Alternative Strategies for Stroke Care
Cost-Effectiveness and Cost-Utility Analyses From a Prospective Randomized Controlled Trial

Anita Patel, MSc; Martin Knapp, PhD; Inigo Perez, MD; Andrew Evans, MRCP; Lalit Kalra, PhD

Background and Purpose—Although stroke units reduce mortality and institutionalization, their comparative cost-effectiveness is unknown.

Methods—Healthcare, social services, and informal care costs were compared for 447 acute stroke patients randomly assigned to stroke unit, stroke team, or domiciliary stroke care. Prospective and retrospective methods were used to identify resource use over 12 months after stroke onset. Cost-effectiveness and cost-utility analyses were undertaken.

Results—Mean healthcare and social care costs over 12 months were £11 450 for stroke unit, £9527 for stroke team, and £6840 for domiciliary care. More than half the costs were for the initial episode of care. Institutionalization was a large proportion of follow-up costs. Inclusion of informal care increased costs considerably. When informal care was excluded, the incremental cost-effectiveness ratio per percentage point in deaths or institutionalizations avoided in the first year was £496 for the stroke unit over domiciliary care; incremental cost per quality-adjusted life year quality-adjusted life year gained was £64 097 between these 2 groups. The stroke team was dominated by domiciliary care.

Conclusions—Cost perspectives, especially those related to long-term and informal care, are important when stroke services are evaluated. Improved health outcomes in the stroke unit come at a higher cost. (Stroke. 2004;35:196-204.)

Key Words: costs and cost analysis ■ randomized controlled trials ■ rehabilitation ■ stroke management

Stroke is a major cause of mortality and institutionalization and accounts for substantial amounts of healthcare resources.1–4 Stroke-related costs may make up as much as 3% to 4% of the annual national healthcare budget.1,2 Given these demands on health systems and the large economic impacts of stroke, understanding the relative cost-effectiveness of different interventions is imperative.

There have been few robust economic evaluations of stroke interventions; adopting a societal perspective is rare, and exploring quality-adjusted life years (QALYs) is still unusual.2 Costs associated with acute hospitalization, community therapy, and institutionalization have been widely reported, but little attention has been paid to costs of community health and social services, voluntary sector services, out-of-pocket (nonreimbursed) expenses for patients and families, or informal care.2,3

Many studies have shown that stroke units reduce death and institutionalization and may be cost-effective compared with general wards,6,8 but they lack a societal perspective, and there is little information about their cost-effectiveness compared with other strategies of organized care. Community-based care for stroke has been emphasized,5,8 in keeping with the Europe-wide strategy of shifting the balance from secondary to primary health care.5–11 There is also advocacy on cost grounds for a model in which a trained multidisciplinary stroke team provides specialist care in general medical wards, but again there is little information on comparative cost-effectiveness.12

A randomized controlled study of 457 acute stroke patients showed that, on the primary outcome measure of mortality or institutionalization over a 1-year period, a stroke unit compared favorably with a stroke team (21 of 152 [14%] versus 45 of 149 [30%]; P<0.001) and domiciliary care (21 of 152 [14%] versus 34 of 144 [24%]; P=0.03).13 The proportion of patients alive without severe disability at 1 year was also significantly higher for the stroke unit compared with the stroke team (129 of 152 [85%] versus 99 of 149 [66%]; P<0.001) or domiciliary care (129 of 152 [85%] versus 102 of 144 [71%]; P=0.002). This article describes comprehensive service use and informal care patterns, associated costs, and corresponding outcomes for a 12-month follow-up period for each of the 3 trial groups.

Methods
The study was undertaken with 457 acute stroke patients within 72 hours of stroke onset who were allocated to stroke unit (n=152), stroke team (n=152), or domiciliary (n=153) care. Inclusion and
exclusion criteria, randomization techniques, and the different interventions have been described in detail previously. The study was approved by the local ethics committee, and subjects gave informed consent.

