Hospitalization Within the First Year After Stroke
The Dijon Stroke Registry

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Background and Purpose—This population-based study aimed to identify unplanned hospitalization within the first year after stroke to determine factors associated with it and consequences on survival.

Methods—All first-ever acute strokes occurring in Dijon, France, from 2009 to 2011, were prospectively collected from a population-based registry. Demographics and clinical data, including stroke severity measured by the National Institutes of Health Stroke Scale and disability after stroke, were recorded. For each patient, the first unplanned hospitalization that occurred within 1 year after stroke was retrieved by linking data with the national French Hospital Discharge Database. Predictors of hospitalization and survival at 1 year were identified using logistic regression models.

Results—Among the 613 patients recorded, 94 (15.3%) were excluded because of early death. Of the 519 remaining patients, 167 (32.2%) were hospitalized at 1 year. Subsequent hospitalization led to in-hospital death for 16 (9.6%) patients. In multivariable analyses, only a history of hypertension and atrial fibrillation were associated with hospitalization. In stratified analyses, the National Institutes of Health Stroke Scale score was associated with a higher risk of hospitalization (odds ratio, 1.13; 95% confidence interval, 1.03–1.22; P=0.006), whereas only a trend was noted for disability (odds ratio, 2.26; 95% confidence interval, 0.82–6.22; P=0.113) in patients who returned home after the index stroke. Hospitalization was negatively associated with being alive at 1 year (odds ratio, 0.36; 95% confidence interval, 0.19–0.66; P<0.01).

Conclusions—Stroke survivors are at high risk of hospitalization after the episode, and subsequent admission is associated with poor survival, thus highlighting the need for follow-up interventions after discharge to prevent readmission. **(*Stroke*. 2015;46:190-196. DOI: 10.1161/STROKEAHA.114.007429.)**

Key Words: acute stroke ■ epidemiology ■ mortality ■ outcome ■ registry

In recent years, the increase in the number of elderly people growth has been associated with a rise in the absolute number of people suffering a stroke each year.[1] In addition to these demographic changes, major advances in the management of stroke have taken place, including the implementation of dedicated acute stroke care pathways, improvements in diagnostic procedures, the development of stroke units, and the use and thrombolysis for acute ischemic stroke. These changes have largely contributed to increasing the number of stroke survivors, and this phenomenon will undoubtedly be magnified in coming years. As a result, clinicians will be faced with a great challenge with regard to outcomes in these patients. One major issue is that the risk of all-cause readmission to hospital after stroke is high, ranging between 31% and 49% at 1 year according to various studies.[2–9] Readmission to hospital has a deleterious effect on the well-being of patients and leads to an increase in socioeconomic costs.[8,10] The better identification of patients at risk could therefore be useful so as to develop preventive strategies to reduce the number of emergency hospitalizations after stroke.

The aim of this population-based study was to assess the proportion of patients who needed to be hospitalized within the first year after their stroke, to determine factors associated with subsequent hospitalization, and to evaluate consequences in terms of survival.

Methods

Study Population

All patients with a first-ever stroke that occurred between January 1, 2009, and December 31, 2011, were prospectively identified among residents of the city of Dijon, France (151 543 inhabitants), from the Dijon Stroke Registry, a population-based study that was established in 1985.[11] This registry complies with the defined criteria for conducting stroke incidence studies,[12,13] and its methodology has been extensively described elsewhere.[11] Hence, to attempt to achieve complete case-ascertainment, hot and cold pursuit procedures based on multiple overlapping sources of information were used to identify fatal

Received September 11, 2014; final revision received October 3, 2014.

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Stroke **is available at http://stroke.ahajournals.org** **DOI: 10.1161/STROKEAHA.114.007429**

and nonfatal stroke in hospitalized and nonhospitalized patients in the geographically defined area. Stroke was defined according to the World Health Organization diagnostic criteria as rapidly developing clinical signs of focal (at time global) disturbance of cerebral function, lasting >24 hours or leading to death with no apparent cause other than that of vascular origin.[14] Patients who received intravenous thrombolytic therapy or mechanical revascularization were considered as having stroke, even though total recovery was observed within 24 hours. Only first-ever symptomatic stroke in a lifetime was considered for this study and was classified as ischemic stroke (IS), spontaneous intracerebral hemorrhage (ICH), or undetermined stroke. The etiologic classification of patients with IS was as follows: large artery IS, cardioembolic IS, lacunar IS, IS from other identified cause, and IS from undetermined cause. Only patients aged ≥18 years were included in this study.

