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Epidemiology of stroke in Europe: Geographic and environmental differences

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Abstract

The development of stroke registries has allowed the accumulation of a wealth of data on the descriptive epidemiology of stroke and its evolution in space and in time. For instance, there has been an observed decrease of stroke incidence and mortality in Western Countries during the past 20 years.

The use of brain imaging technologies including CT scan and MRI, along with improved cardiac and vascular imaging, has allowed better identification of risk factors for stroke. Hypertension remains the main risk factor for both ischemic and hemorrhagic strokes, and its treatment is effective in reducing first-ever and recurrent stroke incidence. Major medical progress has been achieved in the development of effective medications for hypertension control in the last 2 decades. Despite these advances, we observe large differences in the incidence and mortality rates of stroke throughout the European community. In this review we pose some questions regarding the possible reasons for these differences and we analyze the issue of environmental factors such as meteorological factors and pollution as stroke risk factors.

Keywords: Stroke; Epidemiology; Environmental factors; Risk factors; Europe

1. Introduction

1.1. Stroke: a major health public problem

Stroke represents one of the major health public problems worldwide, particularly in industrialized countries [1–4]. Strokes are a frequent cause of acute hospitalization (150 000 cases per year, against 130 000 cases of cardiac infarcts in France), severe morbidity (first cause of motor handicap, second cause of dementia) and the third cause of overall mortality.

Despite significant progress in stroke prevention, management and treatment—such as fibrinolysis within the first 3 h of ischemic strokes, there are major differences in the epidemiologic data of stroke in the European community [5,6]. We analyze here the possible reasons for these geographical variations, as well as the differences in vascular risk factors, access to prevention and to emergency care, meteorological factors and environmental pollution.

2. Methods

Population-based studies allow the comparison of stroke epidemiological data. Incident cases can be ascertained using exhaustive, specific and continuous methods [7]. Imaging is the major and single criterion to identify ischemic stroke (80% of the cases) resulting from atherothrombosis (75% of the cases) or embolic sources (25% of the cases), as well as hemorrhagic strokes (20% of the cases). The TOAST classification [8] has been validated internationally to identify sub-types of ischemic strokes including ischemic stroke from atheroma of large vessels (30%), atheroma of small perforating vessels inducing

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Table 1
Annual incidence rates (n/100 000/year) of stroke by age groups [21]

Study	<35 years	35–44 years	45–54 years	55–64 years	65–74 years	75–84 years	>85 years
Söderhamn							
1975–1978	15	49	92	218	893	1958	3047
1983–1986	80	48	89	315	912	2341	3968
Tilburg							
1978–1980				201	688	1609	
Espoo-Kauniainen							
1978–1980	13	38	121	241	647	1347	
Oxford							
1981–1982			16	305	645	1546	
Umbria							
1986–1988				194	506	1227	2378
Enköping-Häbo							
1986–1988		7	74	203	656	1764	3542
Valle d'Aosta							
1989			23	234	729	1642	3236
Warsaw							
1991–1992	3	35	97	289	575	949	1793
Frederickberg							
1971–1990			16	271	492	1122	1745
1990			21	306	702	1310	1600

lacunar infarcts with a diameter < 1.5 cm (20%), cardioembolic stroke (20%), and ischemic stroke from other mechanisms (such as dissection) (5%) or of unknown origin (25%).

3. Results

From the analysis of the literature we identified 5 major sources of stroke epidemiology around the world and from Europe. These include the meta-analysis of Hankey and Warlow [1], Feigin et al. [3], the population-based registry of Oxford (UK) in 2004 [2], the European Registries of Stroke [5,6] and Dijon (France) [9].

3.1. Incidence rates

Table 1 and Fig. 1 summarize stroke incidence rates throughout the European community, [3,9–21]. The Erlangen (Germany) study [10]) was the first one to provide incidence rates by mechanisms according to the TOAST Classification (Table 2).

