Projected stroke volumes to provide a 10-year direction for New Zealand stroke services

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ABSTRACT

AIMS: Stroke incidence and mortality are declining due to effective public health initatives and modern healthcare advances. However, due to population growth and ageing, the burden of stroke continues to rise worldwide. This paper aims to provide stroke volume projections for the next 1–2 decades and explores potential solutions to anticipated challenges.

METHODS: Health administrative, where available epidemiological, and New Zealand Statistics data was used to model stroke service demand up to 2028.

RESULTS: Despite improvements in stroke prevention and management, stroke volumes are projected to increase by 40% by 2028 due to population growth and, more importantly, ageing. Associated with this increase will be a need for more hospital beds and staff resources.

CONCLUSION: Efforts to optimise stroke service performance and, increasingly, stroke prevention are required to ensure that the New Zealand Health Service will be able to manage the increased volumes of patients. Better data is required to validate the presented figures, which are largely based on unvalidated health administrative data.

Stroke is a leading cause of death and disability worldwide.[1] In New Zealand, it has been estimated that around 8–9,000 people have a stroke each year and 50,000 people live with the consequences of stroke.[2] The current annual cost has been estimated to sit at $NZ 700 million.[3] Reducing the burden of stroke is a key goal to improve health outcomes in New Zealand.

Global and New Zealand stroke epidemiological studies have found important trends in stroke incidence and mortality over the past several decades.[4] When comparing New Zealand to other high-income countries, stroke incidence is relatively high. For example, the age-adjusted incidence rate is reported to be 119 per 100,000 in Auckland compared with 76 per 100,000 in Adelaide.[4] Mortality was also higher in New Zealand compared to other countries such as Australia. However, other less developed countries have incidence rates of 250 per 100,000.

The longitudinal Auckland Regional Community Stroke (ARCOS) studies have explored stroke incidence and mortality in the greater Auckland region over the past three decades and provide the most up-to-date high-quality local data.[5] Overall stroke incidence has decreased by 23% and stroke mortality by 62% from 1981 to 2012. Māori and Pacific groups had a slower rate of decline and continue to experience stroke at a significantly younger age (mean ages 60 and 62 years) compared with New Zealand Europeans (mean age 75 years). The 28-day stroke case fatality has also dropped by 14% and this was seen across all ethnic groups.

It is reassuring that modern day public health initiatives, primary care preventive strategies, and secondary and tertiary level acute health interventions have made a difference. However, in light of a growing and ageing population the burden of stroke is likely going to increase despite these advances and initiatives. In addition, just like there are international variations in stroke incidence one can anticipate that there are geographic variations within New Zealand not readily captured by the ARCOS data.

This paper uses health administrative data to define the current stroke incidence across New Zealand, exploring geographic variation, and will provide future projections based on epidemiological trends. Potential solutions to address future challenge will be explored and discussed.

Methods

Building a model

The New Zealand demand for stroke services is primarily based on the incidence and prevalence of stroke in New Zealand. These in turn are influenced by demographic changes, lifestyle changes, risk factor management and efficacy of post-stroke intervention over time. Other contributing factors that influence demand include baseline population growth. Complexity and availability of diagnostics and interventions also impacts demand. Supply of stroke services depends largely on the workforce availability, which depends on training, immigration and attrition/retirement, but is also influenced by use of technology and shifting models of care to potentially more efficient approaches to patient management. Figure 1 presents a graphic model summarising the factors that impact stroke volumes.

Data sources

Up-to-date nationwide New Zealand stroke audit or epidemiological data is not available. The analyses presented are based on Ministry of Health (MoH) National Minimal Dataset (NMDS) hospital discharge data. Over 95% of patients with stroke are now hospitalised, making the NMDS reasonably comprehensive, however data collection relies on hospital coders and does not undergo validation for accuracy introducing some limitation.[5] For this reason, data from the high-quality ARCOS studies will be referenced at times.[5] ARCOS data is limited to greater Auckland and is now several years old (last data collection 2011/12), making it unsuitable as the main data source for this project. International data is referenced also, but does not readily apply to New Zealand due to significant inter-country variations in stroke incidence.[4]

