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Incidence and Risk Factors for Stroke in American Indians: The Strong Heart Study

Ying Zhang, MD, PhD,[1] James M. Galloway, MD,[2] Thomas K. Welty, MD,[3] David O. Wiebers, MD,[4] Jack P. Whisnant, MD,[4] Richard B. Devereux, MD,[5] Jorge R. Kizer, MD, MSc,[5] Barbara V. Howard, PhD,[6] Linda D. Cowan, PhD,[1] Jeunliang Yeh, PhD,[1] Wm James Howard, MD,[6] Wenyu Wang, PhD,[1] Lyle Best, MD,[3] and Elisa T. Lee, PhD[1]

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Abstract

Go to:

Background

Go to:

There are few published data on the incidence of fatal and non-fatal stroke in American Indians. The aims of this observational study were to determine the incidence of stroke and stroke risk factors

among American Indians.

Methods and results

Go to:

This report is based on 4549 participants aged 45–74 at enrollment in the Strong Heart Study, the largest longitudinal, population-based study of cardiovascular disease and its risk factors in a diverse group of American Indians. At baseline examination in 1989–1992, 42 participants (1132/100,000, adjusted to the age and sex distribution of the U.S. adult population in 1990) had prevalent stroke. Through December 2004, 306 (6.8%) of 4507 participants without prior stroke suffered a first stroke at a mean age of 66.5 years. The age- and sex-adjusted incidence was 679/100, 000 person-years. Non-hemorrhagic cerebral infarction occurred in 86% of participants with incident strokes; 14% suffered hemorrhagic stroke. Overall age-adjusted 30-day case-fatality from first stroke was 18%, with a one-year case-fatality of 32%. Age, diastolic blood pressure, fasting glucose, $HbA1_C$, smoking, albuminuria, hypertension, pre-hypertension and diabetes were risk factors of incident stroke.

Conclusions

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Compared to U.S. white and black populations, American Indians have a higher incidence of stroke. The case-fatality rate for first stroke is also higher in American Indians than in the U.S. white or black population in the same age range. Our findings suggest that blood pressure and glucose control and smoking avoidance may be important avenues for stroke prevention in this population.

Keywords: morbidity, mortality, stroke, risk factors

Although cardiovascular disease is the leading cause of death in American Indians[1], no cohort study has examined the prevalence, incidence and risk factors for stroke in this population. Available data on incidence of non-fatal or fatal stroke in American Indians come from a hospital case study[2] and from national survey data with a small number of American Indian participants[3]. Stroke mortality in American Indians has been described in several reports using regional or national death certificate data, which may misclassify

race as well as the causes of death[4–7]. To our knowledge, there are no studies of stroke incidence, risk factors and case – mortality in a prospectively followed cohort of American Indians with accurate measurement of baseline biological parameters. Understanding the morbidity, mortality and risk factors of stroke in American Indians is important, so that appropriate prevention interventions can be implemented.

This study was undertaken to determine stroke incidence among American Indians 45–74 years of age, and to assess risk factors for incident stroke in this population.

METHODS

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Study population

The Strong Heart Study is a population-based cohort study of cardiovascular disease and its risk factors in 13 American Indian tribes/communities in southwestern Oklahoma, central Arizona, and North and South Dakota. Participants (n = 4,549; 2,703 women) aged 45 to 74 years underwent baseline examination from 1989 to 1992. The design, survey methods, and laboratory techniques were described previously [8–10]. The participants in this analysis (n=4,507) had no history of stroke at the baseline examination. Among them, 306 participants suffered incident stroke during a mean follow-up of 13.4 years by the end of 2004. The 1st and 3rd quartiles of follow-up time are 9.2 and 14.4 years, respectively. The Indian Health Service Institutional Review Board, Institutional Review Boards of the participating institutions, and the participating tribes approved the study. Informed consent was obtained from all participants.

Baseline Evaluation

Information on demographic factors, medical history, medication use, and personal health habits (physical activity, smoking, alcohol consumption) was collected by personal interview. A physical examination was conducted and fasting blood samples were collected for laboratory tests, including lipids and lipoproteins, and a 75-g oral glucose tolerance test. Anthropometric measurements were performed and sitting blood pressure (1st and 5th Korotkoff

sounds) was measured three times consecutively using mercury sphygmomanometers (WA Baum Co) after five minutes of rest[11]. The average of the 2nd and 3rd systolic and diastolic blood pressure measurements were used in the analysis.

