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A Prospective Community-Based Study of Stroke in Germany—The Erlangen Stroke Project (ESPro)

Incidence and Case Fatality at 1, 3, and 12 Months

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Background and Purpose—In Germany, basic data on stroke morbidity are lacking. If a population-based register in former East Germany is excluded, only routine mortality statistics have thus far provided information on epidemiology of stroke. Therefore, a population-based register of stroke was set up in Southern Germany to determine incidence and case fatality in a defined German population.

Methods—The Erlangen Stroke Project (ESPro) is a prospective community-based study among the 101 450 residents of the city of Erlangen, Bavaria, Germany. Standard definitions and overlapping case-finding methods were used to identify all cases of first-ever stroke in all age-groups, occurring in the 2 years of registration (April 1, 1994, to March 31, 1996). All identified cases of first-ever strokes were followed up at 3 and 12 months from onset.

Results—During 2 years of registration, 354 first-ever-in-a-lifetime strokes (FELS) were registered. The diagnosis and stroke type were confirmed by CT scan in 95% of cases. Fifty-one percent of all FELS occurred in the age group ≥75 years of age. The crude annual incidence rate was 1.74 per 1000 (1.47 for men and 2.01 for women). After age-adjustment to the European population, the incidence rate was 1.34 per 1000 (1.48 for men and 1.25 for women). The annual crude incidence rate of cerebral infarction was 1.37/1000, intracerebral hemorrhage 0.24/1000, subarachnoid hemorrhage 0.06/1000, and unspecified stroke 0.08/1000. Overall case fatality at 28 days was 19.4%, at 3 months it was 28.5%, and at 1 year 37.3%.

Conclusions—The first prospective community-based stroke register including all age groups in Germany revealed incidence rates of stroke similar to those reported from other population-based studies in western industrialized countries, but lower than that observed in former East Germany. **(*Stroke*. 1998;29:2501-2506.)**

Key Words: epidemiology ■ Germany ■ incidence ■ mortality ■ prognosis

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Stroke is one of the leading causes of death and long-term disability in Europe and already absorbs a considerable proportion of healthcare budgets.[1] The aging of the population in Europe and elsewhere will further increase the socioeconomic burden of stroke disease and limit the medical and social resources available to provide for the needs of stroke sufferers and their families.

To meet this challenge, the Helsingborg Declaration emphasized the need for population-based monitoring of specific key indicators such as stroke incidence and case fatality.[2]

Little is known about stroke incidence and outcome in Germany. Therefore, a community-based stroke register was established in Erlangen, Bavaria, Germany, on April 1, 1994, to determine the key indicators in a defined German population as demanded in the Helsingborg Declaration. This article presents incidence and case-fatality data for stroke from a community-based stroke register during the first 2 years of registration.

Subjects and Methods

Population-based studies can provide the necessary data, but only if they adhere to several "ideal" criteria for definitions, design, and presentation of data. Our register was designed to meet the criteria for "ideal" population-based stroke studies as proposed by Malmgren et al in 1987,[3] updated by Bonita et al in 1995,[4] and most recently updated by Sudlow and Warlow.[5] The major requirements and challenges are (1) to achieve complete case ascertainment, especially

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of strokes treated outside the hospital, and (2) to reach a specific diagnosis by ruling out other causes of strokelike episodes and to distinguish first from recurrent strokes. Diagnosis should therefore be based on careful clinical and neuroradiological assessment of all suspected strokes,[5] particularly in elderly subjects who are likely to present a more complex clinical picture and less likely to be admitted to the hospital.

Study Area and Population

The Erlangen Stroke Project (ESPro) is a community-based survey of all cases of stroke occurring in a university town, located in Bavaria in Southeast Germany. The study population (all residents of the Community of Erlangen) comprises 101 450 inhabitants (49 381 males and 52 069 females) according to the census of December 31, 1994. The proportion of inhabitants older than 65 years of age was 15.1%, compared with 15.3% for the whole German population.[6] Stroke registration started on April 1, 1994, without restriction of age.

There are general practitioners (GPs) serving the population, and access to medical care is free of charge for people of all ages. All the residents of this well-defined geographic area are served by the Erlangen University Hospital and a smaller General Hospital, both of which are located within the community and are open 24 hours, 7 days a week.

