

CLINICAL AND POPULATION SCIENCES

Incidence of Stroke in the Aboriginal and Non-Aboriginal Populations of Australia: A Data Linkage Study

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BACKGROUND: Most estimates of stroke incidence among Aboriginal and Torres Strait Islander (hereinafter Aboriginal) Australians are confined to single regions and include small sample sizes. We aimed to measure and compare stroke incidence in Aboriginal and non-Aboriginal residents across central and western Australia.

METHODS: Whole-population multijurisdictional person-linked data from hospital and death datasets were used to identify stroke admissions and stroke-related deaths (2001–2015) in Western Australia, South Australia, and the Northern Territory. Fatal (including out-of-hospital deaths) and nonfatal incident (first-ever) strokes in patients aged 20–84 years were identified during the 4-year study period (2012–2015), using a 10-year lookback period to exclude people with prior stroke. Incidence rates per 100 000 population/year were estimated for Aboriginal and non-Aboriginal populations, age-standardized to the World Health Organization World Standard population.

RESULTS: In a population of 3 223 711 people (3.7% Aboriginal), 11 740 incident (first-ever) strokes (20.6% regional/remote location of residence; 15.6% fatal) were identified from 2012 to 2015, 675 (5.7%) in Aboriginal people (73.6% regional/remote; 17.0% fatal). Median age of Aboriginal cases (54.5 years; 50.1% female) was 16 years younger than non-Aboriginal cases (70.3 years; 44.1% female; $P < 0.001$), with significantly greater prevalence of comorbidities. Age-standardized stroke incidence in Aboriginal people (192/100 000 [95% CI, 177–208]) was 2.9-fold greater than in non-Aboriginal people (66/100 000 [95% CI, 65–68]) aged 20–84 years; fatal incidence was 4.2-fold greater (38/100 000 [95% CI, 31–46] versus 9/100 000 [95% CI, 9–10]). Disparities were particularly apparent at younger ages (20–54 years), where age-standardized stroke incidence was 4.3-fold greater in Aboriginal people (90/100 000 [95% CI, 81–100]) than non-Aboriginal people (21/100 000 [95% CI, 20–22]).

CONCLUSIONS: Stroke occurred more commonly, and at younger ages, in Aboriginal than non-Aboriginal populations. Greater prevalence of baseline comorbidities was present in the younger Aboriginal population. Improved primary prevention is required. To optimize stroke prevention, interventions should include culturally appropriate community-based health promotion and integrated support for nonmetropolitan health services.

GRAPHIC ABSTRACT: A [graphic abstract](#) is available for this article.

Key Words: Australia ■ Australian Aboriginal and Torres Strait Islander peoples ■ epidemiology ■ Indigenous Peoples ■ stroke

Aboriginal and Torres Strait Islander (hereafter respectfully referred to as Aboriginal) peoples experience substantial disparities in health outcomes, compared with non-Aboriginal Australians, strongly

influenced by the ongoing health and socioeconomic effects of colonization.¹ Life expectancy is 8 years less than in non-Aboriginal Australians overall, and 14 years less in remote and very remote regions. Cardiovascular

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Nonstandard Abbreviations and Acronyms

ICH	intracerebral hemorrhage
IS	ischemic stroke
NT	Northern Territory
SA	South Australia
SAH	subarachnoid hemorrhage
WA	Western Australia

disease accounts for the largest gap in death rates between Aboriginal and non-Aboriginal Australians.^{2,3} Although stroke incidence has been reported to be significantly greater in Aboriginal than non-Aboriginal Australians, data on stroke incidence by sex, age, remoteness of residence, and stroke type, are limited.^{4,5}

Studies of stroke incidence in Aboriginal Australians have only been conducted at single-jurisdiction or regional levels, often using different methodologies. Additionally, due to relatively small sizes of jurisdictional Aboriginal populations, urban-rural-remote, and age-specific estimates are often imprecise and aggregated. Using unlinked data, the Australian Institute of Health and Welfare has estimated that stroke hospitalization rates, a proxy for incidence, in Aboriginal Australians are about twice that of non-Aboriginal Australians (284 versus 147/100 000).⁶ In 2 single-jurisdiction data linkage studies, both stroke incidence and mortality in Aboriginal patients were about 2.5-fold that of non-Aboriginal people.^{5,7}

South Australia (SA), the Northern Territory (NT), and Western Australia (WA) are 3 of the 8 Australian states and territories (Figure S1). Together, they span 4.86 million square kilometers (3.02 million square miles),⁸ an area larger than the European Union. These jurisdictions are home to 27.2% of the Aboriginal Australian population (based on self-identification in the Census, adjusted for under-enumeration) and 18.4% of the total (Aboriginal and non-Aboriginal) Australian population.⁹ Using multi-jurisdictional linked hospital and mortality data from WA, SA, and NT enable interjurisdictional comparison between states with relatively large Aboriginal populations and comparison by remoteness of residence, identifying areas of need for improved health service provision. We aimed to compare age-specific and age-standardized stroke incidence in Aboriginal and non-Aboriginal populations of these jurisdictions. Secondary aims included determining stroke incidence by sex, remoteness of residence, and stroke types, and comparing case fatality and attack rates between the Aboriginal and non-Aboriginal population.