Hypertension was defined by JNC-7 criteria[12] (systolic blood pressure ≥ 140 mm Hg, diastolic blood pressure ≥ 90 mm Hg or use of antihypertensive medication). Pre-hypertension was defined as systolic blood pressure 120–139 mm Hg or diastolic blood pressure 80–89 mm Hg. Normal blood pressure was defined as <120/80 mm Hg.

Diabetes was defined by the 1998 Provisional World Health Organization Report [13](fasting glucose ≥ 7.0 mmol/l (126mg/dl) or post-75–g oral glucose challenge blood glucose of ≥ 11.1 mmol/l (200mg/dl) or use of an oral hypoglycemic agent or insulin). Impaired glucose tolerance was defined as fasting glucose <7.0 mmol/l with post-challenge glucose between 7.8–11.09 mmol/l (140–199.9mg/dl). Impaired fasting glucose was defined as fasting glucose between 6.1–6.9 mmol/l (110–125.9mg/dl) with post-challenge glucose <7.8 mmol/l. Impaired glucose tolerance and impaired fasting glucose were combined as one category designated as “impaired glucose metabolism”. Normal glucose tolerance was defined as fasting glucose <6.1 mmol/l with post-challenge glucose <7.8 mmol/l.

Fasting insulin in serum or plasma was measured by radioimmunoassay using established methods[14].

Micro-albuminuria and macro-albuminuria were defined as urinary albumin/creatinine ratios of 30 to 299mg/g and ≥ 300 mg/g, respectively. Past smoking was defined as smoking at least 100 cigarettes in entire life, smoking cigarettes regularly in the past, and not smoking currently. Current smoking was defined as smoking at least 100 cigarettes in entire life, smoking cigarettes regularly, and smoking currently. Past alcohol user was defined as consuming at least 12 drinks of any kind of alcoholic beverage in entire life and the last drink at least 1 year ago. Current alcohol user was defined as consuming at least 12 drinks of any kind of alcoholic beverage in entire life and drinking currently. Information on leisure-time and occupation-related physical activities was collected using a

physical activity questionnaire. This questionnaire has been validated in Pima Indians and other populations. An estimate of the individual's self-reported physical activity level was averaged over the past year and expressed as hours per week[15,16].

Outcome variables

Incident strokes included fatal and nonfatal events occurring between the baseline examination and December 31, 2004 in participants without a prior history of stroke.

Fatal stroke Fatal events included definite and possible fatal strokes. Deaths occurring between the baseline examination and December 31, 2004 were confirmed through Indian Health Service or private hospital records and through direct contact by study personnel with participants' families or other informants[1,8,9,17]. The process of ascertaining stroke deaths has been reported previously[1]. Physician members of the Strong Heart Study Mortality Committee reviewed all medical records, information obtained from informants, death certificates, and coroner's or medical examiner's reports when available. Two reviewers reviewed each chart and if there was lack of agreement, the chart was then reviewed by the whole adjudication committee. If reviewers found the death was stroke related, this case was sent to neurologists (D.O.W., J.P.W.) for confirmation using previously described criteria[17] that differentiated cardioembolic, lacunar, and other thrombotic cerebral infarctions, intraparenchymal (intracerebral) hemorrhage, subarachnoid hemorrhage, and stroke of unknown type. Mortality follow-up data were available in 99.8% of the participants.

Nonfatal stroke The process to confirm nonfatal stroke was similar to fatal stroke. Neurologists (D.O.W., J.P.W.) made up the adjudication review committee and provided the final diagnosis for nonfatal events (definite and possible non-fatal strokes) that occurred from the baseline examination to the end of 2004 and for prevalent strokes that occurred before the baseline examination [1,8,17,18]. Stroke sub-types used are the same as described in fatal stroke. Transient ischemic attack was not included in the analysis. If more than one event happened in the same individual, the date of the earliest one was considered as the first stroke date.

