke.

Supplementary Table 6. Data sources for estimates of the burden of stroke over a lifetime

Health state	Description	Disability weight
mRS 0	No symptoms	0
mRS 1	No significant disability despite symptoms; able to carry out all usual duties and activities	0.046
mRS 2	Slight disability: unable to carry out all previous activities but able to look after own affairs without assistance	0.212
mRS 3	Moderate disability: requiring some help, but able to walk without assistance	0.331
mRS 4	Moderately severe disability: unable to walk without assistance, and unable to attend to own bodily needs without assistance	0.652
mRS 5	Severe disability: bedridden, incontinent, and requiring constant nursing care and attention	0.944

mRS: modified Rankin Scale

Source: Hong et al (2009)[35]

11.5 Supplementary Results

11.5.1 Short-term costs per person

Supplementary Table 7. Costs per person in the short-term after ischaemic stroke by age and stroke type

	<65 years	65-69 years	70-74 years	75-79 years	80-84 years	85+ years	All ages
				First-ever ischaemic stroke			
Ambulance	$1,075	$1,184	$1,267	$1,317	$1,357	$1,246	$1,222
Emergency department	$2,787	$2,530	$2,532	$2,606	$2,583	$2,399	$2,574
Acute admission	$26,440	$21,147	$21,128	$21,124	$21,101	$15,861	$21,001
Inpatient rehabilitation	$8,711	$8,450	$8,332	$8,639	$8,372	$6,928	$8,120
Palliative care	$1,306	$1,205	$1,196	$1,144	$1,117	$726	$1,084
Other subacute care	$1,261	$892	$890	$1,311	$1,304	$2,013	$1,379
Outpatient services*	$865	$982	$971	$1,048	$1,019	$797	$918
Prescription medications	$285	$353	$348	$351	$340	$262	$311
Total	$42,731	$36,743	$36,663	$37,539	$37,192	$30,231	$36,609
				Recurrent ischaemic stroke			
Ambulance	$1,075	$1,184	$1,267	$1,317	$1,357	$1,246	$1,222
Emergency department	$2,787	$2,530	$2,532	$2,606	$2,583	$2,399	$2,574
Acute admission	$26,440	$21,147	$21,128	$21,124	$21,101	$15,861	$21,001
Inpatient rehabilitation	$8,711	$8,450	$8,332	$8,639	$8,372	$6,928	$8,120
Palliative care	$1,306	$1,205	$1,196	$1,144	$1,117	$726	$1,084
Other subacute care	$1,261	$892	$890	$1,311	$1,304	$2,013	$1,379
Outpatient services*	$865	$982	$971	$1,048	$1,019	$797	$918
Prescription medications	$285	$353	$348	$351	$340	$262	$311
Total	$42,731	$36,743	$36,663	$37,539	$37,192	$30,231	$36,609

* Includes general practitioner, specialist, allied health, pathology and other outpatient services.

** Includes residential aged care, transitional care services, and home car

Supplementary Table 8. Costs per person in the short-term after intracerebral haemorrhage by age and stroke type

	<65 years	65-69 years	70-74 years	75-79 years	80-84 years	85+ years	All ages
				First-ever intracerebral haemorrhage			
Ambulance	$1,243	$1,275	$1,292	$1,339	$1,372	$1,207	$1,299
Emergency department	$2,975	$2,965	$2,945	$2,452	$2,338	$1,895	$2,520
Acute admission	$47,620	$29,296	$29,631	$17,122	$16,247	$14,241	$25,427
Inpatient rehabilitation	$14,078	$10,773	$10,444	$9,667	$8,774	$3,973	$9,924
Palliative care	$1,263	$1,672	$1,629	$436	$409	$854	$780
Other subacute care	$2,214	$1,573	$1,555	$2,190	$2,071	$2,448	$2,171
Outpatient services*	$708	$975	$949	$897	$823	$736	$812
Prescription medications	$136	$169	$164	$168	$153	$109	$148
Total	$70,238	$48,698	$48,608	$34,270	$32,187	$25,461	$43,081
				Recurrent intracerebral haemorrhage			
Ambulance	$1,262	$1,283	$1,278	$1,341	$1,356	$1,206	$1,312
Emergency department	$2,992	$3,012	$2,846	$2,464	$2,219	$1,894	$2,381
Acute admission	$39,286	$27,566	$25,007	$16,440	$14,752	$10,761	$17,836
Inpatient rehabilitation	$13,059	$11,311	$9,317	$9,541	$7,382	$4,218	$8,489
Palliative care	$1,172	$1,765	$1,509	$454	$388	$901	$636
Other subacute care	$2,137	$1,610	$1,500	$2,213	$1,947	$2,420	$2,136
Outpatient services*	$667	$1,019	$855	$907	$726	$735	$808
Prescription medications	$128	$177	$147	$170	$133	$109	$145
Total	$60,703	$47,744	$42,458	$33,529	$28,904	$22,244	$33,744

