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Stroke in the Very Old: Incidence, Risk Factors, Clinical Features, Outcomes and Access to Resources – A 22-Year Population-Based Study

Yannick Béjot[a] Olivier Rouaud[a] Agnès Jacquin[a] Guy-Victor Osseby[a] Jérôme Durier[a] Patrick Manckoundia[b] Pierre Pfitzenmeyer[b] Thibault Moreau[a] Maurice Giroud[a]

[a]Stroke Registry of Dijon (Inserm et Institut de Veille Sanitaire), EA4184, University Hospital and Faculty of Medicine and Department of Neurology, and [b]Department of Geriatrics, University Hospital and Faculty of Medicine of Dijon, Dijon, France

Key Words
Stroke, outcome · Stroke epidemiology · Risk factors, stroke · Elderly · Case fatality · Registries, stroke

Abstract
Background: For several years, the burden of stroke in very old patients has been increasing in western countries. Nevertheless, we have little information about this new challenge in individuals ≥80. ***Methods:*** We ascertained all first-ever strokes in the population of Dijon, France (150,000 inhabitants), from 1985 to 2006. The incidence of stroke, risk factors, clinical presentation, resource mobilization and 1-month outcome were evaluated in individuals ≥80 and compared to the data obtained in younger patients. ***Results:*** We collected 1,410 first-ever strokes in people ≥80 years (39%) versus 2,130 in those <80 years. The incidence was 997/100,000, and 68/100,000, respectively. Over the 22 years, the incidence of stroke in individuals ≥80 years rose significantly. A lower prevalence of diabetes, hypercholesterolemia and alcohol intake, as well as a higher prevalence of hypertension, atrial fibrillation, previous myocardial infarction and use of prestroke antiplatelet agents were noted in patients ≥80 years. The clinical presentation was severer and the 1-month outcome in terms of case fatality and handicap was worse, despite improvements observed over time. Finally, in patients ≥80 years, the use of CT scan, MRI, cervical Doppler, angiography and carotid surgery were significantly lower than for younger patients. Length of stay >30 days was more frequent, and discharge to prestroke residence was less common. However, all these improved between the first and the last study periods. ***Conclusions:*** Our findings have important implications not only for clinical management but also for initiating preventive strategies and health policy.

Introduction

Population aging is a rapidly increasing phenomenon worldwide with important consequences for the organization of health care systems. Considering that stroke incidence is largely related to age, a rise in the absolute number of strokes is expected in elderly people. Moreover, thanks to medical progress in both prevention and acute care for stroke, there has been a decrease in case fatality and mortality in the elderly and thus both an increase in the number of survivors with handicap and longer periods of handicap before death [1–5]. Since the very elderly are the fastest-growing segment of the elderly population in developed countries, the burden of stroke-related disability is expected to rise further [1, 2, 4]. Consequently, it is necessary to have accurate data on the spe-

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Dr. Yannick Béjot
Stroke Registry of Dijon, Department of Neurology, University Hospital
3, rue du Faubourg Raines
FR–21000 Dijon (France)
Tel. +33 3 80 29 37 53, Fax +33 3 80 29 36 72, E-Mail ybejot@yahoo.fr

cific characteristics of stroke in old patients in order to plan health care systems and to allocate resources.

Unfortunately, there is little information on stroke care in patients >80, and very elderly patients are rarely included in clinical trials [6]. Some data are available but are of limited interest because they come from hospital-based studies or only assess ischemic stroke over a short period [1, 2, 7, 8].

The objective of the present study was to evaluate the differences in demographics, risk factors, clinical presentation, resource mobilization and 1-month outcome of first-ever stroke in patients aged ≥80 years and to compare these data with those of younger age groups. Data were obtained from the population-based registry of Dijon, France, from 1985 to 2006.

Material and Methods

Study Area and Population

The study population comprised all residents of the town of Dijon, in eastern France. According to the national census, the population of Dijon was 146,723 in 1990 and 150,138 in 1999. The number of individuals aged ≥80 years increased by 7.3% between 1985 and 2006.

Case Ascertainment

The detailed methodology of case ascertainment has already been described elsewhere [5]. Briefly, multiple overlapping sources of information were used to ensure the completeness of case ascertainment by identifying both hospitalized and nonhospitalized cases of fatal and nonfatal strokes, as recommended for the running of 'ideal' stroke incidence studies [9]. Hence, information was obtained from 6 sources: (1) from the emergency rooms, as well as all of the clinical and radiological departments of Dijon University Hospital, with diagnosis of stroke made by one of the neurologists of the Department of Neurology; (2) from the emergency rooms and all of the clinical departments of the 3 private hospitals of the city and its suburbs, with diagnosis made by private neurologists working in these establishments; (3) from the patient's home or from the nursing homes of the city, with diagnosis assessed by the 250 general practitioners with the help of an outpatient clinic with either a public or private neurologist who notified and registered the cases; (4) from the 3 private radiological centers, where the medical records were reviewed to identify missed cases that had not been transferred to the registry by the general practitioners; (5) from the ultrasound Doppler centers of the University Hospital and private centers, where medical records were reviewed, and (6) from the death certificates with stroke as the underlying cause of death obtained from the local Social Security Bureau that is responsible for registering all deaths in the community. All of the collected death certificates were checked by a member of our team in order to include only patients who died from stroke.

To assess the quality and the validity of the registry, an external audit check has been performed every 4 years by the National Medical Research Institute.

Diagnosis of Stroke Subtype and Classification

Stroke was defined according to World Health Organization recommendations [10] and the International Classification of Disease [11]. The stroke subtype was always diagnosed on a clinical basis completed by cerebral imaging, complementary investigations including 2-dimensional echocardiography (transthoracic or transeosophageal cardiography), carotid and vertebral ultrasonography, as well as standard blood and urine tests.