These data allows the following observations:

(1). There are large geographical variations on the incidences rates through Europe with a decreasing gradient from eastern to western countries with an incidence rate of 600 cases/100,000 per year in Novosibirsk (Russia) against 210 cases/100,000 per year in Dijon (France) [3,11]. We can suggest that these geographical variations are related to environmental factors, air pollutants, meteorological factors, diet, salt intake, alcohol abuse, smoking, or access to prevention. In Avallon, a rural area, 100 km to the north of Dijon, we observed a higher incidence rate (275 against 210 cases/100,000 per year), a higher prevalence of cerebral hemorrhage (26% against 12%) and a higher prevalence of alcohol abuse (26% against 12%) and non-treated hypertension (28% against 15%), compared to Dijon [22].
The above observations indicate disappoint results of stroke prevention in the rural area compared to an urban area, results from lack of control of vascular risk factors (Table 3). Genetics may explain some differences with a high incidence rate in black population compared to white population in London [5].

(2). There are large variations in incidence rates with time. A 34% decrease has been observed since 1970 in Sweden and Finland, more important in women, notwithstanding the age groups [21]. The increase observed in Frederickberg [12] in the years 1970 and

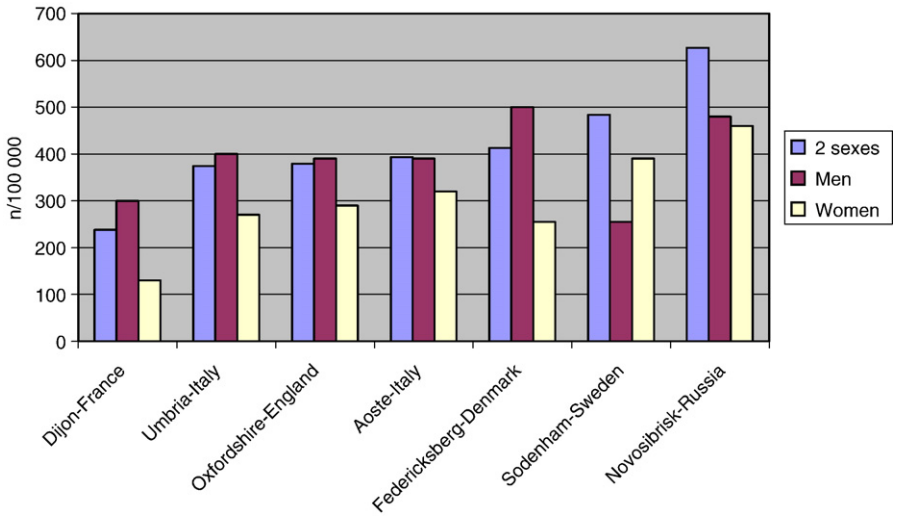

Fig. 1. Standardized annual incidences rates for stroke according to 7 European population-based studies.

Table 2
Annual standardized incidence rates (n/100 000/year) according to stroke sub-types [10]

	Ischemic stroke large vessels	Ischemic stroke small vessels	Ischemic stroke cardioembolic	Ischemic stroke miscellaneous	Unknown ischemic stroke	Total
Total	15.3 (95% CI: 12–19.3)	25.8 (95% CI: 21.5–30.9)	30.2 (95% CI: 25.6–35.7)	2.1 (95% CI: 0.9–3.9)	39.3 (95% CI: 34–45.5)	112.7 (95% CI: 103.6–122.6)
Men	23.6 (95% CI: 17.1–31.6)	35.3 (95% CI: 27.2–45.2)	29.1 (95% CI: 21.7–38.2)	1.4 (95% CI: 0.3–4.1)	40.2 (95% CI: 31.3–50.6)	129.7 (95% CI: 114.3–147)
Women	9.2 (95% CI: 6.1–13.4)	19.8 (95% CI: 15–25.8)	30.8 (95 CI: 24.8–37.8)	2.5 (95% CI: 0.9–5.5)	39.1 (95% CI: 32.5–47)	101.4 (95% CI: 90.5–113.7)

1980, is probably explained by the use of CT scan capable to identify slight strokes.

Recently, the Oxford registry [2] demonstrated an important decrease of 29% in the incidence rates of all strokes, hemorrhagic and ischemic, mainly in women and in all age groups, with a significant decrease of cases of severe stroke. This is related to a decrease of the prevalence of non-treated hypertension, hypercholesterolemia, and smoking. This study is a classic population-based study performed during a very long period of 20 years. A similar study was conducted in Dijon [9] during 20 years but has revealed no decrease of incidence rates, due to the lack of improvement of hypertension control.