Key elements of the 3 care strategies were as follows. For the stroke unit, patients were under the care of specialist stroke physicians; guidelines for stroke management were in place; a multidisciplinary staff with specialist experience in stroke was available; and joint assessment, goal setting, treatment, and discharge planning were incorporated. For the stroke team, patients were on general medical wards and under the care of general physicians; assessments were done by a roving specialist stroke team that advised on

<table>
<thead>
<tr>
<th>TABLE 1. Use of Health, Social, and Voluntary Services and Specialized Accommodation Between Time of Stroke and 12-Month Follow-Up Assessment</th>
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<tr>
<td><strong>Immediate rehabilitation</strong></td>
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<td>Initial admission, d</td>
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<tr>
<td>Stroke team coordinator, h</td>
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<td>Stroke team physician, h</td>
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<td>Physiotherapy, PIU</td>
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<td>Occupational therapy, PIU</td>
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<td>Speech and language therapy, min</td>
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<td>12 mo after stroke</td>
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<td>Secondary care</td>
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<tr>
<td>Admissions, d</td>
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<tr>
<td>Outpatients, visits</td>
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<td>A&amp;E, visits</td>
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<tr>
<td>Day hospital, visits</td>
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<td>Community-based care</td>
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<td>GP at home, visits</td>
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<td>GP at surgery, visits</td>
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<td>District nurse, visits</td>
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<tr>
<td>Dentist, visits</td>
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<tr>
<td>Optician, visits</td>
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<td>Chiropractor, visits</td>
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<tr>
<td>Osteopath, visits</td>
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<tr>
<td>Chiropractor, visits</td>
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<td>Counseling, visits</td>
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<tr>
<td>Geriatrician, visits</td>
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<tr>
<td>Psychologist, visits</td>
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<tr>
<td>Acupuncturist, visits</td>
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<tr>
<td>Social worker, visits</td>
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<tr>
<td>Home help, contacts</td>
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<tr>
<td>Cleaning, contacts</td>
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<tr>
<td>Shopping, contacts</td>
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<tr>
<td>Meals on wheels, meals</td>
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<tr>
<td>Frozen meals, meals</td>
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<tr>
<td>Social services day center, visits</td>
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<tr>
<td>Social club, visits</td>
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<tr>
<td>Lunch club, visits</td>
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<tr>
<td>Voluntary day center, visits</td>
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<tr>
<td>Specialized accommodation</td>
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<tr>
<td></td>
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<tr>
<td>Nursing/residential home, wk</td>
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<td>Respite care, d</td>
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</tbody>
</table>

PIU indicates personal interaction unit (1 PIU is ~30 minutes); A&E, accident and emergency; and GP, general practitioner.

*Mean for users only.
management, investigation, and discharge planning; and nonspecialist nursing and therapy staff were available. Patients in domiciliary care were managed in their own homes under the joint care of a stroke physician and a general practitioner; investigations were performed on an outpatient basis; therapy was handled by specialist staff; district nursing support was available; and personal care came from social services.

A societal perspective, including health services, other formal care agencies, and informal caregivers, was adopted for the economic evaluation. Hospital resource use and therapy inputs were recorded on an ongoing basis. Data on use of other public sector services and informal care were collected retrospectively at 12 months after stroke onset during patient assessment interviews by use of a specially adapted version of the Client Service Receipt Inventory to ensure that it was relevant to stroke patients. Supplementary information was obtained from families or caregivers, health and social services records, and direct observations of services provided. Annual estimations of informal care inputs were based on the number of weeks in the year over which care was received (rather than simply extrapolating figures for an average week to a whole year). Costs were calculated for each patient. Unit costs were obtained from local services whenever possible to approximate actual intervention costs. Some local unit costs were based on charges rather than costs. National statistics were used when local costs were unavailable.