Statistical methods

Person-time incidence rates of stroke were calculated in male, female and male + female participants for three study centers. Age-specific rates and age-adjusted, age- and sex- adjusted rates and their 95% confidence intervals were calculated. The United States 1990 population was used as the standard population in all age-adjustments.

Overall and age-specific proportions of stroke subtypes among all strokes were provided. The proportion of persons with a history of stroke at baseline was calculated for males, females, and all participants for three centers. Age-specific, age-adjusted, and age- and sex-adjusted proportions and their 95% confidence intervals were also calculated.

Age-adjusted thirty day and one-year mortality rates and their 95% confidence intervals for first stroke were calculated for both genders.

Mean age at onset of first stroke was calculated for all incident stroke cases and cerebral infarction cases for 1989–2004 in both genders and three study centers.

Baseline characteristics including age, sex, body mass index, waist circumference, systolic and diastolic blood pressure, and low-density and high-density lipoprotein cholesterol are presented as means (standard deviation) for participants with or without incident stroke. The t test was used to compare means between two groups. Triglycerides, fasting glucose, two-hour glucose, hemoglobin A_{1c}, insulin, and physical activity were presented in quartiles (1^{st} quartile, median, 3^{rd} quartile) and a nonparametric rank sum test [19] was used to compare the distribution of these variables between groups, because of their skewed distributions. Proportions of women, prehypertension, hypertension, diabetes, macroalbuminuria, microalbuminuria, smoking and alcohol use are presented in participants with and without incident stroke and compared between groups by the χ^2 test. Two-tailed $p < 0.05$ was considered to be statistically significant.

The incidence of stroke was also calculated according to different categories of risk factors including blood pressure, high-density

and low-density lipoprotein cholesterol levels, diabetes, fasting glucose, hemoglobin A_{1c}, smoking, and albuminuria. The log-rank test was used to compare the incidence of stroke among the categories. The calculation of incidence and log-rank test were age- and sex- adjusted.

Cox proportional hazard models were used to assess association of stroke with its potential risk factors including age, gender, systolic and diastolic blood pressures, body mass index, waist circumference, low-density and high-density lipoprotein cholesterol, triglycerides, physical activity, smoking, alcohol use, micro-albuminuria and macro-albuminuria. Hypertension and pre-hypertension were entered in alternative models as categorical variables instead of systolic and diastolic blood pressure. All other covariates remained the same. Additional models considered hemoglobin A_{1c} or diabetes instead of fasting glucose; all other covariates remained the same. The multivariable analyses were done separately for all stroke and cerebral infarction but not for hemorrhagic stroke because of the limited number of incident cases (n=37).

The authors had full access to and take full responsibility for the integrity of the data. All authors have read and agree to the manuscript as written.

RESULTS

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Prior stroke

Among the 4549 participants at baseline, 42 participants had a history of stroke. The age- and sex-adjusted prevalence proportion is 1132/100,000. The prevalences for 45–54, 55–64, and 65–74 year-old groups were 450, 1130, 1870/100,000 respectively. Age-adjusted prevalences for men and women were 1625, and 695/100,000 respectively. Age- and sex-adjusted prevalence for Arizona, Oklahoma, and South/North Dakota - 741/100,000 (10 cases, 95% confidence interval: 0–1511.9), 1352 (18 cases, 0–2754.6) and 1193 (14 cases, 0–3091.9) did not differ significantly.

Incidence rate of stroke (table 1)

Table 1

Age- and sex-specific incidence rates of stroke per 100,000 person years (1989–2004)

Sex	Age (year)	Arizona		Oklahoma		South/North Dakota		Rates of All center
		Rate	No.	Rate	No.	Rate	No.	
Male	45–54	472	16	280	11	284	11	340
	55–64	960	14	872	19	938	23	920
	65–74	687	5	1138	13	1113	10	1011
	Total	627	35	594	43	609	44	609
	AAR[§]	689		701		717		707
	95% CI[‖]	55 – 1324		0 – 1806		0 – 1829		0 – 1641
Female	45–54	452	27	321	16	463	24	415
	55–64	653	23	594	23	604	20	617
	65–74	777	12	1035	21	1166	18	997
	Total	561	62	551	60	618	62	576
	AAR	614		622		718		653
	95% CI	202 – 1025		0 – 1509		0 – 1621		0 – 137
Male + Female	45–54	459	43	303	27	387	35	384
	55–64	743	37	694	42	746	43	727
	65–74	748	17	1072	34	1146	28	1002
	Total	584	97	568	103	614	106	588
	ASAR[#]	649		659		718		679
	95% CI	445 – 854		280– 1038		337 – 1098		364 – 994