The classification used since 1985 in the Dijon Stroke Registry is as follows: (1) ischemic strokes from lipohyalinosis of small arteries, so-called lacunar infarct (LACI) defined as a stroke presenting one of the classical lacunar syndromes and confirmed by a small (<15 mm in diameter) subcortical infarct on brain CT scan or MRI in the absence of any other morphological cause of ischemic stroke found in the neuroimaging examination; (2) ischemic stroke from cardiac embolism (CE) due to either atrial fibrillation (AF) diagnosed on EKG or Holter EKG, or to valve disease, patent foramen ovale associated with atrial septal aneurysm or spontaneous intracavitar thrombus on echocardiography; (3) all other ischemic strokes characterized by focal cortical symptoms and cortical infarct on a large vascular territory on CT or MRI. This subtype included ischemic stroke from both atheroma of large arteries, and from other or undetermined cause, but the distinction between these was not made before 2005, which explains why they were gathered together in 1 category; (4) spontaneous intracerebral hemorrhage, and (5) subarachnoid hemorrhage. For cerebral infarction, when it was difficult to differentiate between LACI, CE and other ischemic stroke, medical staff meetings were held to classify the type.

In addition, ischemic strokes were categorized according to the clinical presentation according to the classification of the Oxfordshire Community Stroke Project (OCSP) [12]. Hence we distinguished LACI, total anterior circulation infarct (TACI), partial anterior circulation infarct (PACI) and posterior circulation infarct (POCI).

Prestroke Vascular Risk Factors and Treatments

We collected prestroke vascular risk factors using the same methodology throughout the study period [5]. Hypertension was defined by a history of known hypertension or antihypertensive treatment. Diabetes mellitus was recorded if a glucose level of ≥7.8 mmol/l had been reported in the medical record or if the patient was on insulin or oral hypoglycemic agents. Hypercholesterolemia was defined by total cholesterol level ≥5.7 mmol/l or if the patient was under lipid-lowering therapy. We also recorded alcohol intake (≥1 glass per day), AF, history of transient ischemic attack (TIA), previous myocardial infarction and peripheral vascular disease. Smoking was not included in the analysis because >10% of the data was missing.

Prestroke antithrombotic therapy was also recorded. We distinguished between anticoagulants (warfarin, acenocoumarol or fluindione) and antiplatelet agents (aspirin, clopidogrel, ticlopidine or dipyridamole).

Baseline Clinical Variables

At stroke onset, the following neurological data were recorded: coma, confusion, aphasia, hemiplegia, hemianopsia, hemianesthesia, cerebellar dysfunction, cranial nerve palsy and seizure.

Outcome

Outcome data were collected 1 month after stroke onset. They comprised information on vital status, and for all patients, a self-constructed handicap scale was used to measure functional impairment. The handicap scale included 6 grades (1 = walking alone; 2 = walking with support; 3 = walking stick; 4 = wheelchair; 5 = bedridden; 6 = dead). This scale has been in use since establishment of the registry in 1985. We initially chose it because information for the modified Rankin (m-Rankin) scale [13] was only introduced into the registry database in 1997. Nevertheless, since this date, functional impairment has been measured both by handicap scale and m-Rankin score in 1,315 patients. The level of agreement between the 2 scales (weighted κ coefficient) was 0.92. Hence, in this study the outcome is expressed according to the m-Rankin scale for all patients.

Resource Use

We collected the type of procedure used for the patients (cerebral CT scan and MRI, cervical ultrasound, echocardiography, conventional angiography, carotid surgery), the length of stay (LOS), the type of care system and discharge to prestroke residence.

Data Processing and Statistical Methods

We assumed Poisson distribution for the annual number of events to calculate 95% confidence intervals (CI) for the incidence rates. To evaluate the impact of the time period on stroke incidence, incidence rate ratios (IRR) were calculated using a Poisson regression in which time was considered a continuous variable. Case fatality rates (CFR) based on survival at 1 month were estimated by the Kaplan-Meier method. Their temporal trends were evaluated by linear regression. The χ^2 test was used to assess differences in the proportion of stroke subtypes by age, vascular risk factors, prestroke treatments, baseline clinical features, distribution of ischemic strokes according to OCSP classification, outcome at 1 month and resource use.

The associations between stroke subtype, risk factors and prestroke treatments and both 1-month case-fatality and high handicap, defined as m-Rankin score 4–5, were analyzed using logistic regression to estimate odds ratios (ORs) and 95% CI. In multivariate analyses, we introduced gender, stroke subtype and all potential confounders into the models, with a p value <0.20 in univariate analysis.

p values <0.05 were considered statistically significant. Statistical analysis was performed with STATA® 9.0 software.

Ethics

The study protocol of the Stroke Registry of Dijon was approved by the national and local ethics review board.

Results

Over the 22 years, we collected 1,410 consecutive first-ever strokes in patients ≥80 years (39.8%, including 33% of males) versus 2,130 in those <80 years (60.1%, including 56% of males).

Incidence of Stroke and Stroke Subtypes

Over the whole study period, the incidence of first-ever stroke in people ≥80 years was 997/100,000/year (95% CI: 945–1,050) versus 68/100,000/year (95% CI: 65–71) in those <80 years (table 1). From 1985 to 2006, the IRR was 1.013 (95% CI: 1.004–1.021, p = 0.003), which indicates a significant and continuous increase of 1.3% per year in the incidence of stroke in individuals ≥80. A similar increase was noted in people <65 years, which is in contrast with a decrease observed in those aged 65–80 years.

For every stroke subtype except spontaneous intracerebral hemorrhage, the incidence among people ≥80 years was higher than that among younger patients. Concerning the distribution, a greater proportion of CE ischemic stroke was noted in patients ≥80 years compared to younger patients (table 2). In contrast, the distribution of the other stroke subtypes was similar in the 2 groups.