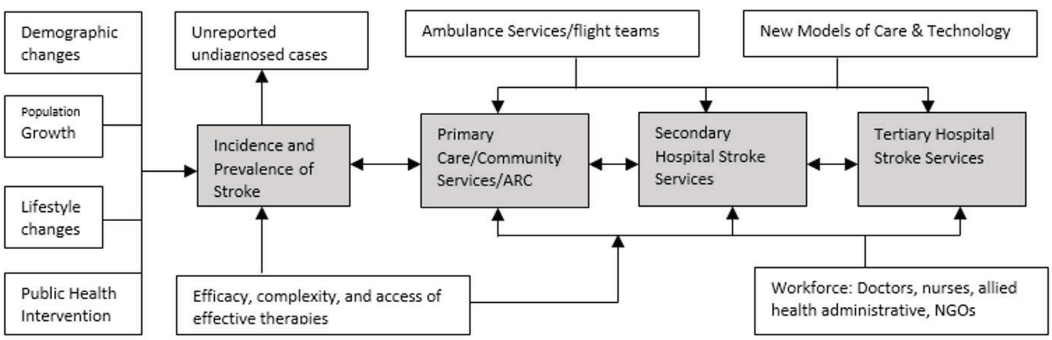
MoH data for the period from 1 July 2015 through 30 June 2016 (latest full financial year data available at the time of this analysis) was used to determine 'current' stroke volumes. Data is grouped by district health board (DHB) population, age and ethnicity.

Populations figures are based on the most recent (2013) national census data. Where available, New Zealand statistics projection estimates for 2015/16 were used (50^{th} percentile figures). DHB-stratified population data was only available for 2013 without published projections and thus the 2013 actual numbers had to be used for the DHB-based rate estimates.

The ARCOS data included for comparison purposes was collected 1 March 2011 through 29 February 2012.[6]

Stroke diagnoses included in this analysis are ICD-10-AM I61 (intracerebral haemorrhage), I63 (cerebral infarction) and I64 (stroke unspecified). Subarachnoid haemorrhage is excluded, as this is generally managed by neurosurgical rather than acute stroke services. TIA is excluded because many TIA patients are managed as outpa-

Figure 1: Proposed model for stroke service impact estimates.



tients and thus not captured in discharge data, resulting in too many missing data points to allow for accurate modelling.[7]

Modelling for future stroke services

Future stroke volume projections were modelled by adjusting for population growth by domicile and age. First, all of New Zealand data was calculated applying both the 2011/12 ARCOS stroke incidence rate and the 2015/16 raw MoH incidence rate by New Zealand population projections in five-year brackets until 2068. Then the current rate of strokes under versus over 65 years of age were calculated, thus arriving at current age-adjusted incidence rates. This allowed projection of stroke rates incorporating New Zealand statistics age bracket prediction for future years. This data was then compared to the ARCOS age-adjusted incidence figures.

Population growth will not occur evenly across New Zealand. To account for such geographic variation, locality specific predictions presented by New Zealand statistics over the next 20 years were explored. For each locality, growth over the next 10 and 20 years is expressed as a factor of 1.0. If the number is less than 1.0 it indicates a drop in population and if greater than 1.0 growth. The decimal digits indicate percentage change (for example 1.15 indicates a 15% growth and 0.95 a 5% drop).

Figures were normalised around 1.0 to depict relative growth difference between DHBs. These figures were then combined with age-adjusted growth to arrive at individual DHB projections for stroke admission volumes in 2028 and 2038. Because growth data by urban area was not available for DHBs, some assumptions had to be made. For example, it was assumed that the main urban centre in each DHB is the main driver of population change based on highest population volume. Generally speaking, the spread across localities within DHBs was minimal (eg, Palmerston North 1.06 and Feilding 1.05 in MidCentral DHB). Overall growth was normalised across all DHBs, meaning the total number of strokes remains accurate. However, it is possible that estimates are off by a few patients in either direction for each DHB.

Modelling future secondary stroke services

The estimates of hospital bed occupancy were derived by multiplying the stroke volumes per DHB by average length of stay (LOS) for acute (6 days)[8,9] and rehabilitation (21 days).[10,11] The rehabilitation figure was multiplied by 0.28 to reflect that on average only 28% of stroke patients are transferred to inpatient rehabilitation (2016/17 MoH DHB reporting data). Aged residential care bed requirements were estimated by multiplying the total number of strokes by 0.15 to reflect an average discharge rate of 15% to these facilitates[11–13] multiplied by the average duration patients reside at ARC facilities. A figure for this is not available specifically for stroke patients. General median LOS prior to dying or discharge was between 5 and 25 months depending on publication.[14] For the purposes of this analysis a figure of 12 months was used.

Final annual figures were divided by 365 days and multiplied by 0.15 to allow for optimum patient flow. This is a conservative figure with international work indicating that optimal patient flow to maximise cost-efficiency and patient safety is achieved by inflating bed numbers by up to 40%.[15] Flow is less critical in longer-stay facilities and ARC bed days were increased by only 5% accordingly.

Staffing levels can be estimated by looking at the number of patients admitted per year averaged per day, proportion of patients seen by a given clinician, duration of consultations, number of assessments per week, shift length and coverage (ie, number of shifts covered per day/week). Non-clinical/administrative time also needs to be factored in. There are available online stroke unit staff calculators available to assist with this (eg, http://www.stroke-education.org.uk/staff-calculators/).

