Estimating the Cost-Effectiveness of Stroke Units in France Compared With Conventional Care

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Background and Purpose—The incidence of stroke in France is estimated at between 120 000 and 150 000 cases per year. This modeling study assessed the clinical and economic benefits of establishing specialized stroke units compared with conventional care.

Methods—Data from the Dijon stroke registry were used to determine healthcare trajectories according to the degree of autonomy and organization of patient care. The relative risks of death or institutionalization or death or dependence after passage through a stroke unit were compared with conventional care. These risks were then inserted with the costing data into a Markov model to estimate the cost-effectiveness of stroke units.

Results—Patients cared for in a stroke unit survive more trimesters without sequelae in the 5 years after hospitalization than those cared for conventionally (11.6 versus 8.28 trimesters). The mean cost per patient at 5 years was estimated at 30 983 € for conventional care and 34 638 € in a stroke unit. An incremental cost-effectiveness ratio for stroke units of 1359 € per year of life gained without disability was estimated.

Conclusions—The cost-effectiveness ratio for stroke units is much lower than the threshold (53 400 €) of acceptability recognized by the international scientific community. This finding justifies organizational changes in the management of stroke patients and the establishment of stroke units in France. **(*Stroke*. 2004;35:770-775.)**

Key Words: cost-benefit analysis ■ economics ■ Markov chains ■ stroke ■ stroke units

Between 120 000 and 150 000 strokes occur in France annually.[1–3] Six-month mortality rates are between 30% and 45%, with surviving patients suffering from various degrees of physical handicap.[1] Managing stroke patients within conventional care has been criticized because of poor coordination between disciplines.

Recent years have seen the introduction of specialized stroke units in an attempt to improve long-term outcome. International guidelines recommend that stroke patients be treated in such units whenever possible.[4] However, they are poorly developed in France, with <10 dedicated stroke units.

The average length of stay varies with the different services provided in stroke units. Care is distributed between 3 types of unit: acute units, which care for patients for 7 days after stroke; rehabilitation units, which admit patients subsequently; and integrated stroke units, which assume these 2 functions simultaneously.[5]

Using a variety of judgment criteria, researchers in a meta-analysis of 23 randomized trials demonstrated improved outcome for stroke units in terms of absolute benefit and relative risk.[6] However, these conclusions cannot be extrapolated simply to France because the few stroke units that do exist in France do not offer rehabilitation, the length of stay being ≤2 weeks.

More widespread implementation of stroke units requires significant investment by health authorities, who legitimately require information indicating that this is economically justified. The present study provides a contribution to this debate. We have developed a Markov model to evaluate the medium-term impact of establishing stroke units in France. This model enables the clinical and economic consequences of establishing these new structures to be compared with conventional care in terms of benefits for patients, resource use, cost determination, and cost-effectiveness.

Materials and Methods

Stroke patients were followed up along possible care pathways. The main outcome criterion for the study was survival with minor disability. Total incurred cost was defined as the sum of expenditure at each step of the care pathway. All calculations of cost were made from the point of view of the healthcare system. Transfer payments and indirect costs were excluded from analysis. The contribution of each clinical state to the overall health cost and to the individual benefit obtained by the patient was determined over a period of 5 years. All expenses were discounted at a rate of 3%.

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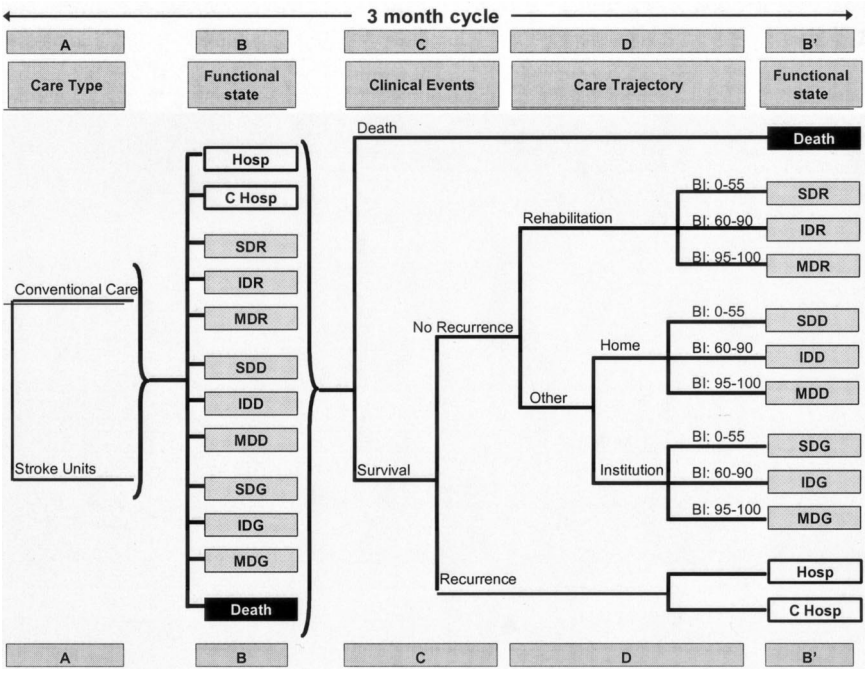