METHODS

This study was developed in response to Aboriginal community-identified priorities and undertaken with Aboriginal researcher involvement (coauthors A.B., O.P., A.D.S.) and

stakeholder oversight (Supplemental Methods S1). This project incorporates the use of third party data from the Australian Government, approved by Aboriginal and other government ethics committees. Any requests to share these data will be subject to formal approval from relevant ethics committees and data custodians.

Study Design

This retrospective study incorporated whole-of-population linked administrative hospital and mortality data.

Data Sources

We used whole-of-population person-linked hospitalization and death registry data from WA, SA, and NT from January 1, 2001 to December 31, 2015 to identify nonfatal and fatal stroke events (Supplemental Methods S2). Death registries from each jurisdiction capture all deaths, irrespective of location of death. Additional emergency department administrative data were used to help determine Aboriginal status and remoteness of residence (Figure S2). Aboriginal status in the hospitalization and emergency department datasets is determined by self-identification at the time of hospital presentation, and by medical practitioners and/or family in death records (Supplemental Methods S3). Data from all public hospitals in WA, SA, and NT, and private hospitals from WA, were included. SA and NT datasets were jointly linked, due to significant cross-jurisdictional flow of patients.

Definition of Stroke

Stroke was identified by *International Classification of Diseases-10 Australian Modification* codes from hospital and mortality records and classified into ischemic stroke (IS; I63), spontaneous intracerebral hemorrhage (ICH; I61, I62.9), nontraumatic subarachnoid hemorrhage (SAH; I60), and unspecified stroke (I64; Table S1).¹⁰ Transient ischemic attack, spontaneous extradural hematoma/subdural hematoma and traumatic ICH were excluded.¹¹

Case Definitions and Selection

The study cases comprised all residents of SA, NT, and WA aged 20 to 84 years (total population 3 223 711, 3.7% Aboriginal), with incident or recurrent stroke occurring during the calendar years 2012 to 2015. Stroke events comprised all hospitalizations for stroke identified using principal diagnosis fields and all deaths where stroke was identified as the underlying cause of death. To account for interhospital transfers, records where the admission date was within 1 day of the previous record's discharge date were deemed the same episode of care. Incident stroke events were defined as (1) first-ever admission to hospital from 2012 to 2015 with a discharge diagnosis of stroke as the main cause for admission (principal diagnosis field) with no previous hospitalization for stroke (any diagnosis field) using a 10-year lookback period, or (2) death from first-ever stroke (underlying cause of death), with no previous hospitalization for stroke (any diagnosis field) in the preceding 10 years. Where individuals had >1 stroke event within the study period, the first encounter was deemed the incident event. Readmission or death within 28 days was considered to be related to the

incident event, rather than a new stroke.¹² Fatal incident events were defined as (1) first-ever stroke resulting in death from any cause within 28 days from the admission date of the stroke hospitalization, (2) stroke death within 28 days of a non-stroke hospitalization, or (3) stroke death with no hospitalization in the prior 28 days. Nonfatal incident events comprised the remainder of cases. Recurrent stroke events were defined as nonincident stroke events within the study period, including subsequent hospital admissions with stroke, or death from stroke, >28 days after the admission date of the index event. Total stroke events included all incident and recurrent events within the study period.

Indigenous status was defined using an algorithm incorporating Indigenous identification from all available data sources (Supplemental Methods S3). Remoteness of residence was categorized using the postcode-based Accessibility/Remoteness Index of Australia, which categorizes regions according to relative access to services.¹³ The 5-category Accessibility/Remoteness Index of Australia strata were consolidated into 3 groups (metropolitan/inner-regional, outer-regional, and remote/very remote location of residence) to provide sufficient numbers of Aboriginal cases within each category, and to align with health service access. Hospitals were categorized into metropolitan (covering urban and most of inner-regional population catchments) and nonmetropolitan (rural and remote combined).