Patients with acute neurological illness are usually admitted to the Department of Neurology of the University Hospital, the only such department in the area. This department has 70 general neurology and 10 critical care beds and specializes in providing diagnostic, acute care, and rehabilitation services to patients with acute stroke, who occupy approximately 60% of the beds. Stroke patients are admitted regardless of age, socioeconomic circumstance, stroke severity, or prior health status. Patients who need longer-term rehabilitation are referred to the local neurological rehabilitation clinic within the study area.

Case Ascertainment

Several overlapping sources of information were used to ensure complete case ascertainment: (1) hospital admission and discharge lists and computer-linked records systems; (2) regular checks of all relevant hospital wards and residential and nursing homes; (3) records of ambulance and emergency services; (4) GPs; and (5) death certificates.

Nonhospitalized Stroke Patients

To estimate accurately the number of nonfatal strokes managed outside the hospital, the GPs in the community of Erlangen were notified of the study and regularly asked to refer all patients suspected of stroke for neurological evaluation. Each GP was also contacted personally every 3 months. To ensure complete case ascertainment among the elderly, nursing and residential homes, and the local psychiatric long-stay institutions, were checked weekly for nonhospitalized stroke patients. Additionally, the GPs serving the nursing and residential homes were asked to send all patients, even those with mild strokes, to the Department of Neurology of University Hospital for neurological evaluation.

To ensure inclusion of patients transferred to other institutions outside the community, regular checks were also performed at nursing homes just outside the study area (P.L.K.-R., P.U.H., C.G., S.S.) and at the Regional Clinic for Neurological Rehabilitation (T.R.v.S.). Finally, all death certificates and records of emergency services were scrutinized monthly to obtain information about those who might have died of a stroke before they could be admitted to the hospital.

These efforts were made despite the fact that easy access to medical services and adequate provision of acute care beds mean that almost all acute stroke patients are either seen by a GP or are referred to the Department of Neurology or the emergency unit of University Hospital.

Hospitalized Stroke Patients

To identify patients admitted to the hospital, daily checks of hospital admission and discharge records were made in the Erlangen University Hospital and on the wards of the Departments of Medicine (E.L.) and Geriatrics (K.-G.G.) of the General Hospital. All patients with symptoms even vaguely suggestive of a stroke (eg, acute vertigo, confusion, collapse, unexplained coma) were assessed.

As an additional check, computerized lists of patients from the study area with a discharge diagnosis including the ICD-9 (*International Classification of Diseases, 9th Revision*) codes 430 to 438 were matched with our registered cases, and all discrepancies were reviewed. Some other hospitals outside the study area, which are located in a rural region, have stroke patients diagnosed according to the World Health Organization (WHO) criteria, but do not provide imaging and neurological assessment. Patients suspected of stroke when admitted to these hospitals are referred to the Department of Neurology at University Hospital for further clinical evaluation. Therefore, checks of these hospitals outside the study area were not considered.

Study Definitions

Diagnosis

Stroke was defined according to WHO criteria, as "rapidly developing clinical symptoms and/or signs of focal, and at times global, loss of cerebral function, with symptoms lasting more than 24 hours or leading to death, with no apparent cause other than that of vascular origin."[7] Patients with transient episodes lasting less than 24 hours and those with asymptomatic lesions detected by brain imaging ("silent infarcts") were not included.

Criteria for Subtypes

Only patients with first-ever-in-a-lifetime stroke (FELS) during the study period were counted for the measurement of stroke incidence and case fatality. Previous history of stroke was checked as well by a personal interview with patients and caregivers and by reviewing the medical records. All acute events occurring within 21 days from the onset of the first event were considered as part of the same event. Recurrent strokes occurring more than 21 days after the initial event were registered, and a new form was filled out, but they were not included in the present analysis. Case fatality was assessed at 28 days according to the WHO standard[5,8] and at 3 and 12 months after stroke onset as recommended in the Helsingborg Declaration.[2]

Pathological Diagnosis

Pathological subtype (ischemic versus hemorrhagic stroke) was usually established by means of a noncontrast brain CT scan (Siemens Somatom DRH) immediately after admission. To reveal hemorrhagic transformation, control CT scans were performed regularly between 3 and 14 days after onset. MRI (Siemens Magnetom 1.5 T) was usually performed when the CT scan was normal. All patients with stroke in whom imaging could not be performed were classified as "unspecified type." To ensure uniform diagnostic standards, the study group met weekly to discuss each patient and to register all new cases in the study. The final classification of stroke subtype was made by 1 of the authors (P.L.K.-R.).