Vascular Risk Factors and Prestroke Treatments

Whatever the sex, there was a lower prevalence of diabetes, hypercholesterolemia and alcohol intake among stroke patients ≥80 years compared with younger patients (table 3). In contrast, in this older group, a significantly higher prevalence of hypertension, AF, previous myocardial infarction and use of antiplatelet agents was found. Of note, the use of anticoagulants in patients with a history of AF was lower in men ≥80 years.

Clinical Features

Among men ≥80 years, a significantly higher proportion of coma, hemiplegia and aphasia at stroke onset was noted compared with younger patients (table 3). In women ≥80 years, hemiplegia and aphasia were more frequent. Conversely, whatever the sex, cerebellar dysfunction was more frequent in younger patients. For ischemic stroke, TACI was more common in older subjects. Nevertheless, the frequency of this clinical presentation decreased over time (table 4).

Handicap

In stroke patients ≥80 years, a higher proportion of moderate (m-Rankin score 2–3) and severe handicap (m-Rankin score 4–5) at 1 month was observed (table 3). After multivariate analysis, TACI presentation, hemorrhagic stroke and male sex were associated with an increased risk of severe handicap (table 5).

Case Fatality Rates at 30 Days

The CFR in stroke patients ≥80 years were higher than those in patients ≤65 and 65–85 years (23.2 vs. 7.2

Table 1. Incidence rates of first-ever stroke in patients <65, 65–80 and ≥80 years, by study periods

	Age ≤65				65< age <80			
	cases	at risk mean/year	rate (n/100,000/year)	95% CI	cases	at risk mean/year	rate (n/100,000/year)	95% CI
1985–2006	757	127,273	27	25–29	1,373	16,044	389	369–410
1985–1990	196	124,602	26	23–30	362	14,915	405	364–448
1991–1995	118	125,792	19	16–22	311	15,691	396	354–443
1996–2000	196	126,879	31	27–36	326	16,397	398	356–443
2001–2006	247	128,071	32	28–36	374	17,173	363	327–402
IRR		1.020 (1.009–1.032)		p = 0.001		0.988 (0.980–0.996)		p = 0.005

Table 2. Incidence rates of first-ever stroke subtypes from 1985 to 2006

	Age ≤65				65< age <80			
	cases	proportion %	rate (n/100,000/year)	95% CI	cases	proportion %	rate (n/100,000/year)	95% CI
Hemorrhagic stroke	158	20.9	6	5–7	164	11.9	46	40–54
SIH	96	12.7	3	3–4	147	10.7	42	35–49
SAH	62	8.2	2	2–3	17	1.2	5	3–8
Ischemic stroke	588	77.7	22	20–23	1,158	84.4	343	323–362
LACI	194	25.6	7	6–8	346	25.2	98	88–109
CE	36	4.8	1	1–2	234	17.0	66	58–75
OIS	358	47.3	13	12–14	578	42.1	164	151–178
Undetermined stroke	11	1.4	0	0–1	51	3.7	14	11–19

SIH = Spontaneous intracerebral hemorrhage; SAH = subarachnoid hemorrhage; OIS = other ischemic strokes.

and 14.2%, respectively; $p < 0.001$), but they significantly decreased over the 22-year study period (linear trend: –0.56%, p = 0.041; table 6). This decrease was due to a fall in the CFR of hemorrhagic stroke, whereas those of ischemic stroke did not change over time. After multivariate analysis, both TACI and POCI presentation, hemorrhagic and undetermined stroke, as well as history of AF were predictors of 1-month case fatality (table 5). In contrast, history of hypercholesterolemia was associated with lower risk.

Resource Mobilization

Compared with younger patients, stroke patients ≥80 years were more frequently managed at the public hospital and less frequently at private hospitals (table 3). In addition, elderly women were less often treated at home. Over time, a slight shift from management at public hospital to management at private hospital was observed in stroke patients ≥80 years (table 4). In these older people, the use of CT scan, MRI, cervical Doppler, angiography and carotid surgery were significantly lower than for younger patients (table 3). LOS >30 days was more frequent, whereas a higher proportion of younger patients had a LOS <10 days. Both men and women ≥80 years were less likely to be discharged to their prestroke residence after stroke. However, all these patients improved between the first and the last study periods (table 4).

Discussion

In this comprehensive population-based study, we found that 39% of the strokes occurred in individuals aged ≥80. This proportion is similar to the few data reported in the literature [1, 2, 4]. The growth in the number of old people is faster than that in the population at large, and it is well known that the prevalence of vascular risk factors, lower compliance with medication and low

Age >80			
cases	at risk mean/year	rate (n/100,000/year)	95% CI
1,410	6,430	997	945–1,050
333	6,258	887	794–988
319	6,377	1,000	894–988
334	6,483	1,030	923–1,147
424	6,602	1,070	971–1,177
		1.013 (1.004–1.021)	p = 0.003

Age >80			
cases	proportion %	rate (n/100,000/year)	95% CI
148	10.5	105	88–123
139	9.9	98	83–116
9	0.6	6	3–12
1,190	84.4	892	844–943
305	21.6	216	192–241
328	23.3	232	207–258
557	39.5	394	362–428
72	5.1	51	40–64

socioeconomic status all increase with age [14–16], leading to a rise in the risk of stroke in the elderly [3, 4, 17]. Despite these observations, people aged ≥80 are rarely included in clinical trials. However, primary prevention seems to be efficient in this age group, as demonstrated by trials on antihypertensive therapy [18, 19]. In addition, there is little information about either the management or the epidemiology of stroke in this population [14–17].

