

## Review Article

# Incidence of Stroke in Young Adults: A Review

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*Introduction.* Stroke in the young may have a dramatic impact on the quality of life in survivors. This study was aimed to evaluate incidence of first-ever stroke in the young by means of a systematic review. *Materials and Methods.* All papers on incidence of stroke in the young published after 1980, were identified by electronic search of Medline and manual search of reference lists. Only studies recruiting subjects under 44 years of age and with a lower age limit not higher than 20 years were included. Incidence rates were standardized to the 2000 European population according to the direct method. Poisson regression analysis was used to compare studies. *Results.* 29 studies including 3548 participants were identified. Incidence rates, after excluding a few outliers, ranged between 8.63 and 19.12 for crude rates and between 8.70 and 21.02 for standardized rates. Heterogeneity among studies was statistically significant but improved after excluding 4 studies. Few studies reported the proportions of stroke subtypes. *Conclusions.* Stroke in subjects under 45 years of age is not such a rare disease and requires specific preventive programs.

## 1. Introduction

According to available data, fewer than 5% of all strokes occur in subjects under 45 years of age, in Western countries [1]. Higher proportions, between 19 and 30%, were reported in developing countries [2, 3]. Stroke incidence studies in the young were reported in several surveys and a few community-based studies that used different methodology and results were often very different [1, 3–30]. Moreover, in many studies, reported incidence rates had wide confidence intervals because of the small number of incident cases in the young [1, 3–30].

This study was aimed to evaluate incidence of first-ever stroke in the young by means of a systematic review of the literature.

## 2. Materials and Methods

In the present review, data were identified by searches of Medline and from the references of relevant articles published after 1980. Different subsets of studies were potentially eligible for different parts of this review. The search terms “population-based,” “community-based,”

“community,” “epidemiology,” “epidemiological,” “incidence,” “survey,” “surveillance,” “stroke,” “isch(a)emic stroke,” “intracerebral,” “intraparenchymal,” “subarachnoid,” and “h(a)emorrhage” were used. Only papers published in English were reviewed. Only papers reporting incidence rates of first-ever stroke in a lifetime in subjects under 45 years of age were included. Moreover, studies were included if the lower age limit was less than 20. Stroke had to be defined according to the WHO definition, that is the occurrence of rapidly developing signs of focal or global disturbance of cerebral function, lasting longer than 24 hours or leading to death, with no apparent cause other than that of vascular origin.

Two of the authors reviewed all published data of selected studies and assessed age and sex distribution of population at risk and of cases of first-ever stroke occurring in those populations.

Repeated reporting of the same studies were excluded, so that each data set was considered only once. Stroke type classification was considered only in those studies where CT, MRI, or autopsy findings were available for at least 80% of stroke cases. Strokes were classified into four major types: ischemic stroke (if CT or MRI within 30 days of stroke

TABLE 1: Studies on incidence of stroke in the young.

Study	Person* year	Crude rate	95% CI		Adjusted rate*
			LL	UL	
Stockholm	4,712,240	15.56	14.43	16.68	17.25
Benghazi	158,348	39.79	29.96	49.61	48.51
Lund-Orup	97,283	9.25	3.21	15.30	9.28
Denmark	13,144,499	14.94	14.28	15.60	11.21
Dijon	75,880	26.36	14.81	37.91	31.42
Florence	531,597	8.84	6.31	11.37	8.88
OCSF	226,936	9.64	5.60	13.68	9.74
Russia†	350,432	19.12	14.54	23.70	19.13
Baltimore whites	388,532	13.64	9.97	17.31	14.14
Baltimore blacks	272,464	30.83	24.24	37.42	34.20
Reggio Emilia	212,646	13.64	8.67	18.60	13.95
Aosta 1988	67,784	13.28	4.60	21.95	13.26
Rochester	1,297,209	8.63	7.03	10.23	14.21
Malmö†	127,581	11.76	5.81	17.71	10.06
Israel	2,170,500	5.76	4.75	6.77	6.14
Auckland	456,667	20.15	16.03	24.26	21.02
Perth	93,086	20.41	11.23	29.59	13.83
Warsaw	230,108	16.51	11.26	21.76	13.51
Belluno	126,513	10.28	4.69	15.86	16.70
Innherred†	73,862	12.18	4.22	20.15	12.02
Northern Sweden	774,608	11.36	8.99	13.73	11.17
South London	327,384	10.69	7.15	14.23	11.48
L'Aquila	874,375	10.18	8.06	12.29	10.23
OXVASC	178,071	8.99	4.58	13.39	13.12
Erlangen	62,453	16.01	6.09	25.94	14.58
Northen Manhattan†	321,739	23.00	17.76	28.24	23.03
Aosta 1997†	66,698	16.49	6.75	26.24	16.38
Melbourne	84,888	20.03	10.51	29.55	19.25
Brazil	844,378	11.55	9.26	13.85	8.70

CI indicates confidence interval.