Patient Assessment

All patients were examined by the consulting physician on call or the GP. A detailed neurological examination and CT scan were performed in all suspected stroke patients admitted to the hospital or seen in outpatient clinics, and all FELS were registered. A further standard neurological examination was made 24 hours after the onset of symptoms to exclude transient ischemic attacks. Once it was established that the patient met the diagnostic and residential criteria, the medical and social history were recorded, and the functional status was assessed by 1 member of the study group (P.L.K.-R., P.U.H., C.G., or S.S.).

For stroke patients treated outside the hospital or unable to communicate, the interview was held with close relatives, or other suitable informants familiar with the patient's health, and the

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TABLE 1. Age- and Sex-Specific Crude Annual Incidence Rates of First-Ever-in-a-Lifetime Stroke per 1000 Population of Erlangen, Germany, 1994–1996

	Men			Women			Total		
Age Group, y	No./No. at Risk	Rate	95% CI	No./No. at Risk	Rate	95% CI	No./No. at Risk	Rate	95% CI
0–24	0/13 139			0/13 120			0/26 259		
25–34	3/11 642	0.06	0.02–0.16	1/10 229	0.02	0.00–0.10	4/21 871	0.04	0.01–0.10
35–44	2/7 386	0.14	0.02–0.43	4/6 937	0.29	0.10–0.66	6/14 323	0.21	0.09–0.41
45–54	16/6 236	1.28	0.80–1.95	10/6 178	0.81	0.44–1.37	26/12 414	1.05	0.73–1.45
55–64	20/5 319	1.88	1.25–2.73	24/5 900	2.03	1.40–2.86	44/11 219	1.96	1.50–2.52
65–74	46/3 770	6.10	4.70–7.79	47/5 379	4.37	3.38–5.57	93/9 149	5.08	4.25–6.04
75–84	38/1 475	12.88	9.66–16.85	75/3 134	11.97	9.80–14.48	113/4 609	12.26	10.43–14.32
≥85	20/414	24.15	16.06–34.91	48/1 192	20.13	15.64–25.54	68/1 606	21.17	17.16–25.84
All	145/49 381	1.47	1.27–1.68	209/52 069	2.01	1.78–2.25	354/101 450	1.74	1.60–1.90
TotalASR(1)		2.00	1.67–2.33		1.70	1.46–1.94		1.82	1.63–2.01
TotalASR(2)		1.48	0.90–2.05		1.25	0.81–1.68		1.34	0.99–1.68

(1) Age-standardized rates (ASR) adjusted to the 1994 German population.[6]
(2) Age-standardized rates (ASR) adjusted to Segi's European population.[11]

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medical records were checked. Patients were followed up after 28 days, 3 months, and 12 months after stroke onset. If the patient could not be contacted for follow-up, the Population Register of Erlangen was checked for a possible change of address or death. If the patient died during the follow-up period, the death certificate was reviewed, and the cause of death was ascertained from all available medical records.

Statistical Methods

All data were collected prospectively using the standard definitions and basic data sets agreed on by the European Stroke DataBase (ESDB) collaboration.[9,10] Age- and sex-specific incidence rates were used to adjust crude rates to the 1994 German population, by the direct method. To make the results comparable with other community-based studies, the rates were presented in 10-year age groups and adjusted to the standard European population.[5,11] The 95% confidence intervals (CIs) for the incidence and case-fatality rates were calculated by the method of Schoenberg.[12]

Results

During the 2-year period from April 1, 1994 to March 31, 1996, 571 suspected stroke cases were identified. Among them, 3 patients were excluded because of nonstroke diagnoses (1 with brain tumor, 1 with encephalitis, and 1 with multiple sclerosis), and 103 patients were diagnosed as having a transient ischemic attack. Of the remaining 465 patients, 111 (23.8%) were classified as recurrent stroke because they had a clear clinical history of stroke in the past. The total number of patients with FELS was 354, including 12 cases of spontaneous subarachnoid hemorrhage (SAH). Of these, 10 patients presented with focal or global disturbance of cerebral function at onset, and the remaining 2 complained only of sudden headache and meningism.