* Includes general practitioner, specialist, allied health, pathology and other outpatient services

** Includes residential aged care, transitional care services, and home care

Supplementary Table 9. Costs per person in the short-term after undetermined stroke by age and stroke type

	<65 years	65-69 years	70-74 years	75-79 years	80-84 years	85+ years	All ages
				First-ever undetermined stroke			
Ambulance	$1,159	$1,136	$1,271	$1,172	$1,237	$1,262	$1,219
Emergency department	$2,144	$3,087	$3,088	$1,939	$1,936	$2,013	$2,192
Acute admission	$12,217	$32,758	$32,765	$10,867	$10,850	$11,000	$14,713
Inpatient rehabilitation	$1,035	$2,554	$2,554	$2,116	$2,116	$570	$1,337
Palliative care	$884	$1,744	$1,744	$1,316	$1,314	$2,145	$1,669
Other subacute care	$944	$1,486	$1,486	$3,605	$3,605	$1,261	$1,798
Outpatient services*	$791	$853	$854	$1,068	$1,067	$755	$851
Prescription medications	$288	$365	$365	$373	$373	$260	$309
Total	$19,464	$43,984	$44,127	$22,457	$22,498	$19,265	$24,087
				Recurrent undermined stroke			
Ambulance	$1,155	$1,123	$1,258	$1,164	$1,224	$1,296	$1,239
Emergency department	$2,086	$2,943	$2,947	$1,897	$1,888	$2,308	$2,250
Acute admission	$15,113	$27,810	$27,829	$15,403	$15,357	$16,123	$17,351
Inpatient rehabilitation	$954	$2,438	$2,438	$1,942	$1,942	$576	$1,259
Palliative care	$740	$1,356	$1,356	$1,301	$1,294	$2,492	$1,859
Other subacute care	$1,088	$1,683	$1,683	$3,316	$3,316	$1,264	$1,929
Outpatient services*	$738	$794	$794	$996	$995	$889	$898
Prescription medications	$267	$336	$336	$345	$345	$314	$323
Total	$22,141	$38,483	$38,641	$26,363	$26,359	$25,263	$27,109

11.5.2 Long-term costs for first-ever strokes

Supplementary Table 10. Total costs for first-ever strokes

	Ischaemic stroke	Intracerebral haemorrhage	Undetermined stroke	Combined
Healthcare	$2,732,590,664	$312,022,797	$104,524,709	$3,149,138,170
Road ambulance	$232,161,425	$26,107,975	$9,941,799	$268,211,199
Hospital	$2,003,304,128	$238,925,456	$76,251,395	$2,318,480,980
Outpatient services	$295,227,715	$31,752,893	$11,432,694	$338,413,301
Medications	$201,897,397	$15,236,473	$6,898,821	$224,032,690
Productivity	$6,605,852,190	$845,849,179	$207,380,328	$7,659,081,697
Employment	$2,101,290,124	$391,332,740	$60,076,769	$2,552,699,633
Household productivity	$2,176,662,944	$222,643,225	$72,284,269	$2,471,590,438
Informal care	$2,327,899,122	$231,873,214	$75,019,290	$2,634,791,626
Total	$9,338,442,854	$1,157,871,976	$311,905,037	$10,808,219,867