Comorbidities were identified from hospital records from the index admission and in the preceding 10 years (any diagnosis field), including atrial fibrillation, hypertension, diabetes, rheumatic heart disease, heart failure, coronary heart disease, peripheral artery disease, and chronic kidney disease (Table S1). Obesity, cigarette smoking, and dyslipidemia were excluded due to unreliable recording in administrative data.¹⁴ We used the Charlson Comorbidity Index, a weighted scoring system of predefined comorbidities, to measure overall comorbidity burden.¹⁵

Statistical Analysis

Baseline demographic data of Aboriginal and non-Aboriginal patients with incident stroke were compared using Student *t* test (continuous variables) and Fisher exact test (binary outcomes). Population denominators for incidence were determined by averaging mid-year estimates from the 2011 and 2016 Australian Bureau of Statistics censuses from the SA, NT, and WA resident populations, stratified by age, sex, and Indigenous status for each year of the study period.¹⁶ Age-standardized rates of stroke, including fatal and nonfatal incidence rates, and attack rates (incident and recurrent events combined) were calculated by the direct method by 5- and 10-year age groups per 100 000 population/y, standardized to the World Health Organization world population.¹⁷ Rates were calculated for whole-of-catchment, by sex and jurisdiction for cases aged 20-84 years, and for remoteness (Accessibility/Remoteness Index of Australia) for cases aged 20-54 years only, as denominator data by Accessibility/Remoteness Index of Australia were aggregated for the population aged ≥65 years. Homogeneity of measures was tested for age-specific rates (Supplemental Methods S4).

Age-standardized incidence rate ratios, with 95% CI, were calculated to compare Aboriginal and non-Aboriginal populations. Crude 28-day case fatality was determined by the

proportion of fatal incident events (numerator) of all incident stroke events (denominator). We also calculated age- and sex-standardized 28-day case fatality using the direct method by 5-year age group, with the age and sex distribution of all incident strokes as the standard. SAS 9.4 was used for data manipulation and rate calculations. Stata/BE17.0 was used for rate ratio calculations.

Ethics

Ethics approval for the use of de-identified linked records with a waiver of consent was obtained from all relevant Human Research Ethics Committees (HREC) including the Aboriginal HREC of SA (04-15-629), SA Department for Health and Wellbeing HREC (HREC/17/SAH/34), NT Department of Health and Menzies School of Health Research including the Aboriginal Ethics Sub-Committee (2017-2834), the Department of Health WA HREC (2016/17), WA Aboriginal Health Ethics Committee (690) and Monash University HREC (24-513), with support letters from Aboriginal services and stakeholders.

This research conforms to the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology)¹⁸ and American Heart Association disparities reporting guidelines (<https://www.ahajournals.org/disparities-research-guidelines>).

RESULTS

Of the 11 740 patients identified as having a first-ever stroke during the study period, 675 (5.7%) were Aboriginal and 11 065 (94.3%) were non-Aboriginal (Table 1). The median age of Aboriginal patients with first-ever stroke (54.5 years) was almost 16 years younger than non-Aboriginal patients (70.3 years, $P<0.001$; Table 1). The median age of stroke was substantially lower in patients living in remote/very remote regions compared with metropolitan/inner-regional areas; for Aboriginal people, this difference was most pronounced for fatal stroke (Table S2). A greater proportion of Aboriginal patients were female (50.1%) than non-Aboriginal patients (44.1%, $P=0.002$). Most Aboriginal patients (54.5%) resided in remote/very remote Australia; most non-Aboriginal patients (82.6%) resided in major cities. A greater proportion of Aboriginal patients (68.3%) received acute treatment in nonmetropolitan hospitals compared with non-Aboriginal patients (21.1%, $P<0.001$). While crude 28-day case fatality was similar between Aboriginal and non-Aboriginal patients (17.0% versus 15.6%, $P=0.30$), age-standardized case fatality in the Aboriginal cohort was nearly 2-fold that of the non-Aboriginal cohort (28.2% versus 15.3%, $P<0.001$; Table S3).

Risk Factors

Aboriginal patients with incident stroke had a significantly greater comorbidity burden as measured by the Charlson Comorbidity Index,¹⁵ than non-Aboriginal patients ($P<0.001$; Table 1). When restricted to those aged 20-54 years, prevalence of all traditional cardiovascular

Table 1. Baseline Demographic and Characteristics of Patients With Incident Stroke by Indigenous Status: WA, SA, and the NT 2012–2015