Modelling for future tertiary services

Much of stroke care provided at New Zealand tertiary centres mimics the care provided at secondary hospitals. A notable exception is endovascular clot retrieval (ECR). This is a key new intervention provided by acute stroke services that is anticipated to have a significant impact on the future of stroke care provision. Clot retrieval modelling is complex due to several key features: (1) clot retrieval is time critical, needing to be commenced within hours of symptom onset;[16] (2) clot retrieval is technically challenging, requiring highly skilled interventionalists;[17] (3) clot retrieval needs to be available 24 hours per day to avoid treatment gaps requiring a 1:3–1:4 roster; and (4) clot retrieval volumes are relatively low, making it unfeasible to currently offer this service safely at more than three centres in New Zealand.

To achieve equitable provision of clot retrieval, the National Stroke Network has recently produced a National Clot Retrieval Strategy that identifies Auckland, Wellington and Christchurch as the three tertiary centres to offer this service until volumes increase to support a fourth centre. This paper explores projected clot retrieval numbers into the future.

Results

Current stroke volumes

As of 2015, the estimated New Zealand population overall was 4,567,000 people. Per the National Minimum Dataset data there were 8,450 stroke discharges (ICD10-AM I61, I63 and I64) in 2015, resulting in a hospital admission rate for stroke (primary discharge diagnosis) of 185/100,000. This data differs from the ARCOS data, which found a stroke incidence of 147/100,000 new stroke in 2011/2012 in the greater Auckland region. This discrepancy could be explained by several factors. Auckland is not representative of all of New Zealand; the discharge data contains coding errors, captures some people with stroke admissions that include readmissions for the same stroke event, or the ARCOS data missed some patients.

Because this report aims to provide an all of New Zealand perspective with a primary focus on health service utilisation to assist with service modelling, the MoH figures will be used although ARCOS figures will be referred to at times. The limitations are acknowledged and future studies should aim to provide better data to improve the accuracy of such models as are presented here.

Strokes are not evenly distributed across New Zealand. Table 1 shows the stroke admissions per 100,000 by DHB and Figure 2 shows ethnic distribution of stroke admissions by DHB.

The above regional differences correlate with high number of non-New Zealand European populations and likely social deprivation, but this was not explored in detail for this project.

Future stroke volume projections

Per New Zealand statistics, the population will grow to 5,389,700 by 2028, 5,769,800 by 2038, and 6,060,500 by 2048. If stroke incidence remains static, the associated volumes of stroke admissions per annum respectively can thus be anticipated: 9,972, 10,675, 11,213.

However, the population is ageing (see Figure 3) and accordingly one would expect an associated disproportionate increase over time rather than a static incidence across the population.

Adjusting for a disproportionate increase of patients >65 years of age and in light of the fact that 76% of stroke occur in this age group, a more accurate estimate would be the following admission volumes for 2028, 2038 and 2048 respectively: 11,828, 14,282 and 15,532. A breakdown of anticipated stroke volumes by age is depicted in Table 2.

There is also an anticipated growth of Māori and Pacific sub-populations. As the stroke incidence is higher in these ethnic groups (with earlier age of onset) these groups will become increasingly important to consider with an anticipated growth from 836 Māori and 470 Pacific stroke patients in 2015 to 976 Māori and 589 Pacific in 2028 and 1,195 Māori and 725 Pacific patients in 2038. Interestingly the ARCOS data suggests an even greater disparity with an anticipated 1,700 Māori and 1,180 Pacific stroke sufferers in 2028. However, there is no particularly disproportionate growth within this sub-population and the ethnicity spread was thus not further included in subsequent modelling.

Population growth is not evenly distributed. Auckland will experience the greatest growth with up to 72% increase in population in some localities over the next 20 years. Other areas will stay, by comparison, relatively stable (see Table 3).

Table 1: Current stroke volumes by DHB.

DHB	Strokes*	Population†	Strokes per 100K
Auckland	553	436,341	127
Bay of Plenty	422	205,995	205
Canterbury	874	482,178	181
Capital and Coast	389	283,704	137
Counties Manukau	697	469,293	149
Hawkes Bay	303	151,692	200
Hutt Valley	202	138,378	146
Lakes	192	98,187	196
MidCentral	247	162,564	152
Nelson Marlborough	235	136,995	172
Northland	352	151,692	232
South Canterbury	100	55,626	180
Southern	489	297,423	164
Tairawhiti	68	43,653	156
Taranaki	182	109,752	166
Waikato	723	359,310	201
Wairarapa	81	41,112	197
Waitemata	872	525,555	166
West Coast	52	32,148	162
Whanganui	128	60,120	213
Overseas	70		
Grand total	**7,231**	**4,241,718**	**170**

*NMDS figures for 12 months starting 1 July 2015.
†Statistics NZ figures for DHB population based on 2013 census data.

Figure 2: Ethnic distribution by DHB.