Of these 354 patients, 335 (94.6%) were admitted to hospitals within the study area: 85.3% patients to the Department of Neurology, 9.4% to the Departments of Medicine; and 16 (4.5%) patients were treated at home. Three patients (0.8%) died before admission (identified from death certificates). According to the emergency ambulance reports, no stroke patient died while being transported to the hospital. FELS occurred in 209 women (59%; mean age, 75.3±12.7 years [±SD]) and in 145 men (41%; mean age, 69.7±13.4 years [±SD]). All 16 nonhospitalized patients were older than 75 years of age (mean age, 87.1±5.8 years [SD]; range, 77 to 96 years), yet 91% of stroke patients older than 75 years of age were admitted to the hospital.

Subtypes of Stroke

Among the 354 patients with FELS, pathological subtypes were as follows: 278 patients (78.5%) had cerebral infarction, 48 (13.6%) had intracerebral hemorrhage (ICH), 12 (3.4%) had spontaneous SAH, and 16 (4.5%) had a stroke of unspecified type. A CT scan was performed within 30 days of onset in 338 (95.5%) of those patients with FELS. Of the 16 patients who were treated at home, a CT scan was performed in 6 (37.5%).

Incidence

The age- and sex-specific crude incidence rates for FELS with CIs are shown in detail in Table 1. The crude annual incidence rate of FELS for the period 1994 through 1996 was 1.74 (95% CI, 1.60 to 1.90) per 1000; for men 1.47 (95% CI, 1.27 to 1.68), and 2.01 (95% CI, 1.78 to 2.25) for women. The adjusted incidence rates are also shown after direct standardization to the 1994 German population and to the European standard population.

Table 2 shows numbers of cases and incidence rates for the various pathological subtypes of stroke. No significant differences were found between men and women or between those younger or older than 75 years for the distribution of subtypes. The incidence rates increased significantly with age groups in cerebral infarction, ICH, unspecified type, and for men and women. SAH incidence was highest between 35 and 54 years of age in men and 45 and 64 years of age in women.

Case-Fatality Rates

The case-fatality rates at 28 days, 3 months, and 12 months, according to the pathological subtype of stroke, are shown in Table 3. The overall 28-day case-fatality rate for patients with FELS was 19.4% (69/354 patients). Patients with stroke of

TABLE 2. Crude Annual Incidence Rates for Pathological Subtypes of Stroke (FELS) by Sex and Age per 1000 Population of Erlangen, Germany, 1994–1996

	Cerebral Infarction			Intracerebral Hemorrhage			Subarachnoid Hemorrhage			Unspecified Type		
Age Group, y	No.	Rate	95% CI	No.	Rate	95% CI	No.	Rate	95% CI	No.	Rate	95% CI
Men												
0–24	0			0			0			0		
25–34	2	0.04	0.01–0.13	1	0.02	0.00–0.10	0			0		
35–44	1	0.07	0.00–0.32	0			1	0.07	0.00–0.32	0		
45–54	12	0.96	0.56–1.56	2	0.16	0.03–0.50	2	0.16	0.03–0.50	0		
55–64	17	1.60	1.02–2.40	2	0.19	0.03–0.59	1	0.09	0.00–0.45	0		
65–74	40	5.31	4.01–6.90	5	0.66	0.26–1.39	0			1	0.13	0.01–0.63
75–84	30	10.17	7.33–13.77	6	2.03	0.89–4.01	0			2	0.68	0.12–2.13
≥85	16	19.32	12.16–29.20	2	2.42	0.43–7.58	0			2	2.42	0.43–7.58
All	118	1.19	1.02–1.39	18	0.18	0.12–0.27	4	0.04	0.01–0.09	5	0.05	0.02–0.11
Women												
0–24	0			0			0			0		
25–34	1	0.02	0.00–0.10	0			0			0		
35–44	3	0.22	0.06–0.56	0			1	0.07	0.00–0.34	0		
45–54	4	0.32	0.11–0.74	4	0.32	0.11–0.74	2	0.16	0.03–0.51	0		
55–64	16	1.36	0.85–2.06	5	0.42	0.17–0.89	3	0.25	0.07–0.66	0		
65–74	38	3.53	2.65–4.63	8	0.74	0.37–1.34	1	0.09	0.00–0.44	0		
75–84	60	9.57	7.64–11.85	13	2.07	1.23–3.30	1	0.16	0.01–0.76	1	0.16	0.01–0.76
≥85	38	15.94	11.96–20.84	0			0			10	4.19	2.28–7.10
All	160	1.54	1.34–1.75	30	0.29	0.21–0.39	8	0.08	0.04–0.14	11	0.11	0.06–0.17
Total												
0–24	0			0			0			0		
25–34	3	0.03	0.01–0.08	1	0.01	0.00–0.05	0			0		
35–44	4	0.14	0.05–0.32	0			2	0.07	0.01–0.22	0		
45–54	16	0.64	0.40–0.98	6	0.24	0.11–0.48	4	0.16	0.06–0.37	0		
55–64	33	1.47	1.08–1.97	7	0.31	0.15–0.59	4	0.18	0.06–0.41	0		
65–74	78	4.26	3.50–5.14	13	0.71	0.42–1.13	1	0.05	0.00–0.26	1	0.05	0.00–0.26
75–84	90	9.76	8.14–11.62	19	2.06	1.35–3.02	1	0.11	0.01–0.51	3	0.33	0.09–0.84
≥85	54	16.81	13.26–21.04	2	0.62	0.11–1.96	0			12	3.74	2.16–6.05
All	278	1.37	1.24–1.51	48	0.24	0.18–0.30	12	0.06	0.03–0.10	16	0.08	0.05–0.12