Figure 1. Markov model: integration of the branches of 4 modules over 5 years. A, The 2 branches represent 2 possible therapeutic options. B, Each branch corresponds to a Markov health state defined by 3 criteria: clinical state, residential status, and level of disability. Each individual patient outcome can be specified by a combination of these 3 factors. C, Situation of a patient is determined by appearance of random clinical events. Stroke outcome is categorized as death, recurrence, or survival without recurrence during the next 5 years. D, Trajectory taken by patient through healthcare service is specified according to level of disability. Hosp indicates hospitalization; cHosp, hospitalization with complications; R, rehabilitation; D, domicile; G, geriatric institution; SD, severe disability; ID, intermediate disability; MD, minor disability; Rehabilitation, probability of being cared for in a rehabilitation unit; Home-care, probability of being cared for at home; Institution, probability of being cared for in an institution; BI of 0 to 55, severe disability; BI of 60 to 90, intermediate disability; and BI of 90 to 100, minor disability or autonomy.

Analytical Model

Each patient cared for was analyzed by a Markov model (Figure 1).[7] A cohort of patients was followed up for 5 years after stroke. The 5-year period was divided into cycles of 3 months (20 cycles), matching the time base of the source data. The distribution of patients across the health states was determined for each cycle. The model was structured into 4 basic modules for each of the cycles: (1) method of care (stroke unit versus conventional care), (2) health states according to residential status (hospital, home, rehabilitation center, long-term residential institution), (3) clinical outcome (death, recurrence, or survival without recurrence), and (4) course through the healthcare system (Figure 1). Patients with ischemic and hemorrhagic stroke were analyzed separately. Three levels of disability were defined according to the Barthel Index (BI): severe disability (BI, 0 to 55), intermediate disability (BI, 60 to 90), and minor disability (BI, 95 to 100). Overall, 45 Markov states were possible if death was included.

A satellite model using a daily modeling cycle applied for the first 90 days was also constructed and imported into the main model. This technique allowed integration of reported differences in mortality in favor of stroke units between the first and third weeks[6] or between the first and sixth weeks.[8]

Data Sources

The probability of dying as a result of stroke was calculated by use of a declining exponential function (DEALE method).[9] Overall age-specific mortality was obtained from national population statistics (INSEE).[10] Specific stroke mortality rates were taken from the Dijon stroke registry,[11,12] and long-term stroke mortality (>12 months) was taken from the Oxfordshire Community Stroke Project.[13,14] Recurrence rates were determined from the Dijon stroke registry. The epidemiological data related to our Markov model are summarized in Table 1. Data on stroke unit performance were taken from the Cochrane meta-analysis (Table 2).[6]

Three sets of data were used to determine the passage of patients from 1 type of care to another. First, a reanalysis of outcome from 213 patients in the Dijon stroke registry was undertaken to identify the care trajectory after hospitalization.[11] A second multicenter study (Handicap and Disability Outcomes in Stroke study [HADDOCK]) followed the course of 166 patients through the healthcare system for 3 months after discharge from hospital. The third study followed patients discharged from a rehabilitation establishment (Kerpape Centre). More details of the data from the unpublished HADDOCK and Kerpape studies are provided in extenso on our website (www.rees-france.com).

Cost Estimations

Costs were generated for hospital care, medium-term residential unit care, and home care (Table 2). More extensive information on the cost calculations is available on our website (www.rees-france.com)

Costs for hospital care were identified from the Programme de Médicalisation des Systèmes d'Information national cost scale (1997). The cost of care of stroke patients in a rehabilitation unit was estimated from accounting data of the Kerpape center and corresponding PMSI-Soins de Suite et de Réadaptation data, which generated a net cost for each medical unit and identification of the different types of costs (medical procedures, clinical and logistics). Rehabilitation treatments were costed individually by the minute.