All costs were standardized to 1997–1998 prices by use of the NHS Executive hospital and community health services inflation index. Informal care costs were estimated by 2 different methods: 1 based on the UK minimum wage rate (£3.53/h, the opportunity cost method) and 1 based on the unit cost of a social services home help worker (£10.61/h, the replacement cost method) because of the controversy regarding appropriate methods for costing informal care inputs. All unit costs are provided in the Appendix, which is available online at http://stroke.ahajournals.org. Costs are reported in pounds sterling; £1.00 is equal to 1.50 Euros or US $1.50.

Medication costs were not included, except in the sense that unit costs for hospital services included a pharmacy element. A distinction is made between immediate care and 12-month follow-up. The former includes the initial hospital admission at stroke onset and therapy inputs from the stroke team, whereas the latter covers all subsequent admissions and wider resource use over the entire 12-month follow-up period, which overlaps the immediate care period.

### Statistical Analysis

Costs are reported as means with SD. Differences between groups were tested with 1-way analysis of variance (ANOVA) with the Bonferroni procedure to adjust for multiple testing. To allow for

<table>
<thead>
<tr>
<th>TABLE 2. Poststroke Informal Care Inputs</th>
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<tbody>
<tr>
<td>Stroke Unit (n = 148)</td>
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<tr>
<td>-----------------------</td>
</tr>
<tr>
<td>Received care, n (%)</td>
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<tr>
<td>Time care was received, wk</td>
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<tr>
<td>From coresidents, h</td>
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<tr>
<td>Personal care per week</td>
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<tr>
<td>Transport per week</td>
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<tr>
<td>Meal preparation per week</td>
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<tr>
<td>Housework per week</td>
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<tr>
<td>DIY per week</td>
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<tr>
<td>Gardening per week</td>
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<tr>
<td>Shopping per week</td>
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<tr>
<td>Outings per week</td>
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<tr>
<td>Socializing per week</td>
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<tr>
<td>Total per average week</td>
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<tr>
<td>Total over 12 mo</td>
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<tr>
<td>From nonresidents, h</td>
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<tr>
<td>Personal care per week</td>
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<tr>
<td>Transport per week</td>
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<tr>
<td>Meal preparation per week</td>
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<td>Housework per week</td>
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<td>Outings per week</td>
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<tr>
<td>Socializing per week</td>
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<tr>
<td>Total per average week</td>
</tr>
<tr>
<td>Total over 12 mo</td>
</tr>
<tr>
<td>Total over 12-mo assessment period from coresidents and nonresidents</td>
</tr>
</tbody>
</table>

Values are mean ± SD.

*n* = 147 for some components of the data for this group because 1 patient had incomplete data. DIY indicates do it yourself (home maintenance/improvement).
skewed summary costs, 1000 bootstrap replications of the original data were performed to check the robustness of the parametric tests. The primary outcome measure was combined with mean costs to compute incremental cost-effectiveness ratios (ICERs), representing additional cost per additional percentage point of deaths or institutionalizations avoided. Additionally, a cost-utility analysis compared cost, length, and quality of life between groups by computing QALYs. Health states were measured with the EuroQol (EQ-5D) at 6, 12, 26, and 52 weeks after stroke onset. The last-value-carried-forward method of estimation was applied to 7 patients who had missing EQ-5D health states at various assessment points. Utility weights (or social tariffs) for health states were taken from a UK general population survey. A social tariff of zero was assumed for death. Health state measures at each assessment point were assumed to represent the time since the last assessment. Therefore, social tariffs for each assessment point were multiplied by the relevant proportion of a year, and these proportional tariffs were summed to represent a complete year after stroke onset. To measure QALY gain, EQ-5D measurements for the point of stroke onset were modeled statistically because they had not been measured at that point. A random-effects generalized least-squares regression was used to estimate the relationship between EQ-5D social tariffs and Barthel Activities of Daily Living (BADL) scores at all available assessment points (6, 12, 26, 52 weeks). BADL alone explained 37% of the variation in EQ-5D tariffs. Other outcome measures did not improve explanatory power. The resulting estimated regression equation was then used to impute EQ-5D social tariff values for the point of stroke onset based on the BADL at stroke onset. ICERs for the cost-utility analysis represent incremental cost per additional QALY gained.