3.2. Recurrent stroke rates

The Erlangen population-based registry [10] observed over a 2-year period that the highest recurrence rates were for cardioembolic strokes (22%), whereas the lowest rates were observed for large artery atheroma (10%) and lacunar strokes (11%). These data are very important in order to compare with others countries and therapeutic trials.

3.3. Prevalence rates

Prevalence refers to the number of stroke patients on a definite geographical area, and on a definite period. This data measure the burden of the stroke disease within a population. If allows to know the number of stroke patients who need secondary prevention, and the economic cost of the disease [3].

Hankey and Warlow [1] have calculated on the basis of a meta-analysis that for a population of 1 million inhabitants, there will be 1800 incident strokes, 600 recurrent strokes and 500 TIAs. Of the 2400 stroke patients, 480 (20%) will die at 28 days, and 600 cases will have a major motor handicap at the end of the first year.

3.4. Mortality rates

The mortality rates at 28 days remains at about 20% [2–23]. The survival rates at 2 years, calculated in Erlangen [10] between 1994 and 1998, are 85% for lacunar strokes, 65% for ischemic strokes from large artery atheroma, and 55% for cardioembolic ischemic strokes (Fig. 2).

The Oxford study [2] observed during a period of 20 years a significant decrease of 25% of the mortality rates, in both sexes and for all the mechanisms except for hemorrhagic strokes. In Dijon [9] we have observed a similar decrease.

3.5. Environmental factors

Two main environmental factors are validated for the stroke incidence rates: (1) meteorological factors, with an increase of the peak of ischemic stroke during intermediate seasons (springs and autumn) [24], probably in relation to temperature and hygrometric parameters that modify the hemostatic status. (2) Air pollution [25,26], whereby peaks of ozone levels in air

Table 3
Cerebrovascular risk factors according to stroke sub-types [10]

Vascular risk factors	Ischemic stroke large vessels N=71		Ischemic stroke small vessels n=120		Ischemic stroke cardioembolic n=143		Ischemic stroke miscellaneous n=9		Ischemic stroke undetermined n=188		Total n=531		p
Hypertension	37	52%	86	72%	81	57%	1	11%	100	53%	305	57%	<0.01
Diabetes	23	32%	29	24%	33	23%	0	0%	45	24%	130	25%	NS
Smoking	18	25%	22	18%	12	8%	1	11%	18	10%	71	13%	<0.05
Cardiac disease	32	45%	40	33%	116	81%	1	11%	96	51%	285	54%	<0.001

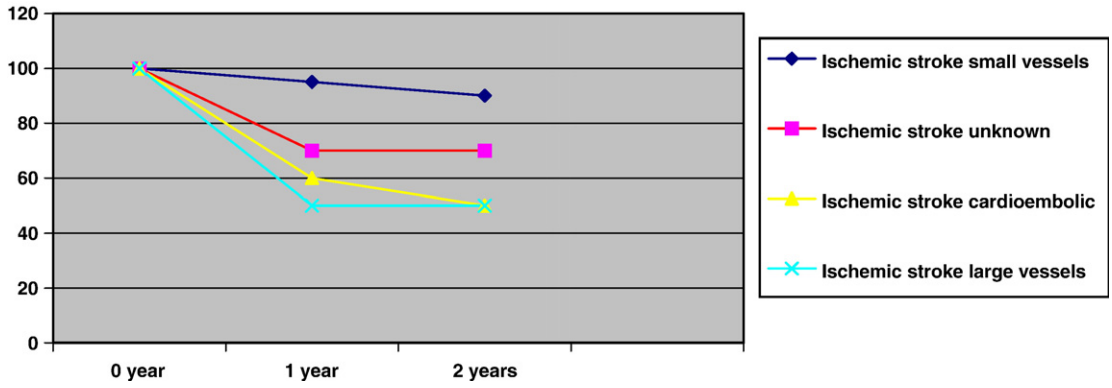

Fig. 2. Stroke survival rates [10].

are related to elevated ischemic stroke incidence. Ozone may act on unstable atheroma plaques, hemostatic and inflammatory parameters.

4. Conclusions

Even in western countries, with similar ethnic populations, economical status and public health policies, the incidence and mortality rates are not quite similar, and seem to reflect important variations in the access of the stroke prevention and acute care, and for meteorological and air pollution. Therefore, the environmental medicine may help the stroke medicine to explain some important geographical epidemiological differences.

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