We used data from 3 sources for the costs of home care: a survey by the French national federation of mutualist societies[15] for patients with minor disability, the INFODAS survey performed by the French Ministry of Employment[16] for patients with intermediate and severe disability, and a microcosting study performed by the University of Nantes[17] to weight the data from the INFODAS survey according to disability level.

Estimation of the cost of care of stroke patients in institutional accommodation was complicated by the heterogeneity in the resources available and their costs. The parameters used in the calculation were as follows: identification of accommodation types (residential homes, retirement homes without a spa facility, retirement homes with a spa facility, and establishments offering long-term care), determination of an average unit cost (from the INFODAS survey[16]), calculation of the real costs (by weighting with the data from the Nantes microcosting study), and calculation of the aggregate cost per level of dependence for all institutions together (by weighting according to the proportion of all patients >65 years of age receiving care in each type of establishment).

Incremental Cost-Effectiveness Ratio

The net difference in cost of the 2 care options was identified. The additional efficacy of 1 treatment compared with another was defined in terms of months gained without recurrence. The quotient of these 2 variables defines the incremental cost-effectiveness ratio.

TABLE 1. Data Sources for Key Assumptions in the Markov Model

Items	Estimate		Source
	Ischemic Stroke	Hemorrhagic Stroke	
Clinical probability (trimester)			
Mortality rate in the general population, y			
71	0.0179	0.0179	INSEE
Specific mortality rate, mo			
0–3	0.0930	0.4118	DSR
3–6	0.0189	0.0000	DSR
6–9	0.0067	0.0000	DSR
9–12	0.0219	0.0219	Oxford Community Stroke Project
Recurrence rate, mo			
0–3	0.0377	0.0378	DSR
3–6	0.0588	0.0598	DSR
6–9	0.0469	0.0469	DSR
9–12	0.0333	0.0393	DSR
>12	0.0060	0.0060	Oxford Community Stroke Project
Probability of changing living place			
0–3 months			
Hospital-home	0.4243	0.3640	HADDOCK/DSR
Hospital-institution	0.0984	0.0910	HADDOCK/DSR
Hospital-RU	0.4773	0.5450	HADDOCK/DSR
3–6 months			
RU-Home	0.8420	0.9375	Kerpape survey
RU-Institution	0.1580	0.0625	Kerpape survey
>6 months			
Home-Home	1	1	Hypothesis
Institution-Institution	1	1	Hypothesis
Level of disability by living place			
0–3 mo			
MiDD	0.3613	0.1000	HADDOCK/DSR
MoDD	0.1488	0	HADDOCK/DSR
SDD	0.4899	0	HADDOCK/DSR
MiDR	0.9043	0.1875	HADDOCK/DSR
MoDR	0.0696	0.5000	HADDOCK/DSR
SDR	...	0.3116	HADDOCK/DSR
MiDI	0.9149	0	HADDOCK/DSR
MoDI	0.0850	0.5000	HADDOCK/DSR
SDI	...	0.5000	HADDOCK/DSR
>3 mo			
MiDD	0.8060	1.000	HADDOCK/DSR
MoDD	0.1290	0.000	HADDOCK/DSR
SDD	0.0650	0.000	HADDOCK/DSR
MiDR	0.4211	0.3125	HADDOCK/DSR
MoDR	0.2631	0.5060	HADDOCK/DSR
SDR	0.3158	0.1875	HADDOCK/DSR
MiDI	0.2330	0.0000	HADDOCK/DSR
MoDI	0.2330	0.5000	HADDOCK/DSR
SDI	0.5340	0.5000	HADDOCK/DSR
Trimestrial costs			
MiDD	731.76 €	731.76 €	Mutualist societies
MoDD	2 241.00 €	2 241.00 €	INFODAS
SDD	12 017.56 €	12 017.56 €	INFODAS
MiDR	19 731.17 €	12 006.12 €	Kerpape Survey
MoDR	25 285.80 €	29 371.89 €	Kerpape Survey
SDR	25 950.18 €	32 478.20 €	Kerpape Survey
MiDI	4 666.77 €	4 666.77 €	INFODAS
MoDI	4 862.36 €	4 862.36 €	INFODAS
SDI	5 666.38 €	5 666.38 €	INFODAS
Efficacity of stroke units, BI			
95–100	+5	+5	Cochrane
60–90	−4	−4	Cochrane
0–55	−1	−1	Cochrane

DSR indicates Dijon Stroke Registry; MiD, minor disability; D, home; MoD, intermediate disability; SD, severe disability; RU or R, rehabilitation unit; and I, institution.