Data Collected

Medical history was collected as previously described:[11] hypertension (high blood pressure noted in a patient's medical history or patients under antihypertensive treatment), diabetes mellitus (glucose level ≥7.8 mmol/L reported in the medical record or patients under insulin or oral hypoglycemic agents), hypercholesterolemia (total cholesterol level ≥5.7 mmol/L reported in the medical history or patients treated with lipid-lowering therapy), atrial fibrillation, history of coronary heart disease, peripheral artery disease, heart failure, smoking, cancer, and previous transient ischemic attack defined as the sudden development of signs and symptoms affecting motor, sensory, sensorial and speech, brain stem, and cerebellum functions lasting <24 hours. Pre-stroke dependency defined as living in a nursing home was collected.

Clinical features at onset, including motor paresis, aphasia, and coma, were noted. Stroke severity was quantified using the National Institutes of Health Stroke Scale (NIHSS) score obtained at the first clinical examination. In a small number of cases in which patients presented late or were assessed elsewhere for events occurring on vacation, for example, the NIHSS score was estimated on the basis of the review of the clinical history and medical records with the methodology reported elsewhere.[15] Disability after stroke was evaluated thanks to the modified Rankin scale score (mRS) either at discharge from the acute stay for hospitalized patients or at clinical evaluation for outpatients. We also considered the destination after discharge (home versus not home).

Identification of Hospitalization

The outcome variable for this study was the first unplanned hospitalization that occurred within the first year after stroke and that corresponded to the first hospitalization either after discharge of the acute stay for hospitalized stroke patients or at any time after the index stroke for outpatients. Planned hospitalizations for complementary investigations or treatment (ie, elective carotid surgery) or related to a chronic disease or an obstetric reason were excluded from the analyses. To identify hospitalizations, we crossed data from the Dijon Stroke Registry with those obtained from the French Hospital Discharge Database (PMSI: Program de Médicalisation des Systèmes de Santé) between January 1, 2009, and December 31, 2012. This national database, which is used to determine hospital payments, contains the medical records of all patients discharged from both private and public hospitals.[16] The database includes all admissions nationwide because French hospitals are financed by a single payer. Each admission is characterized by discharge diagnoses and procedure codes that determine the diagnosis-related group and thus reimbursement. A unique anonymous patient identification number is attributed to each patient. So once the index stroke case was identified, all following hospitalizations were retrieved, thanks to the patient's identification number. A review of medical files of the patients corresponding to the hospitalizations was systematically performed by the investigators so as to determine its cause. We only considered the main diagnosis that was responsible for the hospitalization.

Statistical Analysis

Proportions and mean values of baseline characteristics were compared between groups using the chi square test and the Wilcoxon–Mann–Whitney test when appropriate. Logistic regression models were used to identify predictors of hospitalization and being alive at 1 year after stroke. In multivariable models, we introduced age, sex, and all variables with a P value <0.20 in unadjusted models. Two models were generated using either the initial NIHSS score or the mRS score after stroke. The mRS score was dichotomized as mRS 0 to 2 (independent patient) and mRS 3 to 5 (moderate-to-severe disability). Interaction terms were added to the models using the likelihood ratio test. Because significant interactions were noted between either the NIHSS score or the mRS score and discharge to home, stratified analyses were performed according to discharge to home. STATA@ 9.0 software (StataCorp LP, College Station, TX, USA) was used for the statistical analysis.

Ethics

The Dijon Stroke Registry was approved by the Comité National des Registres (French National Committee of Registers) and the InVS (French Institute for Public Health Surveillance) and has authorization of the Commission Nationale de l'Informatique et des Libertés (National Commission for the Protection of the Privacy of Electronic Data).

Results

Over the study period, 613 patients with a first-ever stroke were recorded. Death occurred in 94 patients (15.3%) during their acute stay for stroke. These patients were thus excluded from the final analyses. Among the 519 remaining patients, 167 (32.2%) were hospitalized within the first year after their stroke. The mean time between the stroke and the subsequent hospitalization was 139±109 days, (median, 118; interquartile range, 40–229). The mean length of stay for this hospitalization was 10.6±15.5 days (median, 7; interquartile range, 3–12). The most frequent reasons for hospitalization were neurological diseases (26.9%), cardiac and other vascular events (16.8%), orthopedic/rheumatologic reasons (13.8%), and infections (10.8%; Table 1). Miscellaneous causes accounted for one third of hospitalizations. Hospitalization led to death for 16 (9.6%) patients and among survivors and 114 (75.5%) returned home.