\*Standardized to the 2000 European population.

†Standardized only by sex.

TABLE 2: Estimated incidence rates stratified by age and sex.

Age class	Males	Females
0–14 yr	0.99	0.73
15–24 yr	4.20	2.95
25–34 yr	10.68	7.67
35–44 yr	30.66	23.99

showed infarct or no relevant lesion and/or autopsy showed ischemic stroke), primary intracerebral haemorrhage (if shown on CT, MRI, or autopsy), subarachnoid haemorrhage (classified by characteristic findings in CSF analysis and/or autopsy, CT, or cerebral angiography), and undetermined stroke (no CT, MRI, autopsy, cerebral angiography, or [for subarachnoid haemorrhage only] CSF examination was done).

The incidence of first-ever stroke was calculated per 100,000 person-years. Age standardisation was performed with the direct method using the 2000 European population as the reference population [26]. Age-standardised incidence rates were plotted with the corresponding 95% CI for each study to facilitate comparison. Poisson regression analysis was used to compare incidence rates from different studies. Fitted values were assumed as the best estimates of the true stroke incidence in the young at the various age classes. Sensitivity analysis was performed by excluding those studies that produced a significant deviance change when removed from the model.

### 3. Results

During the review period we identified 29 studies including altogether 3548 patients under 45 years of age with

TABLE 3: Proportion of different stroke types in the included studies.

Study	IS		ICH		SAH	
	%	95%CI	%	95%CI	%	95%CI
Stockholm	21.0	18.1–24.0	22.0	19.0–25.0	55.4	51.8–59.0
Benghazi	77.9	67.7–88.2	12.6	4.4–20.8	9.6	2.3–16.8
Lund-Orup	67.5	48.1–87.0	16.7	1.2–32.2	15.8	0.6–31.0
Florence	38.5	24.5–52.4	21.5	9.7–33.2	36.2	22.5–49.9
OCSF	66.7	48.9–84.4	3.7	0–10.8	29.6	12.4–46.9
Baltimore whites	77.4	66.1–88.6	22.6	11.4–33.9	—	—
Baltimore blacks	70.2	60.5–80.0	29.8	20.0–39.5	—	—
Reggio Emilia	58.7	40.7–76.6	20.5	5.8–35.2	20.5	5.8–35.2
Malmö	53.3	28.1–78.6	20.0	0–40.2	13.3	0–30.5
Perth	47.5	32.0–63.0	20.0	7.6–32.4	32.5	18.0–47.0
Belluno	30.8	05.7–55.9	38.5	12.0–64.9	30.8	5.7–55.9
Innherred	55.6	23.1–88.0	33.3	2.5–64.1	11.1	0–31.6
L'Aquila	57.3	47.0–67.6	20.2	11.9–28.6	22.5	13.8–31.1
OXVASC	66.7	48.9–84.4	3.7	0–10.8	29.6	12.4–46.9
Erlangen	70.0	41.6–98.4	10.0	0–28.6	20.0	0–44.8
Northen Manhattan	43.5	32.2–54.8	30.4	20.0–40.9	26.1	16.1–36.1

CI indicates confidence interval.

IS indicates ischemic stroke; ICH indicates intracerebral hemorrhage; SAH indicates subarachnoid hemorrhage.

a diagnosis of stroke. Person-year at risk, crude incidence rates, and rates standardized to the 2000 European population are reported in Table 1. Crude rates ranged from 5.76/100,000 to 39.79/100,000 and standardized rates ranged from 6.14/100,000 to 48.51/100,000. However, after excluding 4 outliers (Benghazi, Dijon, Baltimore-blacks, and Israel, ranges became much tighter (8.63 to 19.12/100,000, for crude rates, and 8.70 to 21.02, for standardized rates). Figure 1 shows that rates were approximately similar among studies.

Poisson regression analysis revealed a significant heterogeneity among studies ( $P < .0001$ ). However, after excluding the above mentioned outliers, heterogeneity markedly reduced, although was still statistically significant ( $P = .021$ ). Fitted values for each age class of both sexes are reported in Table 2 and show rates clearly higher in men than in women.

The distributions of stroke types were reported by half of the papers only, mostly without age and sex stratification (Table 3). The proportion of ischemic stroke ranged between 21.0% and 77.9%, the proportion of intracerebral hemorrhage ranged between 3.7% and 38.5%, and the proportion of subarachnoid hemorrhage ranged between 9.6% and 55.4%.