Uncertainty around cost-effectiveness was examined by reporting a range of ICERs based on the inclusion or exclusion of key cost components (immediate care for stroke episode, follow-up care, informal care based on the 2 different costing approaches). Uncertainty in cost-utility estimates was additionally represented through cost-effectiveness acceptability curves using the net benefit approach (based on total health and social care costs over 12 months). These curves are an alternative to confidence intervals around ICERs and show the probability of each strategy being cost-effective (or optimal) compared with the others for a range of values that a decision maker would be willing to pay for an additional QALY.

Results

Of the 457 patients randomized, 10 were excluded from analyses because of unconfirmed stroke. Of the 447 patients with confirmed stroke, 3 stroke team patients and 9 domiciliary care patients were excluded because of loss of follow-up at 12 months. Another 10 dysphasic patients (3, 4, and 3 in stroke unit, stroke team, and domiciliary care groups, respectively) had missing EQ-5D data at several assessment points and thus were excluded from the cost-utility calculations.

Resource Use and Costs

Patients used many health, social, and voluntary sector services (Table 1). There were no significant between-group differences in proportions of patients requiring hospital admission after the initial episode, patients admitted to institutional care, or patients receiving informal support (Table 2). Although the stroke team group received less informal care in total per week from coresidents than other groups, the difference was not significant. However, they received significantly less help with personal care compared with the stroke unit ($P=0.016$) and domiciliary care ($P=0.003$) groups and less help with meal preparation than the stroke unit group ($P=0.004$). Stroke unit patients received more informal care (mean, 1436 hours) than stroke team patients (846 hours; $P=0.025$).

Immediate care costs accounted for more than half the total costs in all 3 groups and were due mainly to inpatient admissions (Table 3). The 12-month follow-up costs were largely made up of specialized accommodation costs.

Sensitivity Analysis

The inclusion of informal care costs increased overall costs considerably. For example, stroke unit group costs rose by 45% or 134%, depending on whether minimum wage or home help worker rates were applied to care hours, respectively. Total costs were highest for patients managed in the stroke unit and lowest for those managed at home, regardless of how costings were undertaken. Including informal care magnified cost differences between stroke unit and stroke team care but reduced the previously significant difference between stroke team and domiciliary care costs ($P=0.043$) to nonsignificant levels.

Cost-Effectiveness and Cost-Utility Analyses

The percentages of patients who avoided death/institutionalization were 87%, 69%, and 78% in the stroke unit, stroke team, and domiciliary care groups, respectively; mean QALYs gained were 0.297, 0.216, and 0.221. When cost-effectiveness for ≥2 strategies is compared, ICERs are calculated using rules of dominance (and extended dominance if necessary). Strategies are ranked by cost, from the least expensive to the most expensive, and if a strategy is more expensive and less effective than the previous strategy, it is said to be dominated and is excluded from the calculation of ICERs. On this basis, the stroke team was dominated by domiciliary care on both outcome measures, from all cost perspectives, thus reducing the comparison to stroke unit versus domiciliary care. Because the stroke unit did not dominate domiciliary care, ICERs were calculated to indicate the additional outcomes obtained for the additional costs of the stroke unit (Table 4). The additional cost of avoiding an additional 1% of death and institutionalizations in the stroke unit group was £534 based on immediate care costs alone and £496 from the perspective of total healthcare and social care costs over 12 months. This increased to £682 when informal care costs (based on lower rates) were added to healthcare and social care costs and doubled to £1033 on the basis of the broadest cost perspective incorporating the higher informal care rates. ICERs per additional QALYs gained ranged between £64 097 and £136 609, depending on the cost perspective taken. To explore the uncertainty around decisions based on ICERs, the Figure additionally reports the estimated probability that each strategy is cost-effective for a range of potential maximum values that health/social services would be willing to pay for an additional QALY. If decision makers were willing to pay nothing for QALY gains, there is a 59% probability that domiciliary care is the most cost-effective (ie, optimal) of the 3 strategies (and a 16% and 26% probability that the stroke unit and stroke team, respectively, are the most cost-effective). The probability that domiciliary
Care is the most cost-effective strategy decreases with increasing levels of willingness to pay for QALY gains, leveling out at about the £60 000 threshold, but remains higher than the other 2 strategies across the full range of specified values. Correspondingly, the probability of the cost-effectiveness of the other 2 strategies generally increases up to the £60 000 threshold (as the sum of probabilities for all strategies must equal 1.0 at any given level of willingness to pay); however, the relative cost-effectiveness of these 2 strategies is less clear, with probabilities equalizing at the £16 000 threshold and beyond £30 000. At a willingness to pay of £30 000 per additional QALY (the implicit current threshold value per QALY in the United Kingdom), the probability that the stroke unit and stroke team are the most optimal of the 3 strategies is equal at 29% and higher for domiciliary care at 42%.