The baseline characteristics of patients according to hospitalization are shown in Table 2. Patients hospitalized at 1 year were older and had a higher prevalence of hypertension, atrial fibrillation, coronary heart disease, heart failure, and peripheral artery disease. Although no difference in the stroke mechanism was observed, the initial severity of the index stroke was higher in patients who had subsequent hospitalization. In addition, these patients had a higher residual disability and were less likely to return home after the index stroke.

Multivariable analyses showed that in the first model using initial severity, only a history of hypertension (odds ratio [OR], 1.72; 95% confidence interval [CI], 1.08–2.74; P=0.022) and atrial fibrillation (OR, 1.62; 95% CI, 1.01–2.60; P=0.047) were independently associated with hospitalization at 1 year. When considering the mRS score after stroke in the second model, similar results were observed (OR, 1.73; 95% CI, 1.09–2.76; P=0.020 for hypertension and OR,1.64; 95% CI, 1.02–2.63; P=0.040 for atrial fibrillation; Table 3). In stratified analyses, both hypertension and prestroke dependency

Table 1. Reasons for First Hospitalization Within the First Year After Stroke

Causes	Number of Patients
Neurological causes	45 (26.9%)
Recurrent stroke or TIA	23
Worsened neurological state	7
Epilepsy	5
Headache	3
Dementia	1
Neurological symptoms without diagnosis	6
Cardiac and other arterial vascular events	28 (16.8%)
Acute heart failure	14
Coronary heart disease	4
Rhythm disorder	3
Syncope	2
Cardiac arrest	1
Pericardial effusion	1
Hypertension	1
Acute limb ischemia	1
Aortic aneurysm rupture	1
Orthopedic and rheumatologic causes	23 (13.8%)
Fall with bone fracture	12
Fall without bone fracture	4
Other trauma	5
Osteoporosis	1
Algodystrophy	1
Infections	18 (10.8%)
Pneumonia or bronchitis	13
Spondylodiscitis	2
Urinary tract infection	1
Septic arthritis	1
Gastrostomy abscess	1
Miscellaneous causes	53 (31.7%)
Gastrointestinal disorder	14
Venous thromboembolic disease	5
Others	34

TIA indicates transient ischemic attack.

were associated with hospitalization in patients who were not discharged home, whatever the model considered (Table 4). In patients who returned home, an association between male sex and hospitalization was observed in both models. In addition, the NIHSS score was associated with a higher risk of hospitalization (OR, 1.13; 95% CI, 1.03–1.22; P=0.006), whereas only a trend was noted for residual disability (OR, 2.26; 95% CI, 0.82–6.22; P=0.113; Table 4).

Further analyses were performed on patients who needed to be hospitalized so as to identify factors associated with hospitalization for each cause. As a result, a history of heart failure was associated with an increased risk of hospitalization for cardiovascular reasons (OR, 4.42; 95% CI, 1.45–13.4; P=0.01). In addition, a trend toward an association between hospitalization for an infectious disease and both prestroke coronary heart disease (OR, 3.44; 95% CI, 0.99–11.9; P=0.05) and residual disability (OR, 2.66; 95% CI, 0.89–7.97; P=0.08) was observed. Finally, no factor was independently associated with hospitalization for neurological reasons of orthopedic/rheumatologic complications, even though disability after stroke tended to be related to more frequent hospitalization for the latter (OR, 2.52; 95% CI, 0.87–7.26; P=0.09).

Finally, 1-year survival in patients who needed to be hospitalized within the first year after their stroke was lower than that in patients who did not (77.8% versus 91.2%; OR, 0.34; 95% CI, 0.20–0.57; P<0.01). After adjustment for confounding variables, hospitalization was negatively associated with being alive at 1 year (OR, 0.36; 95% CI, 0.19–0.66; P<0.01; Table 5).