Several factors could explain the increase in the incidence of stroke observed in this study. As the incidence rises with age, it could be the consequence of an increase in the mean age of those in the >80-year stratum over time. Another reason could be a change in the prevalence of risk factors in this age group. Indeed, although we cannot extrapolate our results to all residents in our community, since patients who suffer from stroke represent a failure of preventive therapies, an increase in the prevalence of prestroke diabetes and hypercholesterolemia was noted. Finally, changes in the incidence could be partly related to the better detection of minor stroke thanks to improvements in diagnosis techniques.

In the comparison with younger patients, the predominance of women in patients ≥80 years can be explained by the natural higher mortality in men [1–5, 16]. With regard to the stroke subtype, the proportion of cardioembolic stroke in patients ≥80 years is characteristic of this age, as previously reported [2, 20, 21], because the prevalence of AF, which accounts for approximately half of the overall CE strokes, rises with age [20, 21], and may explain, for a large part, the greater incidence of stroke in patients ≥80 years. In addition, this high proportion of CE strokes could explain in part the relatively lower occurrence of diabetes, hypercholesterolemia, as well as alcohol and tobacco abuse in this age group, as these risk factors are rather associated with other ischemic stroke subtypes [22].

The similarly large proportion of untreated hypertension in patients <80 and ≥80 years may suggest that the early diagnosis and treatment of hypertension is not efficient enough in our city, whatever the age, indicating a need for new preventive strategies. In addition, only 8.6% of the men and 9.9% of the women ≥80 years with a history of AF were on anticoagulants, even though this treatment is efficient in preventing stroke in this age group [21]. However, the increase in the use of anticoagulants as well as that of antiplatelet agents over the 22 years suggests a real improvement in medical practices.

Some differences in clinical features at onset were noted according to the age group. For ischemic stroke, TACI presentation was more frequent in elderly patients. One possible reason is the large proportion of cardioembolic ischemic strokes that are known to be associated with severer stroke symptoms. These data might explain the poor functional prognosis ≥80 years observed in our work and by others [1, 2]. Hence, in our multivariate analysis, TACI presentation was associated with a greater risk of both 1-month case fatality and severe handicap. In addition, CFR were significantly higher in patients ≥80 years. The effect of age on acute and short-term mortality is consistent with previous reports [1, 2, 23]. Nevertheless, CFR in the elderly decreased over the 22 years, concurrently with the increase in the proportion of patients with either no or slight handicap (m-Rankin score 0–1), or moderate handicap (m-Rankin score 2–3), suggesting an improvement in the quality of acute management, better control of prestroke risk factors but also, at least in part, in the ability to diagnose minor stroke. The decrease in the proportion of patients ≥80 years with TACI presentation and the increase in that of those with LACI is consistent with this

Table 3. Distribution of vascular risk factors, prestroke treatments, baseline clinical features, outcome at 1 month and resource use in stroke patients ≤65, 65–80 and ≥80 years, over the whole study period

	Men						
	≤65 years		65–80 years		≥80 years		
	%	95% CI	%	95% CI	%	95% CI	p
Risk factors							
Hypertension (treated or not)	56.2	51.6–60.7	71.3	68.1–74.6	71.9	67.8–75.9	<0.001
Untreated hypertension	20.4	16.7–24.1	15.8	13.2–18.4	17.9	14.4–21.4	0.127
Diabetes	16.3	12.9–19.7	18.4	15.6–21.1	12.2	9.2–15.1	0.016
Hypercholesterolemia	28.4	24.3–32.5	23.7	20.7–26.8	13.9	10.7–17.0	<0.001
AF	4.8	2.8–6.7	19.4	16.6–22.3	29.6	25.5–33.8	<0.001
Myocardial infarction	10.2	7.4–13.0	26.0	22.9–29.2	30.5	26.3–34.7	<0.001
Previous TIA	9.5	6.9–12.2	16.6	13.9–19.3	15.4	12.1–18.6	0.002
Alcohol intake	15.2	11.9–18.5	8.8	6.8–10.9	3.2	1.6–4.8	<0.001
Prestroke treatments							
Antiplatelet agents	12.6	9.5–15.6	22.8	19.8–25.8	26.7	22.6–30.7	<0.001
Anticoagulants	3.9	2.1–5.7	8.0	6.1–10.0	6.4	4.2–8.6	0.017
Patients with history of AF							
Antiplatelet agents	22.7	3.7–41.7	24.1	17.1–31.2	23.7	16.6–30.9	0.989
Anticoagulants	31.8	10.7–53.0	22.1	15.2–28.9	8.6	3.9–13.4	0.001
Baseline clinical features							
Coma	7.2	4.8–9.5	10.5	8.3–12.7	13.2	10.1–16.3	0.01
Confusion	11.5	8.6–14.4	10.9	8.6–13.1	13.9	10.7–17.0	0.277
Hemiplegia	70.1	65.9–74.3	75.1	72.0–78.2	78.7	75.0–82.4	0.01
Hemianesthesia	38.2	33.7–42.6	35.4	31.9–38.8	36.7	32.3–41.1	0.618
Aphasia	22.3	18.5–26.2	32.6	29.2–35.9	32.8	28.6–37.1	<0.001
Hemianopsia	14.3	11.1–17.5	14.1	11.6–16.6	16.6	13.2–20.0	0.442
Cerebellar dysfunction	11.1	8.2–13.9	6.7	4.9–8.5	3.2	1.6–4.8	<0.001
Cranial nerve palsy	24.3	20.4–28.2	19.6	16.7–22.4	20.3	16.6–23.9	0.13
Seizures	4.6	2.6–6.5	4.0	2.6–5.4	3.4	1.8–5.1	0.672
OCSP classification							
LACI	38.2	33.3–43.2	37.0	33.2–40.7	32.1	27.5–36.8	0.166
TACI	12.3	9.0–15.6	18.3	15.3–21.3	20.3	16.3–24.3	0.009
PACI	26.5	22.0–31.0	24.5	21.1–27.8	28.3	23.8–32.8	0.399
POCI	23.0	18.7–27.3	20.2	17.1–23.4	19.3	15.3–23.2	0.414
Outcome at 1 month							
m-Rankin score 0–1	68.3	64.1–72.6	57.2	53.7–60.8	42.4	37.9–46.9	<0.001
m-Rankin score 2–3	15.6	12.3–18.9	17.3	14.6–20.0	19.0	15.4–22.5	0.04
m-Rankin score 4–5	9.3	6.7–12.0	11.5	9.2–13.8	15.1	11.9–18.4	0.021
Death	6.7	4.4–9.0	13.9	11.4–16.4	23.5	19.6–27.3	0.005
Resource use							
Cerebral CT scan	97.0	95.4–98.5	95.3	93.8–96.8	95.3	93.8–96.8	<0.001
Cerebral MRI	15.2	11.9–18.5	7.1	5.3–9.0	1.1	0.1–2.0	<0.001
Cervical artery Doppler	63.1	58.7–67.5	59.8	56.3–63.3	43.7	39.2–48.2	<0.001
Angiography	21.5	17.7–25.2	4.0	2.6–5.4	1.5	0.4–2.6	<0.001
Carotid surgery	8.7	6.1–11.3	3.5	2.2–4.8	2.1	0.8–3.4	<0.001
Length of stay <10 days	45.3	40.8–49.9	53.9	50.3–57.5	50.5	46.0–55.1	0.015
Length of stay 10–30 days	46.4	41.9–51.0	38.7	35.2–42.2	35.4	31.1–39.7	0.002
Length of stay >30 days	8.2	5.7–10.8	7.4	5.5–9.3	14.1	10.9–17.2	<0.001
Public hospital	72.9	68.8–77.0	70.1	66.8–73.4	77.6	73.8–81.4	0.016
Private hospital	18.0	14.5–21.5	18.8	16.0–21.6	13.2	10.1–16.3	0.035
Home	9.1	6.5–11.7	11.1	8.9–13.4	9.2	6.5–11.8	0.404
Discharge to prestroke residence	65.3	60.9–69.7	55.6	52.1–59.2	43.7	39.2–48.2	<0.001