TABLE 2. Meta-Analysis of Randomized Clinical Trials Comparing Care in Stroke Units With Conventional Care

	Conventional Care		Stroke Unit				
	n	%	n	%	Relative Risk		Absolute Difference
Home (BI, 95–100)	463	33	546	39	1.41	1.19–1.67	[+5; 1.8]
Home (BI, 60–90)	226	16	246	18	1.01	0.72–1.41	[0; −4.3]
Institution (BI, 5–55)	300	22	270	20	0.83	0.68–1.03	[−1; −4.1]
Death (BI, 0)	399	28	320	23	0.80	0.67–0.95	[−4; −7.0]
Total	1388	100	1382	100			

[-] Confidence intervals

Results

Efficacy of Care

Patient outcome was compared with the Markov model (Table 3). The number of trimesters of life lost because of stroke was 7.74 in 5 years when patients were cared for conventionally compared with 4.84 trimesters in patients treated in a stroke unit, a reduction of 37.5%. The primary efficacy variable used in the cost-effectiveness analysis was the number of trimesters with minor disability. Survivors in stroke units spent 240 days longer with minor disability than stroke patients cared for traditionally (8.28 versus 10.96 trimesters, respectively). Care in a stroke unit was associated with a gain of nearly 7 months in the amount of time spent at home during the 5-year follow-up period.

Calculation of Cost per Patient

Our model predicted the total cost per patient to be 30 983 € in a conventional care unit over 5 years and 34 638 € in a stroke unit (Table 4). Hospital costs in a stroke unit are only slightly higher than costs in a conventional care facility (4268 versus 4177 €, respectively). An increase in home care is observed from 8682 € in a conventional care unit to 10 010 € for patients cared for in a stroke unit.

The expenditure required for conventional care of the 120 000 new strokes a year in France would be 3718 million € over 5 years; the corresponding figure for stroke units is ≈4156 million € (Figure 2).

TABLE 3. Outcome Duration (Cumulative Number of Trimesters) According to Care Strategy

	Conventional Care,		Stroke Units,	
	n	%	n	%
Outcome				
Hospitalization	0.42	2.1	0.45	2.2
Minor disability	8.28	41.8	11.0	55.6
Intermediate disability	1.60	8.2	1.57	8.0
Severe disability	1.73	8.7	1.94	9.8
Death	7.74	39.2	4.84	24.4
Total	19.8	100	22.0	100
Residential status (survivors)				
Hospital	0.42	3.5	0.45	3.0
Rehabilitation center	0.40	3.3	0.42	2.8
Home	9.23	76.5	11.5	77.2
Institution	2.01	16.7	2.52	17.0
Total	12.06	100	14.89	100
Disability level (survivors)				
Minor disability	8.28	71.1	10.96	75.9
Intermediate disability	1.63	14.0	1.57	10.8
Severe disability	1.73	14.9	1.90	13.3
Total	11.64	100	14.40	100

Incremental Cost-Effectiveness

In terms of effectiveness, treatment in stroke units provided a benefit of 2.69 trimesters of survival without disability over 5 years at an additional cost of 3655 €. These figures yield a cost-effectiveness ratio of 1359 € per year of life gained without disability (BI, 95 to 100; Table 4).

Sensitivity Analyses

We assessed the sensitivity of the model to the absolute cost of treatment in stroke units. When the cost of the stroke unit branch is increased by 25%, 50%, and 75% compared with 1997, the cost-effectiveness ratio increases to 1736, 2153, and 2549 €, respectively, per year of life without disability. If the cost is increased 10-fold, the cost-effectiveness ratio is 15 646 €.

TABLE 4. Cost per Patient and per Health State Over 5 Years and Cost-Effectiveness

	Conventional Care		Stroke Units	
Health State	€	%	€	%
Hospitalization	4 177.41	13.6	4 267.81	12.3
Minor disability	14 149.56	45.6	17 254.03	49.8
Intermediate disability	5 251.56	16.9	4 977.61	14.4
Severe disability	7 404.75	25.9	8 138.64	23.5
Total cost	30 983.28		34 638.09	
Difference in cost, €	3 654.81			
Efficacy*	8.28		10.97	
Difference in efficacy	2.69			
Incremental cost-effectiveness, €	1 359.42			

*Efficacy is measured as the total number of trimesters spent in minor disability, including corrections for half-cycles.