Discussion

This population-based study demonstrated that among patients alive after a first-ever stroke, 32% were subsequently hospitalized at 1-year. Our results are consistent with those from other studies on this topic, which suggested that between 31% and 49% of patients were readmitted within the year after the index stroke.[2–9] In addition, a cohort study showed that stroke patients had a 2-fold greater risk of readmission within 1 year compared with their matching nonstroke controls.[6] However, direct comparisons are made difficult by variations in case-mix between studies and the fact that previous works were limited by either the use of administrative databases with sometimes only scarce data on either the index stroke or the subsequent hospitalization, whereas other studies were hospital-based or considered readmissions to the same hospital only or both planned and unplanned hospitalizations. In contrast, in the present study, the use of a population-based registry and data linkage with those obtained from the national discharge database allowed the exhaustive identification of stroke patients and subsequent hospitalizations, wherever they were managed.

We identified that prestroke hypertension and atrial fibrillation were the only independent factors associated with hospitalization. To the best of our knowledge, such associations have not been described previously, although 1 study concluded that hypertension was related to a higher risk of stroke readmission in patients aged ≥85 years.[17] Our findings could reflect the fact that patients with hypertension or atrial fibrillation are at a high risk of medical complications, including cerebrovascular or cardiovascular disease, which could lead to readmission after stroke. In addition, it could be assumed that patients who needed to be hospitalized had a poorer control of these risk factors, although we had no data to explore this hypothesis. Nonetheless, from a global point of view, because stroke patients are at a high risk of hospitalization as a result of the high prevalence of risk factors, our study strongly highlights the need for regular surveillance of the treatment of their vascular risk factors and comorbid conditions, so as to reduce subsequent unplanned hospitalizations.

In contrast, stroke type was not related to the risk of hospitalization, which is in agreement with previous works.[3,18] In univariate and multivariate analyses without stratification, stroke severity, either initial severity measured by the NIHSS score or residual disability measured using the

Table 2. Characteristics of Patients According to Hospitalization at 1 y

	Not Hospitalized Patients (n=352)			Hospitalized Patients (n=167)			
	n	%	95% CI	n	%	95% CI	*P* Value
Age, mean±SD	72.4±16.97			76.1±14.50			0.023
Age, median (IQR)	76.6 (63.4–84.2)			79.1 (68.5–85.6)			0.016
Age groups, y							0.148
<60	70	19.9	15.7–24.1	23	13.8	8.5–19.1	
60–70	60	17.0	13.1–21.0	22	13.2	8.0–18.4	
70–80	80	22.7	18.3–27.1	41	24.6	18.0–31.1	
>80	142	40.3	35.2–45.5	81	48.5	40.8–56.2	
Men	174	49.4	44.2–54.7	85	50.9	43.2–58.6	0.755
Medical history							
Hypertension	226	64.2	59.2–69.2	129	77.2	70.8–83.7	0.003
Hypercholesterolemia	108	30.7	25.8–35.5	58	34.7	27.4–42.0	0.356
Diabetes mellitus	47	13.4	9.8–16.9	33	19.8	13.7–25.9	0.060
Smoking	62	17.6	13.6–21.6	36	21.6	15.3–27.9	0.284
Atrial fibrillation	59	16.8	12.8–20.7	45	26.9	20.1–33.7	0.007
Coronary heart disease	42	11.9	8.5–15.3	31	18.6	12.6–24.5	0.044
Previous TIA	30	8.5	5.6–11.5	15	9.0	4.6–13.4	0.862
Heart failure	33	9.4	6.3–12.4	28	16.8	11.0–22.5	0.016
Peripheral artery disease	16	4.5	2.4–6.7	18	10.8	6.0–15.5	0.009
Cancer	44	12.5	9.0–16.0	26	15.6	10.0–21.1	0.340
Prestroke dependency	15	4.3	2.1–6.4	15	9.0	4.6–13.4	0.035
Clinical features							
Hemiparesis	246	69.9	65.1–74.7	136	81.4	75.5–87.4	0.006
Aphasia	126	35.8	30.8–40.8	65	38.9	31.5–46.4	0.490
Coma	10	2.8	1.1–4.6	7	4.2	1.1–7.3	0.422
Initial stroke severity							
NIHSS, mean±SD	6.0±6.07			7.4±6.48			0.003
NIHSS median (IQR)	4 (2–8)			6 (3–10)			0.015
Stroke mechanism							0.556
Hemorrhagic stroke	36	10.2	7.0–13.4	16	9.6	5.1–14.1	
Large artery IS	84	23.9	19.4–28.3	38	22.8	16.3–29.2	
Lacunar IS	52	14.8	11.0–18.5	21	12.6	7.5–17.7	
Cardioembolic IS	76	21.6	17.3–25.9	49	29.3	22.4–36.3	
Other IS	27	7.7	4.9–10.5	12	7.2	3.2–11.1	
Undetermined IS	77	21.9	17.5–26.2	31	18.6	12.6–24.5	
mRS 3–5 after stroke	116	33.0	28.0–37.9	76	45.5	37.9–53.1	0.006
Discharged to home	187	53.1	47.9–58.4	71	42.5	34.9–50.1	0.024