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*In Rochester, Minnesota, 1985–1989
†The Greater Cincinnati/Northern Kentucky Stroke Study, 1993
‡Framingham Heart Study 1980–2003
§Age-adjusted rates
‖Confidence interval
#Age and sex adjusted rates

From 1989 to 2004, 306 incident strokes occurred among the Strong Heart Study participants without a prior stroke, an age- and sex- adjusted incidence of 679/100, 000 person-years. The incidence increased with older age in both men and women in all three centers. The age-adjusted incidences for men and women were 707, and 653/100,000 person years respectively.

Stroke sub-types (table 2)

Table 2

Proportion of stroke sub-types by age (1989–2004)

Age	Cerebral infarction		Intraparenchymal hemorrhage		Subarachnoid hemorrhage	
(year)	Proportion (%)	No.	Proportion (%)	No.	Proportion (%)	No
45–54	82	73	15.7	14	2.2	2
55–64	87.3	89	10.8	11	2	2
65–74	88.1	59	7.5	5	4.5	3
Total	85.7	221	11.6	30	2.7	7

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Cerebral infarctions were by far the predominant sub-type of stroke, constituting 86% of incident stroke cases; 14% suffered hemorrhagic stroke, mostly intraparenchymal. Intraparenchymal hemorrhages were more common in the youngest age group (45 to 54 years olds).

Age of occurrence of first stroke

The mean age of occurrence of first stroke for all strokes and for cerebral infarction is 66.5 years. Arizona participants with strokes were younger than Oklahoma participants with strokes (mean ages 65 vs. 68 years respectively, p=0.048). The mean age of Dakota participants with strokes (66.4 years) did not differ from Oklahoma or Arizona. The average age of stroke onset was similar in men (66.2 years) and women (66.7 years) (p=0.60).

Survival (table 3)

Table 3

Age-adjusted thirty day- and one-year mortality from first stroke (1989 – 2004)

Time	Categories	Arizona		Oklahoma	
		Mortality (%)	Number	Mortality (%)	Number
Thirty days					
	Male	23.3	8	16.1	7
	95% CI*	15 – 30		10 – 23	
	Female	32	19	9.8	7
	95% CI	25 – 38		5 – 14	
	Male + female	29.1	27	12.4	14
	95% CI	24 – 34		9 – 16	
One-year					
	Male	39.3	13	31.6	14
	95% CI	30 – 47		23 – 40	
	Female	44.7	26	21.5	14
	95% CI	37 – 52		16 – 28	
	Male + female	42.7	39	25.7	28
	95% CI	37 – 48		21 – 31	

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*Confidence interval

Overall 30-day case-fatality from first stroke was 18%, with a one-year case-fatality of 32% (table 3). While the 30-day and one-year case-fatality rates for men and women did not differ, fatality rates were higher in Arizona than the other two centers.

Characteristics of participants with or without incident stroke (table 4)

Table 4

Comparison of baseline characteristics of the Strong Heart Study participants with and without incident stroke

Variables	Without stroke (N=4201)	With incident stroke (N=306)	P value
Age (Year)	56.1 (8.0)	59.3 (8.1)	**<0.001**
Female (%)	59.5	60	0.8
Body mass index (kg/m^2)	30.9 (6.4)	30.6 (5.3)	0.4
Waist circumference (cm)	105.1 (14.7)	105.8 (13.3)	0.4
Systolic blood pressure (mm Hg)	127.2 (19.6)	134.9 (20.2)	**<0.001**
Diastolic blood pressure (mm Hg)	76.6 (10.1)	78.5 (10.8)	**<0.002**
LDL* cholesterol (mmol/l)	3.0 (0.9)	3.0 (0.9)	0.6
HDL* cholesterol (mmol/l)	1.2 (0.3)	1.1 (0.3)	**0.005**
Triglycerides (mmol/l)	1.3 (0.9, 1.9)	1.5 (1.1, 2.2)	**<0.001**
Fasting glucose (mmol/l)	6.3 (5.5, 9.4)	8.2 (5.9, 13.3)	**<0.001**
Two-hour glucose (mmol/l)	7.8 (6.0, 11.5)	8.9 (6.2, 15.2)	**0.02**
Hemoglobin A1c (%)	5.6 (5.0, 7.9)	6.7 (5.5, 10.2)	**<0.001**