**Discussion**

Comprehensive costing of stroke care over a 1-year period shows that stroke care is expensive regardless of where patients are managed; a third to half of the costs can be attributed to informal care. Of the 3 strategies evaluated, stroke unit care was the most expensive, and domiciliary care was the cheapest. This pattern remained unchanged in incremental cost-effectiveness and cost-utility analyses. These results were sensitive to changes in the breadth of cost data included in the calculations, particularly the inclusion of informal care costs.

### TABLE 3. Mean Costs* of Health, Social, and Voluntary Services, Specialized Accommodations, and Informal Care and Their Effectiveness

<table>
<thead>
<tr>
<th></th>
<th>Stroke Unit (n=148)†, £</th>
<th>Stroke Team (n=147), £</th>
<th>Domiciliary Care (n=140), £</th>
<th>ANOVA</th>
<th>Mean Difference, £</th>
<th>95% CI</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Immediate care</strong></td>
<td></td>
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</tr>
<tr>
<td>Admission for stroke</td>
<td>6 821 (6 295)</td>
<td>4 973 (4 608)</td>
<td>2 859 (4 880)</td>
<td>19.940</td>
<td>0.000</td>
<td>1848</td>
<td>358, 3 337</td>
</tr>
<tr>
<td>Stroke team coordinator</td>
<td>...</td>
<td>334 (79)</td>
<td>311 (93)</td>
<td>1063.50</td>
<td>0.000</td>
<td>-334</td>
<td>-353, -314</td>
</tr>
<tr>
<td>Stroke team physician</td>
<td>...</td>
<td>47 (0)</td>
<td>47 (0)</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Therapy</td>
<td>2 005 (1 793)</td>
<td>599 (818)</td>
<td>668 (603)</td>
<td>64.09</td>
<td>0.000</td>
<td>1406</td>
<td>1 071, 1 741</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>8 825 (7 441)</td>
<td>5 952 (5 054)</td>
<td>3 856 (5 062)</td>
<td>25.16</td>
<td>0.000</td>
<td>2873</td>
<td>1 201, 4 546</td>
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<tr>
<td><strong>12-mo follow-up period</strong></td>
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<tr>
<td>Secondary care</td>
<td>931 (2 464)</td>
<td>1 262 (2 805)</td>
<td>803 (2 062)</td>
<td>1.33</td>
<td>0.266</td>
<td>-331</td>
<td>-1 021, 360</td>
</tr>
<tr>
<td>Community-based care</td>
<td>706 (1 473)</td>
<td>632 (1 557)</td>
<td>492 (1 459)</td>
<td>0.76</td>
<td>0.470</td>
<td>74</td>
<td>-3 454, 494</td>
</tr>
<tr>
<td>Specialized accommodation</td>
<td>987 (3 591)</td>
<td>1 681 (4 673)</td>
<td>1 689 (5 047)</td>
<td>1.19</td>
<td>0.305</td>
<td>-694</td>
<td>-1 944, 556</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>2 625 (4 582)</td>
<td>3 575 (5 075)</td>
<td>2 984 (5 749)</td>
<td>1.18</td>
<td>0.309</td>
<td>-950</td>
<td>-2 451, 551</td>
</tr>
<tr>
<td><strong>Informal care</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Annual informal care cost based on UK minimum wage rate</td>
<td>5 068 (8 040)</td>
<td>2 985 (5 468)</td>
<td>3 455 (6 174)</td>
<td>3.95</td>
<td>0.020</td>
<td>2083</td>
<td>217, 3 949</td>
</tr>
<tr>
<td>Annual informal care cost based on cost of home help worker</td>
<td>15 232 (24 166)</td>
<td>8 971 (16 436)</td>
<td>10 386 (18 558)</td>
<td>3.95</td>