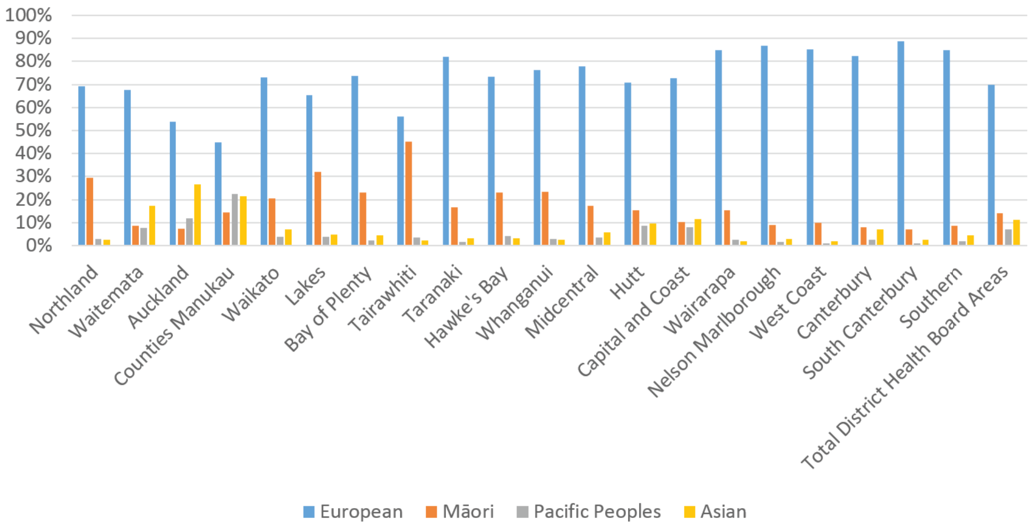


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Figure 3: New Zealand Population age estimated 2008–2068.

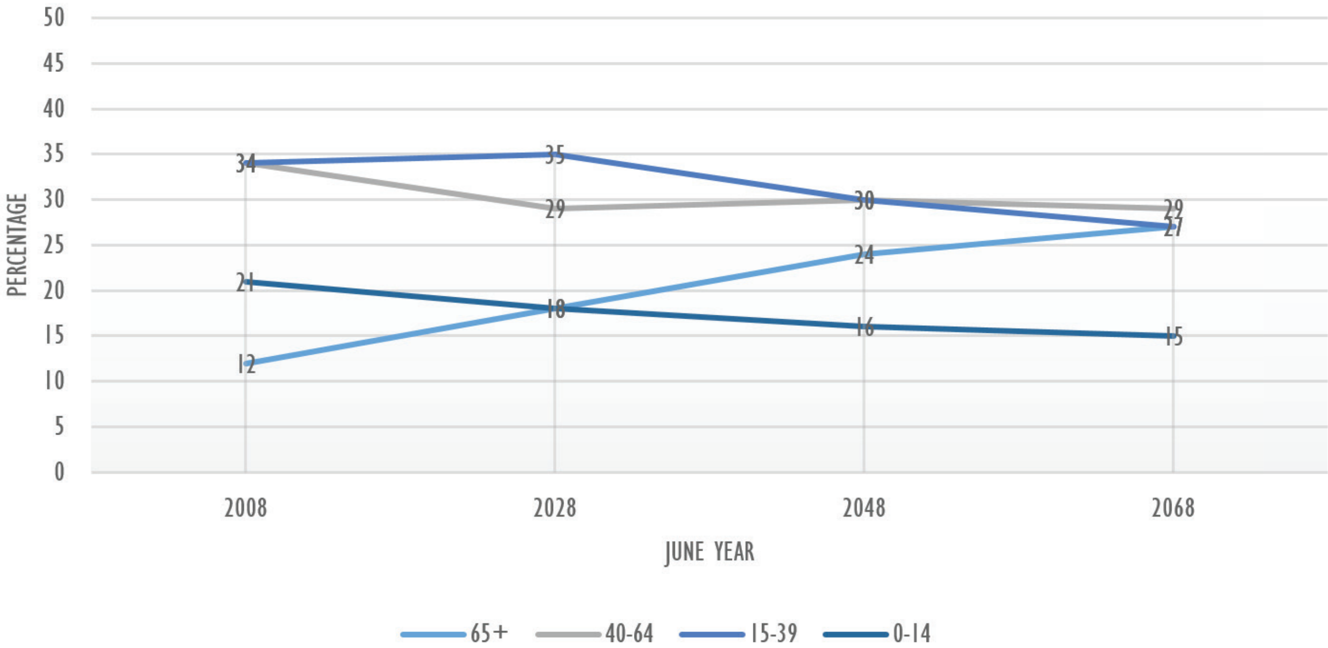

Table 2: Projected stroke volumes adjusted by age.