	Aboriginal; N=675 (5.7%)	Non-Aboriginal; N=11 065 (94.3%)	P value
	n (%)*	n (%)*	
Age, y			
Median (Q1–Q3)	54.5 (45.0–65.6)	70.3 (59.5–78.7)	<0.001
20–54 (%total)	338 (50.1%)	1942 (17.6%)	<0.001
Female	338 (50.1%)	4876 (44.1%)	0.002
Jurisdiction			
WA (%total)	336 (49.8%)	7005 (63.3%)	
SA/NT (%total)	339 (50.2%)	4060 (36.7%)	
Residence†			<0.001
Major cities/ inner-regional	178 (26.4%)	9145 (82.6%)	
Outer regional	129 (19.1%)	1452 (13.1%)	
Remote/very remote	368 (54.5%)	468 (4.2%)	
Hospital type‡			
Metropolitan	210 (31.1%)	8677 (78.4%)	<0.001
Nonmetropolitan	461 (68.3%)	2331 (21.1%)	<0.001
No hospital record§	<5 (0.6%)	57 (0.5%)	0.779
Comorbidities			
Charlson Comorbidity Index			<0.001
0	183 (27.1%)	3970 (35.9%)	...
1–2	224 (33.2%)	4601 (41.6%)	...
≥3	268 (39.7%)	2494 (22.5%)	...
Atrial fibrillation			
20–54 y	20 (5.9%)	56 (2.9%)	0.008
55–84 y	45 (13.4%)	1340 (14.7%)	0.531
Hypertension			
20–54 y	163 (48.2%)	676 (34.8%)	<0.001
55–84 y	186 (55.2%)	5143 (56.4%)	0.696
Diabetes			
20–54 y	134 (39.6%)	211 (10.9%)	<0.001
55–84 y	196 (58.2%)	2211 (24.2%)	<0.001
Valvular heart disease			
20–54 y	30 (8.9%)	36 (1.9%)	<0.001
55–84 y	11 (3.3%)	150 (1.6%)	0.032
Rheumatic heart disease			
20–54 y	17 (5.0%)	12 (0.6%)	<0.001
55–84 y	6 (1.8%)	32 (0.4%)	0.002
Heart failure			
20–54 y	11 (3.3%)	39 (2.0%)	0.158
55–84 y	337 (5.9%)	272 (3.0%)	0.005
Acute coronary syndrome			
20–54 y	6 (1.8%)	6 (0.3%)	0.004
55–84 y	7 (2.1%)	145 (1.6%)	0.502

(Continued)

Table 1. Continued

	Aboriginal; N=675 (5.7%)	Non-Aboriginal; N=11 065 (94.3%)	P value
	n (%)*	n (%)*	
Coronary heart disease			
20–54 y	16 (4.7%)	29 (1.5%)	<0.001
55–84 y	19 (5.6%)	280 (3.1%)	0.016
Peripheral artery disease			
20–54 y	6 (1.8%)	81 (4.2%)	0.031
55–84 y	<5 (1.2%)	151 (1.7%)	0.663
Chronic kidney disease			
20–54 y	57 (16.9%)	23 (1.2%)	<0.001
55–84 y	76 (22.6%)	389 (4.3%)	<0.001

Q1=first quartile; Q3=third quartile. ARIA+ indicates Accessibility/Remoteness Index of Australia; NT, Northern Territory; SA, South Australia; and WA, Western Australia.

*n (%) unless otherwise indicated.

†Determined by ARIA+.¹³

‡SA/NT=Public hospital data only.

§Death register only.

risk factors was significantly greater in Aboriginal than non-Aboriginal patients. The prevalence of rheumatic heart disease was >8-fold greater, and chronic kidney disease was almost 17-fold greater, in younger Aboriginal patients, compared with age-matched non-Aboriginal patients. The only exceptions were heart failure, which was nonsignificantly greater, and peripheral artery disease, which was lower in Aboriginal patients aged 20 to 54 years than non-Aboriginal patients of the same age.

Incidence Rates of Stroke

The age-standardized incidence of stroke in the total Aboriginal population (20–84 years) was 192/100 000 population/y (95% CI, 177–208), nearly 3-fold that of the total non-Aboriginal population (66/100 000 [95% CI, 65–68]). Similarly, fatal incidence rates were over 4-fold greater in the total Aboriginal population than in the non-Aboriginal population (38/100 000 [95% CI, 31–46] versus 9/100 000 [95% CI, 9–10]). In the younger population (20–54 years), age-standardized stroke incidence was over 4-fold greater in Aboriginal than non-Aboriginal Australians (90/100 000 [95% CI, 81–100] versus 21/100 000 [95% CI, 20–22]), and 5.5 for fatal stroke (11/100 000 [95% CI, 7–15] versus 2/100 000 [95% CI, 1–2]).