CI indicates confidence interval; IQR, interquartile range; IS, ischemic stroke; mRS, modified Rankin scale score; NIHSS, National Institutes of Health Stroke scale score; SD, standard deviation; and TIA, transient ischemic attack.

mRS, was not an independent factor associated with subsequent hospitalization either. Only 2 studies considered stroke severity in their multivariable analyses.[3,9] One did not find any significant association between the initial NIHSS score and 1-year readmission,[9] whereas the other concluded that dependency at discharge (mRS >2) but not the initial NIHSS score was associated with a greater risk of readmission at 1 year.[3] Several reasons could account for our negative results. First, patients with severe stroke are at a high risk of medical complications during the early stage of their stroke while still in hospital in acute beds, and in this context, patients who do experience complications are therefore not considered readmitted. Second, the mRS score was assessed either at discharge from the acute stay for hospitalized patients or at the clinical evaluation for outpatients. Patients with severe disability are not usually discharged to home but rather to other care facilities, including rehabilitation units, convalescent homes, or nursing homes.[19] Medical complications occurring in these patients during their stays in these facilities are most of the time treated on site without

Table 3. Factors Associated With Hospitalization at 1 y in Stroke Survivors in Multivariable Analyses

	Model 1*			Model 2†		
Variables	OR	95% CI	*P* Value	OR	95% CI	*P* Value
Male sex	1.33	0.88–2.00	0.174	1.32	0.88–1.99	0.185
Age groups, y						
<60						
60–70	0.78	0.38–1.59	0.492	0.75	0.37–1.55	0.443
70–80	1.11	0.58–2.12	0.754	1.10	0.57–2.10	0.777
>80	1.16	0.62–2.14	0.643	1.10	0.59–2.05	0.758
Hypertension	1.72	1.08–2.74	0.022	1.73	1.09–2.76	0.020
Diabetes mellitus	1.23	0.72–2.10	0.442	1.20	0.70–2.04	0.504
Atrial fibrillation	1.62	1.01–2.60	0.047	1.64	1.02–2.63	0.040
Coronary heart disease	1.21	0.69–2.12	0.512	1.20	0.68–2.10	0.525
Heart failure	1.26	0.69–2.30	0.445	1.24	0.68–2.26	0.486
PAD	1.80	0.83–3.87	0.134	1.84	0.85–3.96	0.122
Prestroke dependency	1.97	0.87–4.48	0.106	2.01	0.89–4.55	0.095
NIHSS, per score	1.02	0.99–1.06	0.240			
mRS 3–5				1.40	0.85–2.29	0.185
Discharged to home	0.88	0.56–1.39	0.591	0.94	0.58–1.54	0.811

CI indicates confidence interval; mRS, modified Rankin scale score; NIHSS, National Institutes of Health Stroke Scale score; OR, odds ratio; and PAD, peripheral artery disease.

*Model adjusted for NIHSS score.

†Model adjusted for mRS score.

hospitalization in acute beds. This, however, depends on the severity of the disease and the availability of dedicated medical services. Therefore, some patients with severe stroke were certainly not readmitted even though they had medical problems after their stroke. The fact that we observed a significant statistical interaction between the destination after discharge and stroke severity on the risk of hospitalization is highly consistent with this hypothesis. Hence, in stratified analyses, stroke severity was associated with 1-year hospitalization only in patients who returned home after the index stroke.