		Aged 0 to 64			**Aged 65+**		
Year	Total people	Population	Strokes		Population	Strokes	
			ARCOS	MoH		ARCOS	MOH
2016	4,693,000	3,994,700	2,197	2,028	698,400	4,770	6,422
2018	4,864,600	4,116,800	2,264	2,090	747,900	5,108	6,877
2023	5,157,900	4,272,200	2,350	2,169	885,700	6,049	8,144
2028	5,389,700	4,344,700	2,390	2,206	1,045,000	7,137	9,609
2033	5,595,000	4,413,000	2,427	2,240	1,182,000	8,073	10,869
2038	5,769,800	4,466,400	2,457	2,267	1,303,400	8,902	11,985
2043	5,923,100	4,552,900	2,504	2,311	1,370,200	9,358	12,599
2048	6,060,500	4,634,800	2,549	2,353	1,425,800	9,738	13,111
2053	6,184,600	4,681,100	2,575	2,376	1,503400	10,268	13,824
2058	6,299,600	4,662,400	2,564	2,367	1,637,200	11,182	15,055
2063	6,409,400	4,651,700	2,558	2,362	1,757,700	12,005	16,163
2068	6,515,800	4,677,700	2,573	2,375	1,838,100	12,554	16,902

Table 3: Population growth by geographic location over next 20 years.

	Total people, all ages						
	2013	2018	Growth	2028	Growth	2038	Growth
Main urban area	3,227,600	3,459,400	1.07	3,798,400	1.18	4,095,100	1.27
Whangarei	53,600	55,000	1.03	56,800	1.06	57,600	1.07
Auckland	1,381,800	1,522,400	1.10	1,743,800	1.26	1,952,000	1.41
Hamilton	214,800	233,000	1.08	259,700	1.21	284,200	1.32
Tauranga	125,700	135,500	1.08	153,900	1.22	171,500	1.36
Rotorua	55,800	56,100	1.01	56,000	1.00	54,400	0.97
Gisborne	35,200	36,100	1.03	37,100	1.05	37,400	1.06
Napier-Hastings	127,600	131,700	1.03	135,400	1.06	136,000	1.07
New Plymouth	54,800	57,900	1.06	61,600	1.12	64,300	1.17
Wanganui	39,300	39,000	0.99	38,300	0.97	36,600	0.93
Palmerston North	81,500	84,500	1.04	89,400	1.10	93,400	1.15
Kapiti	40,700	42,100	1.03	44,800	1.10	47,100	1.16
Wellington	389,600	404,500	1.04	423,200	1.09	435,400	1.12
Nelson	63,300	66,600	1.05	70,400	1.11	72,400	1.14
Blenheim	30,100	30,900	1.03	31,900	1.06	32,100	1.07
Christchurch	369,200	395,400	1.07	424,300	1.15	448,200	1.21
Dunedin	115,100	118,000	1.03	120,400	1.05	121,300	1.05
Invercargill	49,300	50,600	1.03	51,400	1.04	51,100	1.04
Secondary urban area	249,000	260,100	1.04	272,100	1.09	280,100	1.12
Pukekohe (AKL)	27,800	32,100	1.15	39,300	1.41	47,800	1.72
Tokoroa	13,400	13,300	0.99	12,600	0.94	11,400	0.85
Taupo	23,100	23,600	1.02	23,800	1.03	23,300	1.01
Whakatane	18,700	18,700	1.00	18,500	0.99	17,800	0.95
Hawera	11,600	12,000	1.03	12,400	1.07	12,600	1.09
Feilding	15,400	16,200	1.05	16,600	1.08	16,700	1.08
Levin	20,100	20,300	1.01	20,000	1.00	19,200	0.96
Masterton	20,700	21,200	1.02	21,400	1.03	20,900	1.01
Greymouth	9,900	10,000	1.01	9,900	1.00	9,400	0.95
Rangiora (ChCh)	15,700	17,000	1.08	18,900	1.20	20,400	1.30
Ashburton	19,200	20,600	1.07	21,700	1.13	22,600	1.18
Timaru	28,000	28,500	1.02	28,700	1.03	28,300	1.01
Oamaru	13,400	13,700	1.02	13,800	1.03	13,700	1.02
Queenstown	12,100	13,000	1.07	14,500	1.20	15,700	1.30
Minor urban area	351,700	368,100	1.05	381,600	1.09	387,700	1.10
Rural centre	75,400	78,600	1.04	80,900	1.07	81,300	1.08
Other	538,500	572,200	1.06	619,800	1.15	655,000	1.22

Table 4: Stroke volumes (age adjusted) by DHB accounting for regional variation in projected population growth.