Table 3 (continued)

	Women						
	≤65 years		65–80 years		≥80 years		
	%	95% CI	%	95% CI	%	95% CI	p
Risk factors							
Hypertension (treated or not)	41.2	35.6–46.9	67.9	64.3–71.6	69.4	66.4–72.3	<0.001
Untreated hypertension	14.2	10.2–18.2	14.0	11.3–16.8	13.0	10.8–15.1	0.777
Diabetes	10.8	7.3–14.4	18.3	15.3–21.4	11.7	9.6–13.7	<0.001
Hypercholesterolemia	19.6	15.0–24.1	27.3	23.8–30.8	15.1	12.8–17.4	<0.001
AF	5.7	3.1–8.4	22.6	19.4–25.9	30.0	27.0–32.9	<0.001
Myocardial infarction	4.7	2.3–7.2	18.0	15.0–21.0	21.0	18.4–23.7	<0.001
Previous TIA	6.1	3.3–8.8	13.9	11.2–16.6	13.3	11.1–15.5	0.002
Alcohol intake	3.0	1.1–5.0	1.9	0.8–3.0	0.9	0.3–1.4	0.02
Prestroke treatments							
Antiplatelet agents	10.8	7.3–14.4	15.8	12.9–18.7	25.0	22.2–27.7	<0.001
Anticoagulants	2.0	0.4–3.6	7.0	5.0–9.0	6.1	4.5–7.6	0.008
Patients with history of AF							
Antiplatelet agents	29.4	5.3–53.6	19.7	13.1–26.3	29.4	24.1–34.8	0.096
Anticoagulants	17.6	2.6–37.9	14.8	8.9–20.7	9.9	6.4–13.4	0.256
Baseline clinical features							
Coma	12.8	9.0–16.7	12.3	9.7–14.9	15.6	13.3–17.9	0.142
Confusion	11.5	7.8–15.1	11.6	9.1–14.2	13.6	11.4–15.8	0.425
Hemiplegia	64.2	58.7–69.7	72.4	68.9–75.9	82.9	80.5–85.3	<0.001
Hemianesthesia	42.9	37.2–48.6	36.7	32.8–40.5	35.0	31.9–38.0	0.047
Aphasia	22.3	17.5–27.1	31.6	27.9–35.2	39.1	36.0–42.2	<0.001
Hemianopsia	8.4	5.3–11.6	14.4	11.6–17.1	13.8	11.6–16.0	0.032
Cerebellar dysfunction	7.8	4.7–10.8	6.9	4.9–8.8	2.6	1.5–3.6	<0.001
Cranial nerve palsy	24.7	19.7–29.6	23.8	20.4–27.1	20.1	17.5–22.6	0.113
Seizures	5.4	2.8–8.0	5.7	3.9–7.6	3.6	2.4–4.8	0.112
OCSP classification							
LACI	38.3	31.8–44.9	32.6	28.5–36.6	29.5	26.3–32.6	0.042
TACI	11.2	7.0–15.5	17.3	14.1–20.6	25.2	22.2–28.2	<0.001
PACI	25.7	19.8–31.6	28.2	24.3–32.1	26.3	23.3–29.4	0.695
POCI	24.8	18.9–30.6	21.9	18.4–25.5	19.0	16.3–21.7	0.132
Outcome at 1 month							
m-Rankin score 0–1	70.3	65.0–75.5	52.5	48.6–56.4	36.1	33.1–39.2	<0.001
m-Rankin score 2–3	16.2	12.0–20.4	20.4	17.3–23.6	23.6	20.9–26.3	0.02
m-Rankin score 4–5	5.7	3.1–8.4	12.8	10.1–15.4	17.3	14.9–19.7	<0.001
Death	7.8	4.7–10.8	14.4	11.6–17.1	23.0	20.3–25.6	<0.001
Resource use							
Cerebral CT scan	94.3	91.6–96.9	95.4	93.7–97.0	91.1	89.2–92.9	0.003
Cerebral MRI	22.3	17.5–27.1	4.3	2.7–5.9	1.7	0.9–2.5	<0.001
Cervical artery Doppler	53.4	47.7–59.1	54.7	50.8–58.6	43.1	40.0– 46.3	<0.001
Angiography	32.8	27.4–38.1	4.3	2.7–5.9	1.4	0.6–2.1	<0.001
Carotid surgery	8.8	5.5–12.0	1.4	0.5–2.4	1.2	0.5–1.9	<0.001
Length of stay <10 days	48.0	42.2–53.7	47.0	43.1–51.0	43.3	40.1–46.4	0.02
Length of stay 10–30 days	44.9	39.2–50.6	41.8	37.9–45.7	40.7	37.6–43.8	0.436
Length of stay >30 days	7.1	4.2–10.0	11.2	8.7–13.6	16.0	13.7–18.4	<0.001
Public hospital	69.9	64.7–75.2	74.2	70.7–77.6	82.0	79.6–84.5	<0.001
Private hospital	16.9	12.6–21.2	12.4	9.8–15.0	10.0	8.1–11.9	0.005
Home	13.2	9.3–17.1	13.4	10.7–16.1	8.0	6.2–9.7	0.001
Discharge to prestroke residence	61.1	55.6–66.7	50.7	46.8–54.6	40.7	37.6–43.8	<0.001