<td>0.020</td>
<td>6261</td>
<td>651, 11 870</td>
</tr>
<tr>
<td><strong>Total cost excluding informal care</strong></td>
<td>11 450 (9 745)</td>
<td>9 527 (8 664)</td>
<td>6 840 (9 353)</td>
<td>8.96</td>
<td>0.000</td>
<td>1923</td>
<td>-670, 4 516</td>
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<tr>
<td><strong>Sensitivity analyses</strong></td>
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<tr>
<td>Total cost including informal care costs based on minimum wage rate</td>
<td>16 574 (13 157)</td>
<td>12 512 (10 369)</td>
<td>10 296 (11 613)</td>
<td>10.55</td>
<td>0.000</td>
<td>4062</td>
<td>762, 7 361</td>
</tr>
<tr>
<td>Total cost including informal care costs based on home help rate</td>
<td>26 738 (26 817)</td>
<td>18 498 (18 785)</td>
<td>17 226 (21 442)</td>
<td>7.57</td>
<td>0.001</td>
<td>8239</td>
<td>1 900, 14 579</td>
</tr>
<tr>
<td><strong>Effectiveness</strong></td>
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<tr>
<td>Avoided death/ institutionalization, n (%)</td>
<td>129 (87)</td>
<td>102 (69)</td>
<td>109 (78)</td>
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<td></td>
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</tr>
<tr>
<td>Mean QALYs gained (SD)§</td>
<td>0.297 (0.257)</td>
<td>0.216 (0.370)</td>
<td>0.221 (0.344)</td>
<td>2.778</td>
<td>0.063</td>
<td>0.081</td>
<td>-0.011, 0.174</td>
</tr>
</tbody>
</table>

Values are mean±SD when appropriate.
*£1.00 = 1.50 Euros, US $1.50.
†Because 1 person in this group had incomplete informal care data, n = 147 for informal care costs and totals that include informal care costs.
‡Results from Bonferroni procedure for multiple comparisons.
§QALY calculations exclude 10 people with missing EQ-5D data at several assessment points.

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The study has limitations. First, there was some unavoidable double-counting of therapy costs because they were estimated separately from data collected at the patient level although they were already included in unit costs supplied by the hospital. Any resulting error is likely to be small because even patients in the stroke unit received 30 hours of therapy on average over 3 months,13 the costs of which are likely to be fractional compared with "hotel" costs. Second, common to most health economic evaluations, the study was powered on the primary health outcome and not on the cost-effectiveness criterion, possibly resulting in tests of economic hypotheses being underpowered. Third, for intervention-related resources, we were unable to distinguish between those used as part of the trial and those consumed during routine practice. Fourth, the lack of EQ-5D measures at the point of stroke onset made it necessary to rely on statistical inference. Fifth, costs per QALY gained may be overestimated because patients could accrue further gains beyond the study period (although costs will also continue to be incurred alongside these gains). Finally, the generalizability of these findings may be limited to the United Kingdom because of known differences in stroke care patterns across countries.