	Current stats 2015		Population growth by 2028		Projected stroke volumes (age adjusted) by 2028			2015 to 2028
DHB	Population	Strokes	Age unadjusted	Age adjusted	Locality* unadjusted	Locality adjusted	Difference	% Change
Auckland	436,341	553	1.1	1.0402	773	758	-15	37%
Bay of Plenty	205,995	422	1.08	1.02	590	602	12	43%
Canterbury	482,178	874	1.07	1.01	1,222	1,235	12	41%
Capital and Coast	283,704	389	1.04	0.98	544	533	-11	37%
Counties Manukau	469,293	697	1.1	1.04	975	955	-19	37%
Hawkes Bay	151,692	303	1.03	0.97	424	411	-13	36%
Hutt Valley	138,378	202	1.04	0.98	282	294	11	46%
Lakes	98,187	192	1.01	0.95	268	255	-13	33%
MidCentral	162,564	247	1.04	0.98	345	335	-10	36%
Nelson Marlborough	136,995	235	1.05	0.99	329	325	-3	38%
Northland	151,692	352	1.07	1.01	492	497	5	41%
South Canterbury	55,626	100	1.02	0.96	140	134	-6	34%
Southern	297,423	489	1.03	0.97	684	684	0	40%
Tairawhiti	43,653	68	1.03	0.97	95	90	-5	32%
Taranaki	109,752	182	1.06	1	255	255	0	40%
Waikato	359,310	723	1.08	1.02	1,011	1,031	20	43%
Wairarapa	41,112	81	1.02	0.96	113	109	-5	35%
Waitemata	525,555	872	1.1	1.04	1,219	1,268	49	45%
West Coast	32,148	52	1.01	0.95	73	71	-2	37%
Whanganui	60,120	128	0.99	0.93	179	167	-12	30%
Overseas		70			98	102	+4	46%
Grand total	**4,241,718**	**7,231**	**1.05**	**1.0**	**10,112**	**10,112**	**0**	**40%**

*Locality adjusted = volumes adjusted by age and population growth taking into account variation in population growth across the country.

While some especially large urban centres will experience disproportionate population growth, the effect of ageing of the population represents a more significant driver of projected stroke volumes than other factors such as immigration. Table 4 projects DHB-based stroke volumes in 2028 adjusting for both age- and locality-specific anticipated growth—some of which is driven by immigration.

Projected stroke-related resource needs

Based on these projected figures, estimates on anticipated bed requirements and staffing levels are possible. Table 5 shows some staffing estimates for 2028. This list is not exhaustive, focuses on only some professional groups limited to acute inpatient care, and is based on untested assumptions around the time spent with patients per day. This is illustrated as a potential tool to develop comprehensive workforce strategies, but requires further validation before using this data to guide service implementation.

Projected regional tertiary stroke volumes

Regional services will have to be formalised by 2028 to ensure New Zealanders can access endovascular clot retrieval.

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Table 5: Projected institutional stroke resource needs by 2028.

DHB	Stroke in 2028	Acute beds	Rehab beds	ARC	Medical (FTE)*	CNS (FTE)	PT (FTE)
Auckland	758	14.6	14.3	119	1.9	2.3	1.7
Bay of Plenty	602	11.2	10.9	95	1.5	1.8	1.3
Canterbury	1,235	23.1	22.6	194	3	3.7	2.7
Capital and Coast	533	10.3	10.1	84	1.3	1.6	1.2
Counties Manukau	955	18.4	18.1	150	2.4	2.9	2.2
Hawkes Bay	411	8	7.8	65	1	1.3	1
Hutt Valley	294	5.3	5.2	46	0.7	0.9	0.6
Lakes	255	5.1	5	40	0.7	0.8	0.6
MidCentral	335	6.5	6.4	53	0.8	1	0.8
Nelson Marlborough	325	6.2	6.1	51	0.8	1	0.7
Northland	497	9.4	9.2	78	1.2	1.5	1.1
South Canterbury	134	2.6	2.6	21	0.3	0.4	0.3
Southern	684	12.9	12.7	108	1.7	2.1	1.5
Tairawhiti	90	1.8	1.8	14	0.2	0.3	0.2
Taranaki	255	4.8	4.7	40	0.6	0.8	0.6
Waikato	1,031	19.1	18.7	162	2.5	3.1	2.3
Wairarapa	109	2.1	2.1	17	0.3	0.3	0.3
Waitemata	1,268	23.1	22.6	200	3	3.7	2.7
West Coast	71	1.4	1.3	11	0.2	0.2	0.2
Whanganui	167	3.4	3.3	26	0.4	0.5	0.4
Overseas	102	1.9	1.8	16	0.2	0.3	0.2
Grand total	**10,112**	**191.3**	**167.3**	**1,593**	**24.9**	**30.6**	**22.8**

*FTE = Full time equivalents based on a 40-hour work week = 1.0 FTE; ARC = aged residential care; CNS = clinical nurse specialist; PT = physiotherapist.