#### 4. Discussion

In subjects under 45 years of age the annual crude incidence rate of first-ever stroke is usually considered low. However, it is usually higher than that of other invalidating neurological disease.

The strength of the present study relies on the inclusion of a large number of studies and of participants. How-

ever, studies were rather heterogeneous on the basis of methodology and ethnicity. Higher rates were reported by few studies with less accurate identification of the study population [2, 29, 30]. Rates were higher in USA black people and in developing countries. Racial composition of the study population is an important component of incidence variability since young blacks and hispanics have been shown to have greater stroke incidences than young whites [3, 11]. Nevertheless, in some developing countries higher rates may reflect life style and inaccurate control of risk factors.

The proportion of ischemic strokes, ranging between 21.0% and 77.9%, was much lower than that reported for stroke of all ages. This finding probably depended on the occurrence of hemorrhagic strokes due to vascular malformations, and illicit drug use as well as on the lower prevalence of atherosclerosis in young subjects.

Although stroke was a rare event in the young, due to the longer expected survival at this age, young patients accounted for as much as 20% of the years of potential life lost because of the stroke [31]. Primary prevention is likely to be the principal strategy to fight stroke in the young. In addition to conventional stroke risk factors, young patients have special risk factors inherent to genetic and environmental elements, such as cardiac abnormalities, thrombophilic states, migraine, the use of oral contraceptives and illicit drugs that should be identified and adequately controlled [32]. The high proportion of subarachnoid and intracerebral hemorrhages in patients under 45 years reported by some studies, makes mandatory tailored preventive strategies, mainly focused on early detection and treatment of hypertension and possibly including neuroimaging studies for the screening of aneurysms and arteriovenous malformations in subjects at risk.

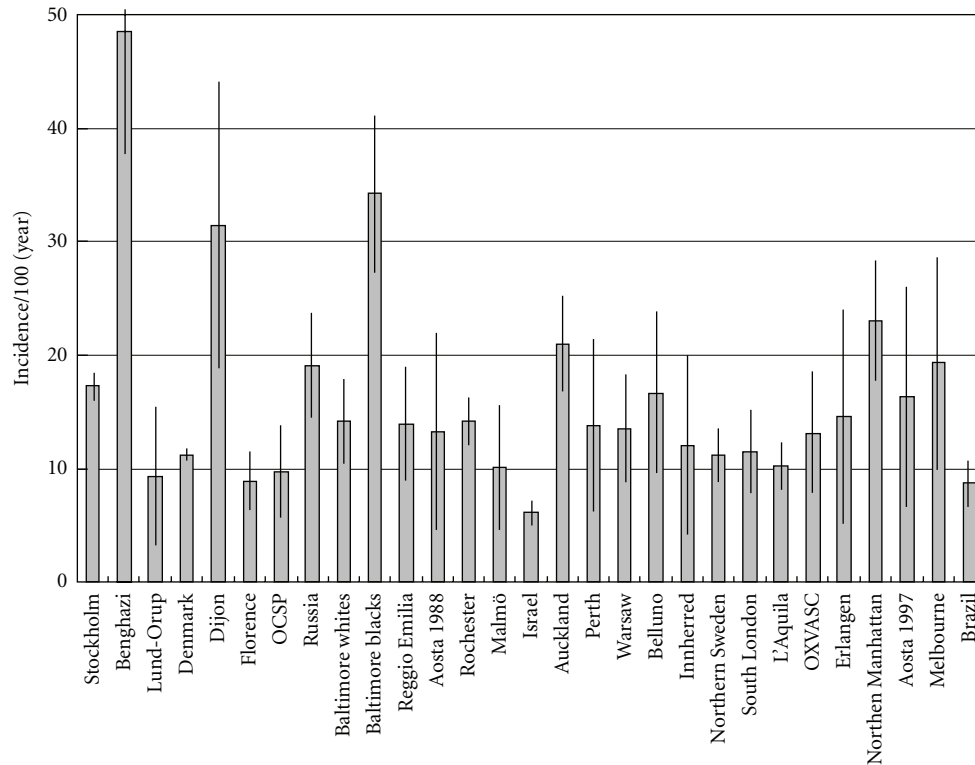


FIGURE 1: Incidence rates of stroke in the young (rates are adjusted for age and sex to the 2000 European population).

## 5. Conclusion

Studies on incidence of stroke in the young provide comparable rates showing that stroke in those subjects is not such a rare condition and requires tailored prevention programs.

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