By Sex

Age-standardized incidence of stroke in the total Aboriginal population was nonsignificantly greater in Aboriginal males than females (206 versus 178/100 000), though the differential was less than for non-Aboriginal males and females (78 versus 57/100 000; Table 2). There were no detectable differences in the age-standardized rates

Table 2. Total Stroke Incidence Rates by Age Group, Sex, and Indigenous Status: Western Australia, South Australia, and the Northern Territory 2012–2015

Total incidence rates per 100 000 population/y																
Age, y	Aboriginal								Non-Aboriginal							
	Males				Females				Males				Females			
	Popula- tion	N	Rate	95%CI	Popula- tion	N	Rate	95%CI	Popula- tion	N	Rate	95% CI	Popula- tion	N	Rate	95% CI
20–34	26 792	30	28	18–38	25 158	24	24	14–33	476 358	115	6	5–7	451 821	105	6	5–7
35–44	12 852	55	107	79–135	13 330	55	103	76–130	294 967	292	25	22–28	287 545	254	22	19–25
45–54	10 022	80	200	156–243	11 173	94	210	168–253	287 934	700	61	56–65	285 904	476	42	38–45
55–64	5719	93	407	324–489	6586	62	235	177–294	245 077	1261	129	122–136	248 086	746	75	70–81
65–74	2169	56	646	477–815	2688	67	623	474–772	168 743	1722	255	243–267	171 962	1160	169	159–178
75–84	619	23	929	550–1309	1117	36	806	543–1069	85 182	2099	616	590–642	101 907	2135	524	502–546
Crude rate	58 173	337	145	129–160	60 051	338	141	126–156	1 558 261	6189	99	97–102	1 547 225	4876	79	77–81
ASR 20–84			206	182–231			178	158–198			78	76–80			57	55–58
ASR 20–54			91	77–105			90	77–103			24	22–25			18	17–20
ASR 55–84			564	473–525			454	383–525			243	236–250			171	166–177

ASR: standardized to the WHO world population. ASR indicates age-standardized rate; and WHO, World Health Organization.

of fatal stroke between Aboriginal males and females 20 to 84 years, nor in younger patients (Table 3). The greatest disparities in stroke incidence were observed between younger Aboriginal and non-Aboriginal females in SA/NT (Figure 1; Table S4).

By Remoteness

Among Aboriginal females aged 20 to 54 years, age-standardized incidence rates of stroke were significantly lower in inner-regional/metropolitan Australia compared with remote/very remote regions (Table 4). Among young Aboriginal males, there was no detectable difference in stroke incidence between remote/very remote and other regions.

By Stroke Type

ICH was more common among younger Aboriginal than non-Aboriginal Australians aged 20 to 54 years with incident stroke (21.0% Aboriginal versus 13.3% non-Aboriginal; Table S5; Figure S3). In this age group, the age-standardized incidence rates of ICH were 11-fold greater for Aboriginal than non-Aboriginal females and over 5-fold greater for Aboriginal than non-Aboriginal males (Figure 2; Table S6). Conversely, in those aged 55 to 84 years, rate ratios of IS between Aboriginal and non-Aboriginal people were greater than ICH. Stroke types (IS, ICH, and SAH) were less frequently recorded in the Aboriginal than non-Aboriginal population, particularly in the older population where 31.8%

Table 3. Fatal Stroke Incidence by Age Group, Sex, and Indigenous Status: Western Australia, South Australia, and the Northern Territory 2012–2015

Fatal incidence rates per 100 000 population/y												
Age group, y	Aboriginal						Non-Aboriginal					
	Males			Females			Males			Females		
	N	Rate	95% CI	N	Rate	95% CI	N	Rate	95% CI	N	Rate	95% CI
20–34	<5	4	0–7	<5	1	0–3	11	1	0–1	<5	0	0–0
35–44	9	18	6–29	8	15	5–25	27	2	1–3	16	1	1–1
45–54	7	17	5–30	13	29	13–45	50	4	3–6	53	5	3–6
55–64	14	61	29–93	12	46	20–71	100	10	8–12	87	9	7–11
65–74	10	115	44–187	8	74	23–126	188	28	24–32	171	25	21–29
75–84	11	444	182–707	18	403	217–589	463	136	124–148	552	135	124–147
Crude rate	55	24	17–30	60	25	19–31	839	13	13–14	882	14	13–15
ASR 20–84		42	29–54		36	26–45		10	9–11		9	9–10
ASR 20–54		11	6–15		11	7–16		2	1–2		2	1–2
ASR 55–84		137	88–187		107	72–142		35	32–37		32	30–34

Counts <5 are not shown for confidentiality. ASR: standardized to the WHO world population. ASR indicates age-standardized rate; and WHO, World Health Organization.