Variables	Without stroke (N=4201)	With incident stroke (N=306)	P value
Insulin (pmol/l)	96.2 (56.9, 155.4)	106.8 (67.8, 157.8)	**0.03**
Prehypertension (%)	32.4	30.2	0.4
Hypertension (%)	38	55.7	**<0.001**
Diabetes (%)	47.3	69	**<0.001**
Microalbuminuria (%)	18.4	27.1	**<0.001**
Macroalbuminuria (%)	9.7	22.7	**<0.001**
Physical activity (hours/week)	10 (1.8, 27.7)	6.9 (0.7, 24.6)	**0.04**
Current smoking (%)	33.7	36.6	0.3
Past smoking (%)	33.6	35.6	0.5
Current alcohol use (%)	42.4	31.7	**<0.001**
Past alcohol use (%)	41.5	50	**0.003**

*Abbreviations: LDL, low-density lipoprotein; HDL, high-density lipoprotein

Participants with incident stroke were older, had higher systolic and diastolic blood pressures, triglycerides, fasting glucose, hemoglobin A_{1c}, insulin, and two hour glucose, and lower high-density lipoprotein cholesterol levels and were less physically active at baseline than participants who remained stroke-free. Hypertension, diabetes, micro-albuminuria and macro-albuminuria were significantly more prevalent at baseline among participants with subsequent stroke, and those with incident stroke were more likely at baseline to be past alcohol users but less likely to be current alcohol users than those who remained stroke-free.

Risk factors for stroke (table 5 and table 6)

Table 5

Stroke incidence (per 100,000 person-years) according to

different risk factors (age and gender adjusted)

	N	No. of stroke	Person-years	Stroke incidence
Blood pressure				**<0.001***
Normal	1283	43	19041	301
Pre-hypertension	1449	92	15563	539
Hypertension	1760	170	17252	837
Systolic blood pressure (mm Hg)				**<0.001**
<120	1641	66	19825	361
120–139	1808	127	21097	610
140–159	744	77	8136	756
≥ 160	294	34	2766	952
Diastolic blood pressure (mm Hg)				**<0.001**
<80	2765	169	31939	513
80–89	1281	97	14955	711
90–99	354	28	4020	769
≥ 100	85	10	882	1540
HDL-C (mmol/l)				**<0.001**
<1.0 (40 mg/dl)	1544	126	17693	750
1.0–1.54 (40–59 mg/dl)	2262	143	26690	537
≥ 1.55 (60mg/dl)	606	28	6918	429
LDL-C (mmol/l)				**0.94**
<2.59 (100mg/dl)	1346	92	14993	617
2.59–3.35 (100–129 mg/dl)	1528	100	18079	555
3.36–4.13 (130–159 mg/dl)	965	59	11545	518
4.14–4.8 (160–189 mg/dl)	315	26	3794	705
≥4.9 (190 mg/dl)	115	8	1323	700
Diabetes (WHO1998)				**<0.001**

	N	No. of stroke	Person-years	Stroke incidence
Diabetes (WHO1998)				**<0.001**
Normal	1332	50	16334	312
Impaired glucose metabolism	891	43	11112	393
Diabetes	2196	211	23536	887
Fasting glucose (mmol/l)				**<0.001**
<6.1 (110mg/dl)	1873	81	22691	367
6.1–6.9 (110–125 mg/dl)	679	40	8377	445
≥ 7.0 (126mg/dl)	1783	172	19387	889
HbA_{1c} (%)				**<0.001**
<5	984	34	11461	330
5–7	1899	115	23282	471
>7	1290	130	13709	971
Smoking				**0.004**
Current	1527	112	17168	709
Past	1516	109	17468	514
Never	1457	85	17318	491
Albuminuria				**<0.001**
Normal	3084	148	38014	395
Micro	831	80	9074	885
Macro	464	67	3907	1708