Table 4. Distribution of vascular risk factors, prestroke treatments, baseline clinical features, outcome at 1 month and resource use in stroke patients ≥80 years, by time periods

	1985–1989		1990–1994		1995–1999		2000–2006	
	%	95% CI	%	95% CI	%	95% CI	%	95% CI
Risk factors								
Male sex	31.2	26.2–36.2	33.9	28.6–39.1	31.7	26.7–36.8	35.6	31.0–40.2
Hypertension (treated or not)	67.9	62.8–72.9	67.1	61.9–72.3	72.2	67.3–77.0	72.9	68.6–77.1
Untreated hypertension	16.5	12.5–20.5	9.1	5.9–12.3	9.6	6.4–12.8	21.2	17.3–25.1
Diabetes	8.7	5.7–11.8	7.5	4.6–10.4	14.1	10.3–17.8	15.8	12.3–19.3
Hypercholesterolemia	6.6	3.9–9.3	7.2	4.4–10.1	14.1	10.3–17.8	27.1	22.9–31.4
AF	37.5	32.3–42.8	28.5	23.5–33.5	27.2	22.4–32.0	26.9	22.6–31.1
Myocardial infarction	26.9	22.6–31.1	30.3	25.4–35.3	22.6	18.0–27.2	29.6	24.7–34.6
Previous TIA	22.2	17.7–26.7	12.9	9.2–16.5	11.7	8.2–15.1	10.1	7.3–13.0
Alcohol intake	2.7	1.0–4.5	0.9	0.0–2.0	0.6	0.0–1.4	2.1	0.7–3.5
Prestroke treatments								
Antiplatelet agents	7.2	4.4–10.0	25.7	20.9–30.5	33.5	28.4–38.6	33.5	29.0–38.0
Anticoagulants	1.5	0.2–2.8	4.7	2.4–7.0	6.9	4.2–9.6	10.4	7.5–13.3
Patients with history of AF								
Antiplatelet agents	9.6	4.4–14.8	34.1	24.1–44.0	37.4	27.2–47.5	34.2	25.4–43.1
Anticoagulants	0.8	0.0–2.4	4.4	0.1–8.7	12.1	5.3–18.9	21.1	13.5–28.7
Baseline clinical features								
Coma	20.7	16.3–25.1	19.7	15.4–24.1	13.2	9.5–16.8	7.8	5.2–10.3
Confusion	18.3	14.1–22.5	9.4	6.2–12.6	15.3	11.4–19.1	12.0	8.9–15.1
Hemiplegia	90.7	87.6–93.8	77.4	72.8–82.0	79.6	75.3–84.0	78.8	74.9–82.7
Hemianesthesia	54.4	49.0–59.7	26.3	21.5–31.2	26.3	21.6–31.1	34.9	30.4–39.5
Aphasia	40.8	35.5–46.1	34.5	29.2–39.7	34.7	29.6–39.9	37.7	33.1–42.4
Hemianopsia	17.7	13.6–21.8	15.4	11.4–19.3	12.0	8.5–15.5	14.2	10.8–17.5
Cerebellar dysfunction	0.3	0.0–0.9	1.6	0.2–2.9	6.0	3.4–8.5	3.1	1.4–4.7
Cranial nerve palsy	3.3	1.4–5.2	14.4	10.5–18.3	32.3	27.3–37.4	28.1	23.8–32.4
Seizures	3.0	1.2–4.8	4.1	1.9–6.3	5.7	3.2–8.2	1.9	0.6–3.2
OCSP classification								
LACI	25.3	20.1–30.5	27.5	22.0–32.9	37.4	31.8–43.0	30.5	25.8–35.3
TACI	23.5	19.5–29.5	21.0	16.0–26.0	19.7	15.1–24.3	14.1	10.5–17.6
PACI	27.5	22.1–32.9	31.7	26.0–37.3	20.8	16.1–25.5	28.1	23.5–32.7
POCI	23.7	21.4–26.0	19.8	15.0–24.7	22.1	17.3–27.0	27.3	22.7–31.9
Outcome at 1 month								
m-Rankin score 0–1	34.2	29.1–39.4	43.3	37.8–48.7	34.7	29.6–39.9	40.3	35.6–45.0
m-Rankin score 2–3	17.7	13.6–21.8	13.2	9.4–16.9	28.7	23.9–33.6	26.9	22.6–31.1
m-Rankin score 4–5	22.8	18.3–27.4	13.2	9.4–16.9	13.8	10.1–17.5	16.5	13.0–20.1
Death	25.2	20.5–29.9	30.4	25.3–35.5	22.8	18.2–27.3	16.3	12.7–19.8
Resource use								
Cerebral CT scan	77.5	73.0–82.0	91.5	88.5–94.6	96.1	94.0–98.2	98.8	97.8–99.9
Cerebral MRI	0.0	0.0–0.0	0.0	0.0–0.0	1.2	0.0–2.4	4.0	2.1–5.9
Cervical artery Doppler	46.2	40.9–51.6	41.1	35.6–46.5	33.2	28.2–38.3	50.7	45.9–55.5
Angiography	0.6	0.0–1.4	2.2	0.6–3.8	0.9	0.0–1.9	1.9	0.6–3.2
Carotid surgery	0.9	0.0–1.9	1.3	0.0–2.5	2.1	0.6–3.6	1.7	0.4–2.9
Length of stay <10 days	33.9	28.8–39.0	45.8	40.3–51.3	53.3	47.9–58.7	48.8	44.0–53.6
Length of stay 10–30 days	39.6	34.4–44.9	39.5	34.1–44.9	40.4	35.1–45.7	36.8	32.2–41.4
Length of stay >30 days	26.4	21.7–31.2	14.7	10.8–18.6	6.3	3.7–8.9	14.4	11.0–17.7
Public hospital	89.5	86.2–92.8	82.8	78.6–86.9	80.2	75.9–84.5	72.2	67.9–76.5
Private hospital	5.4	3.0–7.8	8.2	5.1–11.2	10.2	6.9–13.4	18.4	14.7–22.1
Home	5.1	2.7–7.5	9.1	5.9–12.3	9.6	6.4–12.8	9.4	6.6–12.2
Discharge to prestroke residence	37.8	32.6–43.1	41.1	35.6–46.5	42.8	37.5–48.1	44.3	39.6–49.1