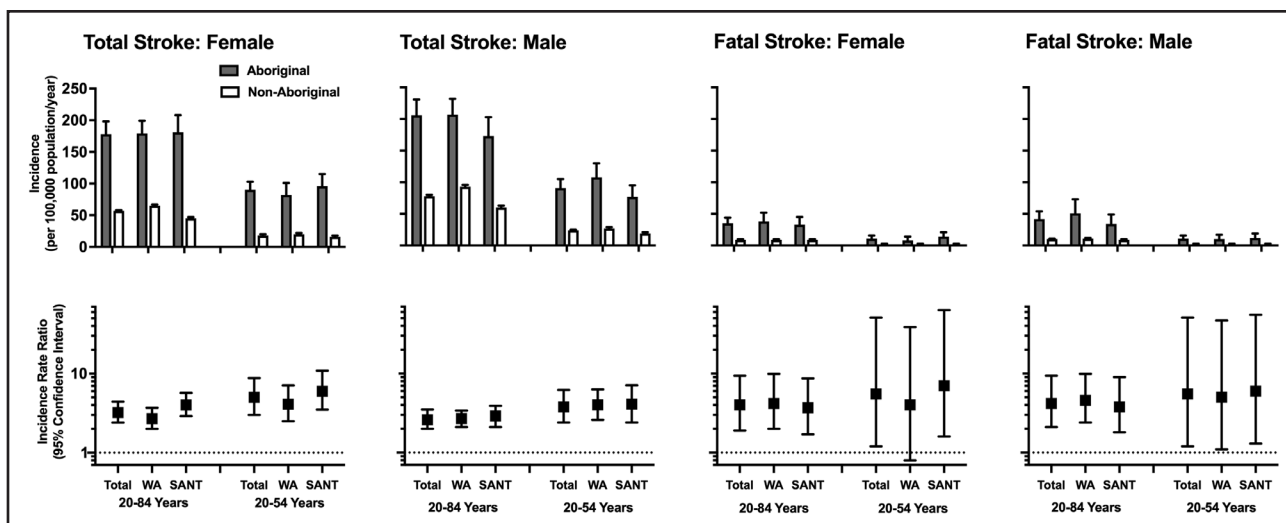


Figure 1. Age-standardized stroke incidence rates and rate ratios of by age group, sex, and Indigenous status: Western Australia (WA), South Australia (SA), and the Northern Territory (NT) 2012–2015.

Rate ratios compare incidence between Aboriginal and non-Aboriginal peoples.

of incident strokes were coded as “unspecified” (Table S5). Incidence of SAH did not differ significantly by Indigenous status, although the incidence rate ratio in young Aboriginal males was 2.4-fold that of young non-Aboriginal males (95% CI, 0.8–8.7; Table S6; Figure 2).

Attack Rates (Incident and Recurrent Strokes Combined) of Stroke

Compared to non-Aboriginal people, the age-standardized stroke attack rates in the Aboriginal population aged 20–84 were 2.8-fold greater for males (236 versus 83/100000) and 3.3-fold greater for females (199 versus 60/100000; Table S7). In WA, age- and sex-standardized attack rates were significantly greater

in Aboriginal males than Aboriginal females (293 versus 199/100000); this pattern was not evident for Aboriginal males and females in SA/NT.

DISCUSSION

We provide evidence of significantly greater incidence of stroke, occurring at younger ages, in the Aboriginal than in the non-Aboriginal population of central and WA. Disparities in stroke incidence between Aboriginal and non-Aboriginal people are particularly evident in those aged 20 to 54 years, as demonstrated by the greater incidence of fatal stroke in this younger population. Differences in ICH and unspecified stroke types were observed between the populations, as were differences in risk factor prevalence,

Table 4. Age-Standardized Stroke Incidence Rates Among People 20–54 Years, By Geographic Strata, Sex, and Indigenous Status: 2012–2015

Age-standardized incidence rates* per 100 000 population/y (20–54 y)												
	Aboriginal						Non-Aboriginal					
	Males			Females			Males			Females		
	N	Rate	95% CI	N	Rate	95% CI	N	Rate	95% CI	N	Rate	95% CI
Total	165	91	77–105	173	90	77–103	1107	24	22–25	835	18	17–20
Fatal	20	11	6–15	22	11	7–16	88	2	1–2	72	2	1–2
By jurisdiction												
WA	89	108	85–130	71	82	63–101	738	27	25–29	528	20	19–22
SA/NT	76	77	60–95	102	96	78–115	369	19	17–21	307	16	14–18
Geographic strata												
Metro/inner-regional	47	110	79–142	35	75	50–100	879	26	24–27	670	19	18–20
Outer regional	24	92	55–128	36	134	90–178	153	31	26–36	111	25	20–29
Remote/very remote	94	135	108–162	102	133	107–158	75	27	21–33	54	25	18–32

NT indicates Northern Territory; SA, South Australia; and WA, Western Australia; and WHO, World Health Organization. *Age-standardized to the WHO world population.