*p-value from the log-rank test for comparing survival curves among categories of the variables

Table 6

Cox proportional hazards model for all strokes

Variables	P	Hazard	95%

Variables	P	Hazard ratio*	95% confidence interval
Age (Year)	**<0.001**	**1.07**	**(1.05, 1.09)**
Gender (male vs. female)	0.77	0.95	(0.71, 1.28)
Systolic blood pressure (per 20 mm Hg)	0.2	1.10	(1.0, 1.22)
Diastolic blood pressure (per 10 mm Hg)	**0.02**	**1.21**	**(1.1, 1.48)**
Body mass index (kg/m^2)	0.43	0.98	(0.94, 1.03)
Waist circumference (cm)	0.95	1.00	(0.98, 1.02)
LDL-cholesterol (mmol/l)	0.8	0.98	(0.85, 1.14)
HDL-cholesterol (mmol/l)	0.08	0.67	(0.43, 1.05)
Triglyceride (mmol/l)	0.9	0.99	(0.84, 1.17)
Physical activity (hours/week)	0.68	1.00	(0.99, 1.01)
Fasting glucose (mmol/l)	**<0.001**	**1.07**	**(1.04, 1.1)**
Current smoking (vs. never smoking)	**<0.001**	**2.38**	**(1.69, 3.36)**
Past smoking (vs. never smoking)	**0.006**	**1.6**	**(1.14, 2.25)**
Current alcohol users (vs. never users)	0.23	0.78	(0.51, 1.17)
Past alcohol users (vs. never users)	0.87	1.03	(0.7, 1.48)
Microalbuminuria (vs. normal)	**<0.001**	**1.73**	**(1.25, 2.38)**
Macroalbuminuria (vs. normal)	**<0.001**	**3.3**	**(2.29, 4.77)**
Alternative models Hypertension and pre-hypertension were put in the model instead of systolic and diastolic blood pressure, other covariates are the same.			
Hypertension (vs. normotensive)*	**<0.001**	**2.2**	**(1.5, 3.2)**
Pre-hypertension (vs.	**0.005**	**1.75**	**(1.18**

Variables	P	Hazard ratio*	95% confidence interval
Pre-hypertension (vs. normotensive)*	0.005	1.73	(1.18, 2.59)
HbA1c was put in the model instead of fasting glucose, all other covariates are the same.			
HbA_{1c} (%)†	**<0.001**	**1.15**	**(1.08, 1.21)**
Diabetes and impaired glucose were put in the model instead of fasting glucose. All other covariates are the same.			
Diabetes (vs. normal glucose tolerance) ‡	**<0.001**	**2.05**	**(1.41, 3.0)**
Impaired glucose metabolism (vs. normal glucose tolerance)	0.49	1.17	(0.75, 1.8)

Participants with elevated baseline levels of blood pressure, fasting glucose, HbA_{1c} and albuminuria had significantly higher incidence of stroke than those with normal levels (Table 5). Participants with lower levels of HDL-C had significantly higher stroke incidence than those with higher levels. Baseline LDL-C levels were not significantly related to stroke incidence, nor were those of non-HDL-C (data not shown). Current smokers had significantly higher stroke incidence than past smokers and non-smokers as did participants with hypertension, pre -hypertension, diabetes, and impaired glucose compared to those who did not have those conditions.

In a Cox proportional hazard model for all strokes, age, diastolic blood pressure, fasting glucose, smoking, and albuminuria were risk factors of stroke incidence. Current and past smokers had 2.4- and 1.6-fold higher risks of incident stroke, respectively, than never smokers. Macro-albuminuria, and micro-albuminuria increased the risk 3.3 and 1.7 times, respectively. When hypertension and pre-hypertension were put in the model instead of systolic and diastolic blood pressures, the risks of incident stroke were 2.2 and 1.8 times higher than in normotensive participants. When HbA_{1c} was put in the model instead of fasting glucose, each percent increase of HbA_{1c} was associated with a 1.15-fold higher risk of incident stroke. When

diabetes and impaired glucose metabolism were put in the model instead of fasting glucose, they increased the risk of incident stroke by 2.1- and 1.2-fold, though the effect of impaired glucose metabolism was not statistically significant. The results of the multivariable model for cerebral infarction only (data not shown) are similar to the results for all strokes. Although insulin levels were associated with incident stroke in univariable analyses, the association was not significant after adjusting for other covariates.