Table 5. Predictors of 1-month case fatality and high handicap defined as m-Rankin score 4–5 in patients ≥80 years

	1-month case fatality						m-Rankin score 4–5					
	univariate analysis			multivariate analysis			univariate analysis			multivariate analysis		
	OR	95% CI	p	OR	95 % CI	p	OR	95% CI	p	OR	95% CI	p
Stroke classification												
LACI	1.00			1.00			1.00			1.00		
TACI	7.27	4.58–11.52	<0.001	6.70	4.20–10.69	<0.001	3.35	2.24–5.00	<0.001	3.22	2.15–4.82	<0.001
POCI	5.29	3.26–8.59	<0.001	5.07	3.11–8.25	<0.001	1.18	0.81–1.73	0.379	1.16	0.80–1.70	0.434
PACI	1.32	0.77–2.27	0.310	1.22	0.71–2.09	0.481	0.65	0.47–0.89	0.008	0.64	0.46–0.88	0.006
Hemorrhagic stroke	8.92	5.35–14.86	<0.001	8.79	5.26–14.72	<0.001	1.93	1.18–3.13	0.008	1.91	1.17–3.12	0.009
Undetermined stroke	11.07	6.03–20.30	<0.001	11.15	6.01–20.68	<0.001	0.92	0.47–1.81	0.818	0.94	0.48–1.86	0.865
Risk factors												
Women	1.00			1.00			1.00			1.00		
Men	1.03	0.79–1.34	0.834	1.06	0.80–1.42	0.682	0.71	0.55–0.92	0.008	0.74	0.57–0.96	0.022
No hypertension (treated or not)	1.00						1.00					
Hypertension (treated or not)	1.00	0.76–1.31	0.988				1.02	0.79–1.33	0.853			
No untreated hypertension	1.00			1.00			1.00					
Untreated hypertension	0.69	0.47–1.01	0.058	0.72	0.48–1.07	0.106	1.00	0.72–1.39	0.996			
No diabetes	1.00			1.00			1.00					
Diabetes	0.70	0.46–1.06	0.094	0.80	0.51–1.26	0.333	1.11	0.78–1.59	0.568			
No hypercholesterolemia	1.00			1.00			1.00					
Hypercholesterolemia	0.61	0.41–0.91	0.014	0.65	0.43–1.00	0.048	0.95	0.68–1.31	0.743			
No AF	1.00			1.00			1.00			1.00		
AF	1.41	1.09–1.83	0.010	1.40	1.05–1.88	0.023	1.19	0.92–1.56	0.192	1.12	0.85–1.48	0.430
No myocardial infarction	1.00			1.00			1.00					
Myocardial infarction	1.24	0.94–1.64	0.134	1.17	0.86–1.60	0.315	1.19	0.90–1.58	0.233			
No previous TIA	1.00						1.00					
Previous TIA	1.05	0.74–1.49	0.791				1.19	0.84–1.68	0.326			
No alcohol intake	1.00			1.00			1.00					
Alcohol intake	1.79	0.75–4.27	0.187	1.86	0.71–4.86	0.206	1.49	0.53–4.22	0.451			
Prestroke treatments												
No antiplatelet agents	1.00						1.00					
Antiplatelet agents	0.84	0.63–1.12	0.233				0.98	0.74–1.28	0.859			
No anticoagulants	1.00						1.00					
Anticoagulants	0.80	0.46–1.37	0.414				0.87	0.54–1.42	0.588			

last remark. However, considering the stroke subtype, the decrease in CFR was only significant in hemorrhagic stroke. This result underlines the need to enroll elderly patients in clinical trials to give them the opportunity to benefit from specific treatments including thrombolysis.