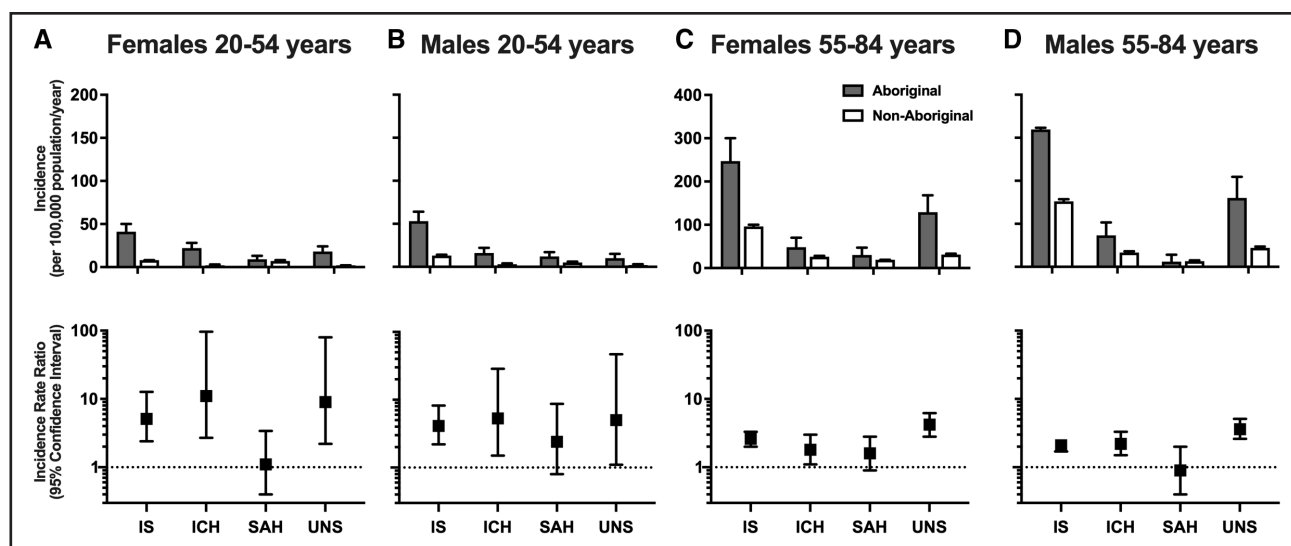


Figure 2. Age-standardized incidence rates and rate ratios of stroke types by sex, and Indigenous status: Western Australia, South Australia, and the Northern Territory 2012–2015.

Rate ratios compare incidence in Aboriginal and non-Aboriginal peoples. ICH indicates intracerebral hemorrhage; IS, ischemic stroke; SAH, subarachnoid hemorrhage; and UNS, unspecified stroke.

especially in younger Aboriginal patients. Although others have similarly reported a 3-fold greater incidence of stroke in the Aboriginal than the non-Aboriginal population,^{5,7,19} our sample was much larger, enabling robust estimates of disparities overall and by subgroups.

The greatest difference in stroke incidence between Aboriginal and non-Aboriginal people appears to be in ICH. When examining incident events by stroke type, a difference in the proportion of ICH was observed, noted also in some previous studies.^{4,19–21} Reasons for this are unclear, though likely relate to the greater comorbidity burden occurring at younger ages, particularly chronic kidney disease, which is especially associated with greater rates of ICH.²² Similar trends of excess rates of ICH have been described in some other Indigenous populations relative to their respective non-Indigenous populations, though data are sparse.²³ Conversely, incidence rates of SAH appeared similar in the Aboriginal and non-Aboriginal populations, as has been reported in one previous population-based hospital study that included just 6 Aboriginal people with SAH.¹⁹ Small overall numbers of SAH events may have reduced our ability to detect differences in rates. A greater proportion of “unspecified” stroke types in the Aboriginal population might reflect deficits in both investigation and stroke coding in regional/remote hospitals, especially for out-of-hospital deaths. Our finding flags potential deficits in primary prevention (especially for ICH), and in etiological investigation and specialized stroke care, which could be minimized either through on-the-ground upskilling or optimized telehealth services, thus facilitating effective stroke prevention.