Supplementary Table 11. Average costs for first-ever strokes

	Ischaemic stroke	Intracerebral haemorrhage	Undetermined stroke	Combined
Healthcare	$96,679	$87,890	$90,992	$95,534
Road ambulance	$8,214	$7,354	$8,655	$8,137
Hospital	$70,877	$67,300	$66,379	$70,335
Outpatient services	$10,445	$8,944	$9,952	$10,266
Medications	$7,143	$4,292	$6,006	$6,796
Productivity	$233,715	$238,258	$180,530	$232,351
Employment*	$74,344	$110,230	$52,298	$77,440
Household productivity	$77,010	$62,714	$62,925	$74,980
Informal care	$82,361	$65,314	$65,306	$79,931
Total	$330,393	$326,148	$271,522	$327,885

* Averages here include all strokes as a denominator (whereas productivity costs were only estimated for those in the typical working ages).

11.5.3 Long-term costs for recurrent strokes

Supplementary Table 12. Total costs for recurrent strokes

	Ischaemic stroke	Intracerebral haemorrhage	Undetermined stroke	Combined
Healthcare	$687,350,750	$77,320,887	$24,692,449	$789,364,086
Road ambulance	$62,963,920	$7,267,245	$2,570,029	$72,801,194
Hospital	$505,032,829	$58,478,827	$17,380,049	$580,891,705
Outpatient services	$70,955,040	$7,825,930	$2,978,687	$81,759,657
Medications	$48,398,961	$3,748,885	$1,763,685	$53,911,530
Productivity	$1,730,472,266	$203,542,001	$62,219,072	$1,996,233,339
Employment	$306,446,680	$53,536,017	$9,086,403	$369,069,100
Informal care	$636,514,326	$63,921,822	$23,247,710	$723,683,858
Household productivity	$787,511,260	$86,084,161	$29,884,959	$903,480,380
Total	$2,417,823,016	$280,862,888	$86,911,521	$2,785,597,425

Supplementary Table 13. Average costs for recurrent strokes

	Ischaemic stroke	Intracerebral haemorrhage	Undetermined stroke	Combined
Healthcare	$73,692	$61,382	$60,240	$71,780
Road ambulance	$6,750	$5,769	$6,270	$6,620
Hospital	$54,145	$46,424	$42,400	$52,823
Outpatient services	$7,607	$6,213	$7,267	$7,435
Medications	$5,189	$2,976	$4,303	$4,902
Productivity	$185,526	$161,584	$151,790	$181,526
Employment*	$32,855	$42,500	$22,167	$33,561
Informal care	$68,242	$50,745	$56,715	$65,808
Household productivity	$84,430	$68,339	$72,907	$82,157
Total	$259,218	$222,965	$212,029	$253,307

* Averages here include all strokes as a denominator (whereas productivity costs were only estimated for those in the typical working ages).

11.5.4 Long-term costs by stroke type and age

Supplementary Table 14. Total long-term healthcare costs for ischaemic stroke

Age group	First-ever stroke	Recurrent stroke
	3 – 12 months post-stroke	
<65 years	$108,289,156	$16,181,295
65-69 years	$59,157,204	$17,616,871
70-74 years	$50,916,262	$15,075,365
75-79 years	$68,332,163	$31,942,675
80-84 years	$42,364,264	$20,279,977
85+ years	$89,938,720	$35,917,056
All ages	$418,997,768	$137,013,237
	3 months – 5 years post-stroke	
<65 years	$403,862,295	$58,003,357
65-69 years	$219,500,693	$60,405,582
70-74 years	$188,332,879	$51,536,515
75-79 years	$241,980,114	$107,154,013
80-84 years	$134,533,115	$60,829,196
85+ years	$194,600,162	$75,617,173
All ages	$1,382,809,257	$413,545,836
	3 months post-stroke – end of life	
<65 years	$1,118,911,943	$151,965,057
65-69 years	$474,746,184	$121,589,682
70-74 years	$358,215,912	$91,536,966
75-79 years	$385,964,736	$161,920,060
80-84 years	$179,671,759	$77,655,949
85+ years	$215,080,131	$82,683,037
All ages	$2,732,590,664	$687,350,750