Our findings also demonstrated that subsequent hospitalization had a deleterious effect on survival and dependency. Almost 10% of readmitted patients died during their

Table 4. Factors Associated With Hospitalization at 1 y in Stroke Survivors in Multivariable Analyses, Stratified by Place of Discharge

	Multivariable Analyses					
	Model 1*			Model 2†		
Variables	OR	95% CI	*P* Value	OR	95% CI	*P* Value
Discharged to home						
Male sex	2.03	1.08–3.85	0.029	2.11	1.13–3.97	0.020
Hypertension	…	…	…	…	…	…
NIHSS, per score	1.13	1.03–1.22	0.006	…	…	…
mRS 3–5	…	…	…	2.26	0.82–6.22	0.113
Not discharged to home						
Hypertension	2.13	1.11–4.09	0.024	2.10	1.09–4.02	0.027
Prestroke dependency	2.86	1.14–7.16	0.025	2.77	1.11–6.90	0.028
NIHSS, per score	1.00	0.96–1.03	0.808	…	…	…
mRS 3–5	…	…	…	1.17	0.66–2.05	0.593

CI indicates confidence interval; mRS, modified Rankin Scale score; NIHSS, National Institutes of Health Stroke Scale score; OR, odds ratio; and TIA, transient ischemic attack.

*Model adjusted for male sex, age, hypertension, hypercholesterolemia, diabetes mellitus, smoking, atrial fibrillation, coronary heart disease, TIA, heart failure, cancer, peripheral artery disease, prestroke dependency, and NIHSS score.

†Model adjusted for male sex, age, hypertension, hypercholesterolemia, diabetes mellitus, smoking, atrial fibrillation, coronary heart disease, TIA, heart failure, cancer, peripheral artery disease, prestroke dependency, and mRS score.

Table 5. Factors Associated With Being Alive at 1 y in Multivariable Analyses

	Model 1*			Model 2†		
	OR	95% CI	*P* Value	OR	95% CI	*P* Value
Subsequent hospitalization	0.34	0.19–0.63	0.001	0.36	0.19–0.66	0.001
Age groups, y						
<60	REF			REF		
60–70	1.22	0.22–6.69	0.281	1.20	0.22–6.56	0.833
70–80	0.37	0.09–1.54	0.173	0.35	0.08–1.15	0.146
>80	0.15	0.04–0.56	0.005	0.16	0.04–0.61	0.007
Diabetes mellitus	4.90	1.47–16.3	0.01	5.14	1.64–17.9	0.006
Prestroke dependency	0.27	0.11–0.71	0.007	0.26	0.10–0.66	0.005
Discharged to home	4.59	2.06–10.2	<0.001	4.54	1.96–10.5	<0.001

CI indicates confidence interval; and OR, odds ratio.

*Model adjusted for age, sex, hypercholesterolemia, diabetes mellitus, atrial fibrillation, prestroke dependency, stroke type, discharge to home, and NIHSS score.

†Model adjusted for age, sex, hypercholesterolemia, diabetes mellitus, atrial fibrillation, prestroke dependency, stroke type, home discharge, and mRS score.

stay, and among survivors, one quarter were not able to be discharged home. Patients who needed hospitalization had a 66% higher risk of death at 1 year after the index stroke, independently of confounding factors. This excess mortality in patients who needed to be readmitted was also found in a study that included stroke patients aged ≥70 years and also demonstrated that readmitted patients were more dependent in daily life activities and had a lower health-related quality of life.[2] Finally, readmission appeared to be also associated with higher medical costs.[8] Taken together, these results clearly indicate that reducing readmission should be a major goal for poststroke care. Consistently with this observation, a randomized clinical study suggested that specific follow-up interventions after poststroke discharge could be of interest so as to prevent readmission.[20]

Some limitations of our study must be acknowledged. Because our goal was to assess the proportion of patients who were readmitted after stroke and associated factors, we considered only the first admission to hospital within the first year after the index stroke, and some patients certainly had additional stays that were not recorded in this study. As a result, we certainly underestimated the true proportion of several complications, including recurrent stroke or transient ischemic attack, falls, and trauma that could have led to subsequent hospitalizations. Some variables were not included in our analyses. For example, complications during the stay for the index stroke were not recorded, even though this factor was shown to be associated with a greater risk of readmission in another study.[3]

To conclude, stroke survivors are at a high risk of hospitalization after their stroke, and subsequent admission is associated with poor survival. These results highlight the need for improving poststroke care so as to prevent unplanned readmission.

Acknowledgments

We thank Mr Philip Bastable for reviewing the English.

Sources of Funding

The Dijon Stroke Registry is supported by the French Institute for Public Health Surveillance (InVS) and Inserm.

Disclosures

None.

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Stroke. 2015;46:190-196; originally published online November 6, 2014;
doi: 10.1161/STROKEAHA.114.007429
Stroke is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231

Print ISSN: 0039-2499. Online ISSN: 1524-4628