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unspecified type had the highest case-fatality rate (68.7%), compared with 50% for those with SAH, and 41.6% for those with ICH; the lowest case-fatality rate was observed for cerebral infarction (11.5%). The overall fatality rate at 3 months was 28.5% (n=101) and at 12 months 37% (n=132).

Discussion

We made every effort to ensure completeness of case ascertainment, particularly for nonhospitalized stroke patients and therefore to guarantee the reliability of our data. We contacted nursing homes weekly and all the GPs in the study area every 3 months. We reviewed all hospital discharge diagnoses and contacted the rehabilitation hospital to find cases that might have escaped attention before. We also reviewed, at monthly intervals, all death certificates with a diagnosis of cerebrovascular disease or sudden death.

The diagnosis of stroke was based on the WHO definition, a clinical definition, although almost all patients (95.5%) underwent a CT scan to exclude other diagnoses and to define the subtype. There has been much discussion of the possible influence of the widespread use of CT and MRI scans on the estimated incidence of stroke, because cases that might have been missed previously can now be identified by neuroimaging. In our study the proportion of recurrent strokes (23.8%) is slightly higher than that reported in most studies from Western industrialized countries, but the proportion is similar to the 27.2% found in a recent Norwegian population–based stroke register.[13] The high rate of recurrence might be because of the extensive and frequent checks of hospital and GPs' medical records in the community and because of the use of "overlapping sources of information," eg, interviewing patients and their relatives and professional caregivers.

In the Erlangen Stroke Project more than 94% of those with strokes were hospitalized, a proportion similar to that observed for many other industrialized countries, especially in urban areas. Although the proportion of strokes managed

TABLE 3. Case Fatality Rates According to Stroke Subtype at 28 Days, 3 Months, and 12 Months after Stroke Onset in Erlangen, Germany, 1994–1996

	28 Days			3 Months			12 Months		
Stroke Type	No.	CFR (%)	95% CI	No.	CFR (%)	95% CI	No.	CFR (%)	95% CI
CI (n=278)	32	11.5	8.50–15.15	56	20.1	15.40–24.89	83	29.9	24.44–35.27
ICH (n=48)	20	41.6	29.59–54.55	24	50.0	35.33–64.67	28	58.3	43.87–72.80
SAH (n=12)	6	50.0	24.53–75.47	7	58.3	25.62–91.05	7	58.3	25.62–91.05
UNS (n=16)	11	68.7	45.17–86.79	14	87.5	69.30–105.7	14	87.5	69.30–105.7
All (n=354)	69	19.4	16.09–23.28	101	28.5	23.80–33.26	132	37.3	32.23–42.35

CFR indicates case-fatality rates; CI, cerebral infarction; UNS, unspecified.