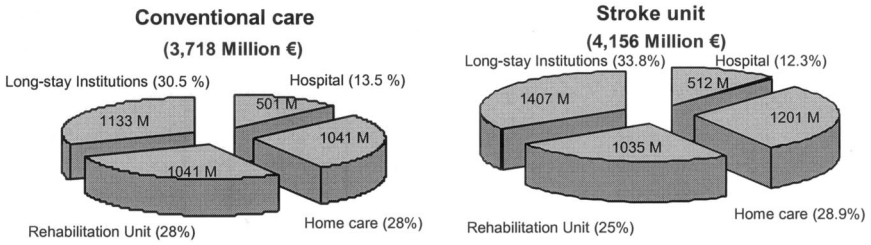

Figure 2. Total cost for 120 000 stroke patients per year over 5 years in conventional care and stroke units.

If the incidence rate for stroke is increased to 144 000 new cases per year in France (ie, 2400 patients per 100 000),[3] the cost of care increases to 4450 million € in conventional care units and 4990 million € in stroke units.

When the duration of the simulation is reduced from 5 years (20 Markov cycles) to 18 months (6 Markov cycles), the cost of care of a patient treated initially in a conventional care unit is 18 757 € or 2.800 million € overall for 150 000 patients.

Discussion

The incremental cost-effectiveness ratio for stroke units was 1359 € per year of life gained without disability, an extremely favorable ratio that justifies organizational changes and the establishment of specialized stroke units. The recognized threshold of acceptability for cost-effectiveness ratio is currently 53 400 €.[18] The cost-effectiveness ratio obtained for stroke units is much lower. However, only running costs were evaluated, whereas the establishment of stroke units would inevitably also involve upstream investment in such items as medical imaging and personnel. We chose to perform only univariate analyses for sensitivity analyses, setting wide boundaries to extreme-case hypotheses, because they identify clearly the impact of cost drivers. Our conclusions remain unchanged when running costs are increased by 25%, 50%, or 75%. Even if the running costs of stroke units are 10-fold greater than the current cost of conventional care, the cost-effectiveness ratio will not exceed 15 646 €.

The information on the efficacy of stroke units was derived from meta-analysis undertaken for the Cochrane Library in 1997.[6] More than two thirds of the trials included in this analysis proposed a duration of hospital stay of >8 weeks. Their conclusions are therefore difficult to apply to stroke units in France, which currently provide only short-term care.

The present study has a number of limitations inherent to the quantity and quality of published data, particularly relating to care of stroke patients at home and in institutions for which costs are not well known. Our estimation may underestimate the true cost of the illness in the first months of care for 2 reasons. First, because most cost accrues early after the stroke, estimation of annual expenditure from the 5-year costs as an unweighted average dilutes initial expenditure excessively. Second, the annual number of new cases of stroke in 2002 appeared to be closer to 150 000 than to 120 000. If the number of new strokes is increased from the 124 000 new cases per year, calculated from data in the Dijon stroke registry, to 144 000 new cases per year, from the data of Hankey and Warlow,[3] the cost of care increases to 4450 million € in conventional care units and 4990 million € in stroke units. This estimation for the annual cost of stroke (890 million €) in conventional care is consistent with other estimates of the cost of this pathology in France made by CREDES in 2001 (1010 million €)[19] and by Lebrun et al[20] in 1996 (840 million €).

Reducing the duration of the simulation in the Markov model from 5 years to 18 months generates an overall cost of 2800 million € for 150 000 patients treated initially in conventional care. This estimate corresponds, with <5% error, to the results obtained by Spieler et al[21] (2900 million €) from an observational study carried out in 12 centers on 435 patients with ischemic stroke. This convergence is an important argument in favor of the pertinence of the assumptions made in our Markov model.

In conclusion, stroke patients require appropriate care integrating multidisciplinary expertise on a single health-care site and matching care provision to the clinical state of the patient. The additional costs of this type of care appear to be justified by the clinical benefits accrued. This study suggests that caring for patients in stroke units improves the medical service given to the patient, which in turn justifies the cost.

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