Clot retrieval treatment volumes can best be estimated by looking at intravenous alteplase treatment rates. This is because approximately one-third to one-fourth of alteplase-treated patients are eligible for clot retrieval. This number needs to be increased by 10–20% to account for the patients who are not eligible for alteplase but were still included in some of the studies (eg, patients presenting after the 4.5 hour intravenous alteplase window or who were taking dabigatran).

Intravenous thrombolysis treatment numbers in 2015 were 125 in the Northern, 101 in the Midland, 103 in the Central, and 76 in the South Island Regions.[18] Based on these figures, and using the above assumptions, one would expect 50 patients to be treated with clot retrieval in the Northern region, 40 patients in the Midland and Central regions and 30 in the Southern region, per year, without any change in current thrombolysis rates.

These numbers will increase over the next 10 years for at least two reasons. Firstly, as presented above, stroke volumes will increase. Second, with greater regional organisation, access to acute therapies including thrombolysis and clot retrieval will increase as was demonstrated in the Telestroke Pilot evaluation.[19] See Table 6 for projections. This is corroborated by data from a South Australian study,[20] that estimates that 7% of ischaemic stroke patients are eligible. Based on current volumes this would mean about 400 clot retrieval-eligible patients in New Zealand now and 500 in 2028.

Table 6: Projected stroke and clot retrieval volumes by DHB in 2028.

DHB	All stroke	Ischaemic strokes	tPA if 10%†	Clot retrieval volumes at 10% tPA rates	tPA (20%)††	Clot retrieval volumes at 20% tPA rates
Northern Region						
Northland	497	424	42	14	85	28
Waitemata	1,268	992	99	33	198	66
Counties Manukau	955	779	78	26	156	52
Auckland	758	643	64	21	129	43
Total	3,479	2,839	284	95	568	189
Midland Region						
Bay of Plenty	602	518	52	17	104	35
Waikato	1,031	863	86	29	173	58
Lakes	255	219	22	7	44	15
Taranaki	255	221	22	7	44	15
Tairawhiti	90	77	8	3	15	5
Total	2,234	1,899	190	63	380	127
Central Region						
Whanganui	167	133	13	4	27	9
Hawkes Bay	411	351	35	12	70	23
Wairarapa	109	93	9	3	19	6
MidCentral	335	292	29	10	58	19
Hutt Valley	294	247	25	8	49	16
Capital and Coast	533	399	40	13	80	27
Total	1,849	1,514	151	50	303	101
South Island						
South Canterbury	134	106	11	4	21	7
Nelson Marlborough	325	274	27	9	55	18
Southern	684	659	66	22	132	44
West Coast	71	60	6	2	12	4
Total	1,214	1,098	110	37	220	73
Grand total	**10,112**	**8,470**	**847**	**282**	**1,694**	**565**

†IV tPA = intravenous tissue plasminogen activator refers to 'thrombolysis' depicting projected volumes assuming a 10% rate (current national target).
†† Thrombolysis rates will increase through improved access via use of telestroke and other changes in model of care resulting in a likely much higher rate of around 20% in 2028 used in the subsequent column to provide a less conservative projections of anticipated clot retrieval volumes for 2028. These are not actual thrombolysis volumes. Each DHB is aware of their own current volumes and can use the above table to estimate current clot retrieval volumes based on their actual thrombolysis rate.

Furthermore, very recent studies already indicate that patient inclusion criteria will expand over time, resulting in more patients being eligible for this intervention.[21] The impact of this remained uncertain at the time of submission of this paper and accordingly was not included in the below table.

As explained in the Methods section, centralisation of clot retrieval services in New Zealand is unavoidable. It is vital therefore that regional hyperacute stroke pathways are established so that there is equitable provision of acute stroke therapy across the country, rather than simply being available to populations living close to large tertiary hospitals. Achieving this will require systems reorganisation across all district health boards, in partnership with ambulance service providers.

New stroke models of care

Technological and scientific advances in the past three decades have seen the development of more specialised inter-disciplinary stroke units, although it is not always possible to offer these in small rural centres.

A number of studies have shown that decentralised thrombolysis services (telestroke, mobile stroke units, local stroke-ready health centres) can achieve similar thrombolysis rates and door-to-needle times for rural populations as a centralised system can achieve for an urban population.[19,22] However, especially in the metropolitan setting when one includes other key therapeutic components and considers both patient outcomes and cost-efficiency, centralised systems tend to fare better.[23]

An example of this was the London Hyper-Acute Stroke Model, which consolidated the treatment of all early-phase (first 72 hours) acute stroke patients in London previously treated at 30 local hospitals into eight specialised high-volume centres designated hyperacute stroke units, or “HASUs”. Paramedic crews would no longer bring suspected acute stroke patients to their local hospital by ambulance, but instead to the nearest HASU, driving past multiple local hospitals that previously would have received them and even bypassing emergency departments.