DISCUSSION

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The present report provides the first detailed information on stroke incidence rates and risk factors in American Indians derived from a large, prospectively-followed population-based sample with broad collection of risk factors and thorough morbidity and mortality surveillance.

Incidence

Compared to other populations of similar age followed over a similar time period with similar diagnostic methods, the present report documents higher overall stroke incidence in American Indians than in either US whites [20,21] or blacks[22]. Incidence rates for stroke were higher in both sexes compared to whites [20,21] but sex specific data comparable to this study were not available in blacks. We also could not find comparable data for a broad sample of the US Hispanic population, though one study reports a stroke incidence for Hispanics that is lower than blacks but higher than whites[23].

Stroke sub-types

Data pooled from Atherosclerosis Risk in Communities study, the Cardiovascular Health Study, and the Framingham Heart Study indicated that ischemic and hemorrhagic strokes account for 87% and 13% of all strokes, respectively[24], almost identical to the proportions of sub-types of first stroke in the Strong Heart Study population. In younger age groups, however, there is a higher proportion of hemorrhagic stroke (mainly intraparenchymal hemorrhage) among American Indians.

Case-fatality of first stroke

Among American Indians, both the thirty-day and 1-year case-fatality rates following first stroke were higher in women than men, similar to national data[24]. The pooled data from Framingham Heart Study, Atherosclerosis Risk in Communities Study, and Cardiovascular Health Study showed that 1-year case-fatality after a first stroke is 21% for men and 24% for women whose age is greater than 40 years old[24]. The 1-year mortality in SHS participants is almost 1.5 times these rates [24]. We could not find comparable data in other populations for thirty-day case-fatality.

Risk factors for stroke

From the Cox proportional hazard model, age, diastolic blood pressure, fasting glucose, current and past smoking, micro- and macro-albuminuria, hypertension, pre-hypertension, HbA_{1c}, and diabetes are all risk factors for first stroke in American Indians.

Age is reported as the strongest non-modifiable risk factor for stroke in several studies[25–27]. In American Indians, age is also a strong risk factor. Although men have a higher risk of stroke than women in other populations, sex was not a significant risk factor for stroke in this population.[28]. The association between diastolic blood pressure and stroke has been demonstrated in both observational studies and clinical trials.[29,30] Though a clinical trial showed that active treatment of isolated systolic hypertension lowered the incidence of stroke by 42%[31], systolic blood pressure was not a risk factor for incident stroke whereas diastolic blood pressure was in the Strong Heart Study population, possibly related to 83 percent of SHS participants being <65 years old at enrollment. Hypertension and pre-hypertension are related to incident stroke when treated as categorical variables. Either current or past history of smoking is related to increased stroke risk in this population, similar to several other studies[32–34]. Diabetes predicted incident stroke in several studies, with similar hazard ratios, possibly related to diabetic angiopathy in cerebral blood vessels[25,35]. Fasting glucose and hemoglobin $A1_C$ were significant risk factors for stroke. Fasting glucose has been a risk factor for stroke in people with or without diabetes in several studies[36–38].

The associations between micro- and macro-albuminuria and stroke were very strong, probably reflecting widespread vascular damage of endothelial dysfunction. Further studies of the association between kidney function and stroke incidence are needed [35,39,40].

Because of the small number of prevalent cases, it is not possible to compare stroke prevalence between the Strong Heart Study cohort and other populations[20]. We also could not compare the age of onset for first stroke with other populations[20] because of the different baseline age range in the Strong Heart Study population.

In summary, incidence and case-fatality rates of stroke in American Indians are high compared to other segments of the US population. Our findings confirm the strong associations between hypertension, diabetes and cigarette smoking and risk of stroke. Each of these risk factors provides important avenues for intervention to reduce risk. The basis of the higher case-fatality from stroke in this population deserves further study.

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Footnotes

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CONFLICT OF INTEREST STATEMENT

We declare that we have no conflict of interest.

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