To our knowledge, we present the first multijurisdictional data on incident stroke by remoteness of residence, demonstrating a substantially lower median age of fatal

stroke for the Aboriginal population living in remote/very remote Australia. Health outcomes are typically poorer in Australians living in rural and remote areas, with a shorter median life expectancy and greater levels of disease and preventable hospitalization, compared with those living in metropolitan regions.²⁴ This is supported by recently published data showing that Aboriginal Australians have greater rates of aeromedical evacuation from remote regions due to cardiovascular and cerebrovascular disease combined, coupled with poorer outcomes at younger ages, than non-Aboriginal Australians.²⁵ Health outcomes are strongly influenced by the social determinants of health, such as suboptimal environmental conditions, limited education, and employment opportunities.²⁴ These factors are compounded by barriers to healthcare access, due to geographic isolation from health services, limited infrastructure (including diagnostic facilities), health workforce shortages, and limited access to specialist care.²⁵

We found similar stroke incidence rates between Aboriginal males and females, whereas incidence rates were greater in non-Aboriginal males than females. Greater incidence of stroke in males is generally observed across most populations, although differences typically reduce with age.²⁶ This unexpectedly high burden of stroke in Aboriginal females may relate to greater rates of stroke in younger Aboriginal females in remote/very remote Australia. This burden of stroke may be partly explained by data showing proportionally greater rates of hospitalizations and deaths for cardiovascular and related diseases for Aboriginal population compared with non-Aboriginal population, with greater disparities for females than for males.²⁷ Despite facing socio-ecological disadvantage and discrimination, Aboriginal women play a critical role as carers and leaders, vital to sustaining the well-being of their

families and communities.²⁸ Findings in this study highlight the importance of effective primary prevention strategies, including strategies designed specifically to target younger Aboriginal females in remote/very remote Australia, for the benefit of individuals and their communities.²⁵

The disparity in prevalence of risk factors between Aboriginal and non-Aboriginal people with stroke is more marked in younger than in older patients. This may have contributed to increased incidence in younger Aboriginal Australians due to conventional risk factors occurring at younger ages. Greater prevalence of cardiovascular comorbidities in Aboriginal patients with stroke has been observed in previous studies,²⁹ and is associated with a greater risk of stroke, and greater case complexity.²⁹ Greater frequency of hypertension and higher ICH risk in younger Aboriginal patients suggests the need for more active treatment of hypertension. The prevalence of rheumatic heart disease was particularly elevated in younger Aboriginal patients. As rheumatic heart disease is a disease of disadvantage,³⁰ resulting from poor environmental conditions, substandard housing, and inadequate access to sanitation, this highlights the need to address the social determinants of health, especially for Aboriginal Australians residing in remote/very remote regions.³¹ The need for commencing cardiovascular screening at earlier ages has been recognized in a recent consensus statement, recommending that screening commence from age 18 years at the latest.³² Our study provides further evidence of the need to facilitate improved cardiovascular risk factor modification in this population.

Strengths of this study include representing the largest multijurisdictional cohort estimating population-based incidence of stroke in Aboriginal Australians, using the most contemporary data, and allowing for insights into stroke incidence by sex, jurisdiction, remoteness of residence, and stroke type. Limitations of this study include the use of administrative data for case ascertainment and comorbidity data, meaning stroke type and comorbidity codes may contain some inaccuracies, especially for out-of-hospital fatal events. Consequently, unspecified stroke type comprised a large proportion of our cases. Additionally, using administrative data to determine Aboriginal status has the potential to underestimate counts in both numerators and denominators. As the degree and effect size of this was unable to be accurately determined, we did not attempt to correct this. However, unlike prior studies, using whole-of-population data enabled us to obtain a sample size large enough for detailed subgroup analysis.^{4,19} Although we were able to identify stroke types, determining stroke etiology was not possible due to the use of administrative data; this highlights the need for further research into stroke subtypes in this population, of which few data are published.¹⁹ Additionally, as records were based on cases resulting in hospitalization or death, our case ascertainment may have missed patients with nonfatal stroke not presenting to hospital, or inaccurate recording of cause of death for out-of-hospital deaths.

However, the proportion of people with stroke admitted to public hospitals is high; in a recent SA population-based study (ASCEND), an estimated 96% of patients with incident stroke presented to hospital.³³ Although data were not available from private hospitals in SA, or the single private hospital in the NT (which does not admit acute stroke patients), only 2% of incident strokes in ASCEND (Adelaide Stroke Incidence Study) were identified uniquely from a private hospital admission.³³ We may not have captured stroke events before the lookback period, potentially over-estimating incident events. However, it is unlikely that this would substantially change incidence estimates, given a previous linked data study from WA found a 10-year lookback was associated with <1% of index cases representing recurrent stroke.³⁴

Our study demonstrates the importance of age-standardizing within younger versus older age groups in the Aboriginal Australian population when making comparisons to the non-Aboriginal population, to provide awareness of greater differentials at young ages. Our findings indicate the need for effective primary and secondary prevention of stroke in Aboriginal Australians, with interventions shaped by Aboriginal stakeholders, that also address the social determinants of health. Greater support for nonmetropolitan health services to facilitate management and prevention of stroke is likely to be beneficial.³⁵ Further research is needed to investigate etiological subtypes of stroke, to facilitate optimal stroke prevention and care in this population.

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Supplemental Material

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