An evaluation found that this new model of care resulted in a 25% reduction in mortality rates, marked improvement in processes of care, a rise in thrombolysis rate from 4% in 2010 to 11% in mid-2012, all while the costs of treating each stroke patient were reduced by 6%.[24]

Despite London’s unpredictable traffic conditions, 98% of patients arrive at the HASU within 30 minutes of being picked up by ambulance. Reports from patients about their experience with the new pathway have been largely positive even considering being cared for ‘further away from home’.[24,25]

A similar model is currently being implemented at night and on weekends in Auckland. Additional infrastructure and coordination resources are required to achieve this change in model of care, but it is well justified based on available data. Another area within New Zealand that would likely benefit from such collaborative centralisation is the Wellington metropolitan area by combining Hutt Valley and Capital & Coast DHB stroke services.

The value of centralisation in more rural areas remains uncertain. Because care is becoming more complex, access to specialists is becoming more important and the use of telemedicine for both acute stroke and rehabilitation will help bridge this gap as has already been demonstrated.[19] Reducing clinician and patient travel times is also of benefit from an economic perspective, freeing up resources for other activities as patient volumes increase.

Use of registries and mobile devices can also help connect clinicians, monitor patient outcomes and service performance, and assist with ongoing service improvement to drive positive change. This will become increasingly important as volumes and patient complexity rise.

Stroke rehabilitation services have had limited attention over the past decades. To improve rehabilitation efficiency, inter-disciplinary teams need to be fully staffed and include all required professional groups to offer comprehensive and timely therapy. Similarly, investing more resources into community stroke services to support earlier and better support of patients in the community will help to reduce rehabilitation bed demand. New models of care, including the use of telerehabilitation to link patients in their homes to practitioners, alternate providers (eg, therapy assistants) and increasingly, self-care strategies, need to be developed and implemented in the stroke rehabilitation space.

It has been suggested that 90% of the world's stroke burden is attributable to modifiable risk factors and that achieving control of behavioural and metabolic risk factors could avert more than three-quarters of strokes worldwide. In Oceania, the top five modifiable risk factors contributing to the stroke burden were high blood pressure, high body mass index, diet low in fruits, smoking and diet low in vegetables in order of impact.[26] National policy changes and public awareness campaigns as well as new ideas as to how to best address these issues are vitally needed.

Finally, with increased complexity of care, care pathways, integration of care, and clear and open discussions around ceilings of care and advanced care planning are harder investments to quantify but should not be forgotten.

Discussion

Based on the available data, stroke incidence and mortality has reduced over the past three decades although internationally New Zealand stroke outcome performance lags behind other OECD countries. The New Zealand population is growing and ageing, and if further reductions in stroke incidence are not achieved stroke volumes can be anticipated to increase by 40% from 7,231 in 2015 to 10,112 in 2028.

Care will be further complicated by a disproportionate growth in volumes in rural areas with high degrees of social deprivation and disadvantaged ethnic population. There will also be an increasing need to centralise stroke services due to the complexity of modern stroke therapies.

Centralisation is inevitable in metropolitan areas and requires technology support in geographically dispersed areas to ensure that the disparity gap does not widen further.

Improving access to acute intervention and rehabilitation services is essential to ensure mortality and disability continue to decline and minimise the societal (and individual) impacts of the New Zealand's increasing stroke burden. Upfront investments in these interventions, including workforce development, will maximise the possibility of containing health service resource requirements within capacity.

Investments in prevention will become increasingly important. We need to achieve a 30% reduction in stroke incidence to keep stroke volumes stable. This will require public policy consideration and massive public awareness campaigns.

This report has several limitations. The greatest limitation is that the main data source is ICD-10-AM hospital coding data that has not been validated. Coding errors are common in these types of data sources and thus the data has to be interpreted keeping this in mind. Prospectively collected proper epidemiological or registry data is not available in New Zealand beyond the Auckland region and even that data is now six years old. International data is too dissimilar to be used in its place. Also, data obtained from New Zealand statistics population data does not always correlate well with the NMDS data as regards time frames or localities, and potential inaccuracies are possible introducing further errors. Much of the projections are based on assumptions and hypothetical scenarios. New Zealand data on models of care is limited. Telestroke and stroke unit care have been found to be effective.[19,27] However, there is no data around centralisation of stroke care, comparative analyses of different models of stroke unit care, or service models such as early supportive discharge in New Zealand. This makes extrapolations to the New Zealand setting tenuous and better New Zealand data is needed.

Conclusion

New Zealand stroke care improvements are not as prominent as in other OECD countries, but significant improvement has certainly been observed and more recent efforts will not be captured in the presented data. Nonetheless, while incidence rates have reduced, the anticipated population growth and ageing over the next decade will see a 40% increase in stroke admissions unless stroke incidence is further reduced through effective national primary prevention programmes. Long-term stroke burden due to disability and aged residential care requirements could be reduced through improved acute and rehabilitation stroke care, but this will require upfront service investments.

Competing interests:

Nil.

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