Supplementary Table 15. Long-term average healthcare costs for ischaemic stroke

Age group	First-ever stroke	Recurrent stroke
	3 – 12 months post-stroke	
<65 years	$16,187	$16,361
65-69 years	$15,963	$16,635
70-74 years	$15,638	$16,210
75-79 years	$15,665	$15,979
80-84 years	$14,991	$15,660
85+ years	$12,116	$11,761
All ages	$14,825	$14,692
	3 months – 5 years post-stroke	
<65 years	$60,368	$58,648
65-69 years	$59,228	$57,040
70-74 years	$57,842	$55,416
75-79 years	$55,475	$53,604
80-84 years	$47,605	$46,972
85+ years	$26,216	$24,760
All ages	$48,926	$44,343
	3 months post-stroke – end of life	
<65 years	$167,251	$153,655
65-69 years	$128,102	$114,816
70-74 years	$110,017	$98,427
75-79 years	$88,483	$81,001
80-84 years	$63,578	$59,966
85+ years	$28,975	$27,074
All ages	$96,684	$73,703

Supplementary Table 16. Total long-term healthcare costs for intracerebral haemorrhage

Age group	First-ever stroke	Recurrent stroke
	3 – 12 months post-stroke	
<65 years	$14,055,095	$1,797,109
65-69 years	$1,528,044	$419,269
70-74 years	$1,304,947	$348,388
75-79 years	$13,542,330	$6,250,438
80-84 years	$7,736,701	$3,463,295
85+ years	$4,142,847	$1,874,068
All ages	$42,309,963	$14,152,568
	3 months – 5 years post-stroke	
<65 years	$53,678,624	$6,551,410
65-69 years	$5,793,437	$1,517,635
70-74 years	$4,927,684	$1,253,025
75-79 years	$48,882,199	$21,673,680
80-84 years	$24,971,182	$10,662,126
85+ years	$8,950,991	$3,895,570
All ages	$147,204,118	$45,553,445
	3 months post-stroke – end of life	
<65 years	$163,494,505	$18,395,045
65-69 years	$13,040,511	$3,275,114
70-74 years	$9,742,890	$2,377,416
75-79 years	$81,300,983	$34,737,049
80-84 years	$34,481,643	$14,262,939
85+ years	$9,962,265	$4,273,324
All ages	$312,022,797	$77,320,887

Supplementary Table 17. Long-term average healthcare costs for intracerebral haemorrhage

Age group	First-ever stroke	Recurrent stroke
3 – 12 months post-stroke		
<65 years	$14,764	$14,150
65-69 years	$14,019	$13,525
70-74 years	$13,593	$12,903
75-79 years	$11,755	$11,838
80-84 years	$10,357	$10,127
85+ years	$8,386	$9,232
All ages	$11,918	$11,250
3 months – 5 years post-stroke		
<65 years	$56,385	$51,586
65-69 years	$53,151	$48,956
70-74 years	$51,330	$46,408
75-79 years	$42,432	$41,049
80-84 years	$33,429	$31,176
85+ years	$18,119	$19,190
All ages	$41,466	$36,211
3 months post-stroke – end of life		
<65 years	$171,738	$144,843
65-69 years	$119,638	$105,649
70-74 years	$101,488	$88,052
75-79 years	$70,574	$65,790
80-84 years	$46,160	$41,705
85+ years	$20,167	$21,051
All ages	$87,894	$61,463