Age seemed to be the major discriminating factor for the use of diagnostic resources as demonstrated by Di Carlo et al. [2]. Other authors observed a lower quality of care in elderly stroke patients compared to that in younger ones [24, 25]. Despite severer stroke and handicap in older patients, brain imaging, Doppler sonography, echocardiography and angiography were performed significantly less often. The more frequent use of palliative care in the elderly could contribute to this lower application of diagnostic resources. However, the limited use of complementary investigations in older patients may also contribute to the worse prognosis [2, 26]. Indeed, a higher level of access to care is generally associated with lower stroke mortality rates [27]. Further analyses will be needed to evaluate the relationship between limited investigations and outcome in older patients.

Older patients were more likely to have a longer LOS and to be discharged to an institution other than home, as previously reported in other studies [25, 26]. The higher LOS in patients ≥80 years could be the consequence of the greater stroke severity in this age group. In addition, these patients were more frequently admitted to and cared for in public hospitals. Hence, these results could be explained, at least in part, by the lack of family and social support [25, 28]. Moreover, medical, cognitive and social factors are all known to affect the risk of being institutionalized [1, 2, 25, 28]. Finally, despite the universal funded health care system in France, unequal access to specialized stroke care may exist among different sub-

Table 6. Case fatality rates at 1 month according to age, stroke subtype and study period

	Periods	Age ≤65 years		65< age <80 years		Age ≥80 years		p
		%	95% CI	%	95% CI	%	95% CI	
Overall strokes	1985–2006	7.2	5.5–9.3	14.2	12.5–16.2	23.2	21.0–25.4	<0.001
	1985–1990	10.9	7.2–16.2	20.3	16.5–24.9	25.3	21.0–30.3	<0.001
	1991–1995	9.3	5.3–16.2	20.0	16.0–24.9	30.5	25.7–35.9	<0.001
	1996–2000	6.2	3.6–10.6	10.5	7.6–14.3	22.8	18.6–27.6	<0.001
	2001–2006	4.1	2.2–7.4	7.0	4.8–10.0	16.3	13.1–20.1	<0.001
	linear trend	−0.49	−0.77 to 0.21	−0.91	−1.21 to 0.61	−0.56	−1.09 to 0.03	
	p	0.002		<0.001		0.041		
Hemorrhagic stroke	1985–2006	18.5	13.2–25.5	33.6	26.9–41.3	41.9	34.4–50.3	<0.001
	1985–1990	26.2	16.1–40.8	39.0	26.0–55.6	59.1	39.9–79.1	0.049
	1991–1995	17.5	7.7–37.2	33.3	20.9–50.4	57.6	41.7–74.4	0.012
	1996–2000	14.0	6.5–28.4	32.6	21.1–48.1	48.7	34.5–56.5	0.003
	2001–2006	13.9	6.0–30.2	28.9	17.2–46.1	20.4	11.8–33.8	0.272
	linear trend	−1.21	−2.12 to 0.31	−0.62	−1.56 to 0.32	−2.53	−3.52 to 1.55	
	p	0.011		0.182		<0.001		
Ischemic stroke	1985–2006	4.2	2.9–6.2	11.6	9.9–13.5	21.0	18.8–23.3	<0.001
	1985–1990	5.6	2.8–10.8	17.9	14.1–22.6	22.9	18.6–28.0	<0.001
	1991–1995	6.7	3.1–14.4	18.1	14.0–23.2	27.4	22.6–32.9	<0.001
	1996–2000	4.0	1.8–8.6	6.8	4.4–10.5	19.3	15.3–24.3	<0.001
	2001–2006	2.4	1.0–5.6	4.5	2.7–7.3	15.7	12.3–19.8	<0.001
	linear trend	−0.29	−0.58 to 0.01	−0.91	−1.22 to 0.61	−0.45	−0.97 to 0.06	
	p	0.043		<0.001		0.082		

groups (very elderly, rural areas, and social exclusion). These factors, which were not evaluated in our study, are also known to affect the success of rehabilitation and influence recovery after stroke [25, 29, 30].

Our work presents a number of strengths. The exhaustiveness of case ascertainment was ensured by using multiple overlapping sources of information. In contrast to other multicenter studies [1, 2, 7, 29], our data set was particularly homogenous in demographic features with a stable population, little migratory flow and a stable ethnic composition, and we included a wider range of elderly patients (n = 1,410) than that in previously published works [1, 2, 23].

However, some limitations must be mentioned. We were not able to differentiate between ischemic stroke from atheroma of large arteries, and undetermined and other causes because the TOAST classification [31, 32] had only been introduced in our registry in 2005. Actually before this date, we had not distinguished between these 3 ischemic stroke subtypes in our database. In addition, the NIHSS was not used to measure the severity of stroke at onset. Finally, the outcome was measured at 1 month, which is a short-term evaluation.

To conclude, considering the increasing number of strokes in the most elderly segment of the population, the longer stays in hospital and the use of resources, our results provide information to help understand the stroke outcomes in patients >80 and the approaching burden and challenges faced by health care systems.

Our findings suggest that stroke in the elderly is a specific medical issue with important implications not only for clinical management but also for initiating preventive strategies, therapeutic research and health policy. The recognition of this public health problem may encourage organizations to design clinical trials for the elderly, to facilitate access to stroke prevention and to stroke emergency care, which may lead to improvements in survival and quality of life in the elderly.

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