outside the hospital was much lower than that in the Oxfordshire Community Stroke Project (OCSP),[14] fatal out-of-hospital cases accounted for a proportion of the total (0.8%) similar to that reported in the OCSP (1.8%) and that from a recent Italian study (1.0%).[15]

The incidence rates of stroke observed in our study are in line with those found in South and Central Europe.[15–20] In the SEPIVAC study, for example, the stroke incidence rate, age-adjusted to the European population, was 1.55/1000 inhabitants,[18] whereas in Warsaw it was 1.11/1000.[20]

On the other hand, our incidence rates are lower than those observed in community-based studies in Northern Europe.[13,21–24] The incidence of stroke in Innherred, Norway, has been reported to be 3.12/1000 in the same period from 1994 to 1996.[13] One study in the South of Finland reported an incidence of 1.91/1000 during the period 1989 to 1991,[24] but this was lower than the average for Scandinavian countries, including other studies within Finland.[25,26] Our rates are also lower than those observed in community-based studies in Estonia and Russia,[27,28] but are similar to those found in predominantly white communities in the United States and Australia.[29–32]

The incidence of stroke by subtype is similar to those observed in other European countries,[13,15,17,18] the incidence of cerebral infarction reflects that of all strokes. ICH tended to increase with age, a phenomenon also observed elsewhere.[13,15,17,24] It is true that there were no cases of ICH among women older than 85 years of age, but the high case-fatality rate of unspecified type of stroke in that group suggests that some of these cases might have been ICH. Unfortunately, we do not have enough data yet to draw any conclusions on the hemorrhagic subtypes of stroke.

Our register is the first community-based study of stroke in Germany without age restriction and encompassing a large and well-defined population. Only 1 previous incidence study of stroke in former West Germany has been published,[33] but that study included only hospitalized stroke patients older than 60 years of age. The only previous population-based study was conducted in a group of communities in former East Germany during the period 1982 to 1986 but included only people 25 to 74 years of age.[34] That study was part of the WHO MONICA Project, and slightly more recent data have been published as part of the MONICA results,[35] with incidence rates similar to those in the study by Eisenblätter et al.[34]

Although our stroke incidence rates are generally similar to those reported in other Western European countries, the age-specific rates from the East German study were higher and closer to the rates observed in other Eastern European countries. This is not unexpected, because the 2 Germanys have been completely separated for 45 years, not only politically but socioeconomically. It remains to be seen whether reunification will narrow this gap in stroke incidence and fatality rates.

Our 28-day case-fatality rates are also similar to those found in other Western European studies,[13,17–19,22,24,36] although higher rates were reported from the 2 Italian studies, Valle d'Aosta (31%)[37] and Belluno (33%),[15] perhaps because of a more widespread use of CT for elderly people and those persons with mild strokes. The trends in 3- and 12-month case-fatality rates in our study are similar to those reported for Finland[24] but are slightly higher compared with both of the Western European community-based studies (OCSP[17] and Dijon[19]), possibly because of the higher proportion of recurrent strokes in our study.

Our efforts to include all incident stroke cases among the elderly population involved substantial work in checking long-stay institutions and in screening people presenting with a variety of vague neurological symptoms. Because it is often difficult to obtain reliable clinical information in very old people who may have complex symptoms and possibly impaired communication or cognition, studies with an upper age limit of 75 or even 65 years are much easier and cheaper to do, and may be less susceptible to diagnostic misclassification.

On the other hand, the rapid increase in the number of very elderly people in most countries makes it vitally important to obtain reliable information in this sector of the population, in order to estimate the socioeconomic impact of stroke and its likely effects on healthcare systems. In our study more than 20% of cases of first-ever stroke occurred in people older than 85 years of age who accounted for only 1.6% of the total population. When the effects of second or third events are considered, the burden of long-term dependency because of stroke disease in this age-group is likely to account for an even greater proportion of the total.[38]

In all aspects of the study we have made use of the standard clinical terminology, definitions, classifications, and assessments agreed on by the European Stroke DataBase collaboration. The main aim of this expanding collaborative network is to develop a common clinical language for stroke, which

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will enable all information from future studies to be compared and combined, thus creating an effective tool for studying and hopefully eventually controlling the effects of this devastating disease.

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