Supplementary Table 18. Total long-term healthcare costs for undetermined stroke

Age group	First-ever stroke	Recurrent stroke
	3 – 12 months post-stroke	
<65 years	$3,034,205	$365,364
65-69 years	$1,571,295	$364,461
70-74 years	$1,380,710	$320,255
75-79 years	$2,237,042	$930,316
80-84 years	$1,435,332	$597,482
85+ years	$4,837,873	$2,178,443
All ages	$14,496,457	$4,756,319
	3 months – 5 years post-stroke	
<65 years	$11,988,789	$1,441,724
65-69 years	$6,676,754	$1,419,830
70-74 years	$5,853,231	$1,245,937
75-79 years	$9,460,136	$3,519,626
80-84 years	$5,520,463	$2,047,876
85+ years	$12,287,239	$5,149,752
All ages	$51,786,610	$14,824,745
	3 months post-stroke – end of life	
<65 years	$35,801,145	$4,146,598
65-69 years	$16,433,332	$3,259,830
70-74 years	$12,652,498	$2,517,305
75-79 years	$17,041,145	$5,999,377
80-84 years	$8,185,211	$2,897,353
85+ years	$14,411,378	$5,871,986
All ages	$104,524,709	$24,692,449

Supplementary Table 19. Long-term average healthcare costs for undetermined stroke

Age group	First-ever stroke	Recurrent stroke
3 – 12 months post-stroke		
<65 years	$15,560	$13,049
65-69 years	$15,872	$13,016
70-74 years	$15,870	$12,810
75-79 years	$13,558	$12,404
80-84 years	$13,414	$12,194
85+ years	$9,793	$10,731
All ages	$12,639	$11,658
3 months – 5 years post-stroke		
<65 years	$61,481	$51,490
65-69 years	$67,442	$50,708
70-74 years	$67,279	$49,837
75-79 years	$57,334	$46,928
80-84 years	$51,593	$41,793
85+ years	$24,873	$25,368
All ages	$45,150	$36,335
3 months post-stroke – end of life		
<65 years	$183,596	$148,093
65-69 years	$165,993	$116,423
70-74 years	$145,431	$100,692
75-79 years	$103,280	$79,992
80-84 years	$76,497	$59,130
85+ years	$29,173	$28,926
All ages	$91,129	$60,521

Supplementary Table 20. Long-term total employment impacts for first-ever strokes occurring in 2023

Age group	Total PALYs lost*	Total cost of productivity loss	Average PALYs lost*	Average cost of productivity loss
0-19 years	978	$92,359,488	4.823	$455,666
20-24 years	318	$30,901,154	7.641	$743,125
25-29 years	1,282	$127,285,653	7.806	$775,277
30-34 years	1,279	$132,904,669	7.428	$772,098
35-39 years	3,483	$369,869,397	6.840	$726,321
40-44 years	2,807	$295,960,420	6.125	$645,854
45-49 years	5,189	$531,445,789	5.043	$516,465
50-54 years	3,903	$381,477,990	3.722	$363,730
55-59 years	4,793	$439,145,635	2.243	$205,568
60-64 years	1,818	$147,813,143	0.875	$71,158
65-69 years	68	$3,536,295	0.017	$903
All ages	25,916	$2,552,699,633	2.236	$220,255

* Only over the working lifetime (aged 18-67 years)

Supplementary Table 21. Long-term total employment impacts for recurrent strokes occurring in 2023

Age group	Total PALYs lost*	Total cost of productivity loss	Average PALYs lost*	Average cost of productivity loss
0-34 years	-	-	-	-
35-39 years	555	$58,963,705	7.633	$810,519
40-44 years	445	$46,876,625	6.790	$716,069
45-49 years	910	$93,273,785	5.604	$574,081
50-54 years	677	$66,183,615	4.088	$399,662
55-59 years	841	$77,053,172	2.441	$223,718
60-64 years	314	$25,564,376	0.938	$76,332
65-69 years	22	$1,153,820	0.020	$1,032
All ages	3,764	$369,069,100	0.342	33,561

* Only over the working lifetime (aged 18-67 years)

11.5.5 Stroke Care Coordinators and Clinical Nurse Consultants

Supplementary Table 22. Median FTE Stroke Care Coordinators and Clinical Nurse Consultants per hospital

Admissions per year	Median FTE of Stroke Care Coordinators and Clinical Nurse Consultants per hospital
<75	0.4
75-199	0.5
200-349	1
350-499	1
500-999	1.5
1000+	2

FTE: Full time equivalent

Research partner

Sponsored by

Medtronic

Contact us

1300 194 196

strokefoundation.org.au

SF1754_0924