The lower costs of domiciliary care are in keeping with findings from other trials. Beech et al5 reported that early discharge and community therapy produced comparable outcomes at lower cost compared with conventional care. Similarly, a cost-minimization analysis in which outcomes were shown to be similar incorporating hospital/rehabilitation/
TABLE 4. ICERs for Stroke Unit Over Domiciliary Care From Different Cost Perspectives

<table>
<thead>
<tr>
<th>Cost Perspective</th>
<th>Additional Cost Per Additional 1% of Deaths/Institutionalizations Avoided, £</th>
<th>Additional Cost Per Additional QALY Gained, £</th>
</tr>
</thead>
<tbody>
<tr>
<td>Immediate care costs</td>
<td>534</td>
<td>67,323</td>
</tr>
<tr>
<td>Total health and social care costs</td>
<td>496</td>
<td>64,097</td>
</tr>
<tr>
<td>Total cost including informal care costs based on minimum wage rate†</td>
<td>682</td>
<td>89,132</td>
</tr>
<tr>
<td>Total cost including informal care costs based on home help rate†</td>
<td>1033</td>
<td>136,609</td>
</tr>
</tbody>
</table>

*Cost-utility calculations exclude 10 people with missing EQ-5D data at several assessment points.
†Cost estimates exclude 1 person from stroke unit group with incomplete informal care data. Therefore, the total number of deaths/institutionalizations avoided was reduced to 128, and the total QALYs gained were reduced to 42.66 for the cost-effectiveness and cost-utility calculations, respectively.

The considerable contribution of informal caregivers is an important finding from this study. Although there were differences between the groups in terms of the number of weeks for which care was received during the follow-up period, differences between groups remained in comparisons of informal care hours per day alive: 3.98 hours in the stroke unit group, 2.44 hours in the stroke team group, and 2.70 hours in the domiciliary care group (F=3.681; df=2; P=0.026). On this basis, stroke unit patients received significantly more care than stroke team patients (P=0.035) for a similar level of disability. This finding parallels the higher use of social services by the stroke unit group compared with other groups and suggests either that the needs of patients in the stroke unit were better provided for or that these patients were simply taking advantage of available services that they may not have needed.

This randomized controlled trial shows improved health outcomes in the stroke unit group, but they come at a higher cost. The variability of our results to changes in cost perspectives highlights the considerations that should be taken when results of stroke service evaluations are interpreted. More important, they highlight the choices that need to be made by health services and society regarding how much we are prepared to pay for improvements in outcomes.

Acknowledgments

This project was funded by the NHS R&D Executive’s Health Technology Assessment Programme (grant 93/03/026). The service aspects of the project were funded by a grant from the Bromley Health Authority. Dr Evans is supported by a grant from the Stroke Association. Professor Knapp’s part-time post at the London School of Economics is supported by a grant from the Department of Health. We thank Jack Astin and Jose Fernandez for statistical support and Elizabeth Fenwick for providing an Excel program macro for creating cost-effectiveness acceptability curves. We also acknowledge the contributions made by Anne Melbourn (stroke coordinator), Jayne Steadman and Judith Eade (physiotherapists), Sue Chadwick (district nursing), Barry Porter (social services), Rose Gibb (NHS management), and Caroline Long and Susan Bonifacio (secretaries).
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Editorial Comment

Stoke Cost-Effectiveness Research: Are Acceptability Curves Acceptable?

In this issue of Stroke, Patel et al examine the cost-effectiveness of 3 different care strategies for patients with moderately disabling stroke: stroke unit care, stroke team care, and domiciliary care.1 The results show that stroke unit care was more effective and more costly than the other 2 competing strategies, and based on the incremental comparison of stroke unit care compared with domiciliary care (stroke team care was dominated because it was less effective and more costly than stroke unit care), stroke unit care costs an additional £64 000 to £136 000 per quality-adjusted life year (QALY) gained. The authors rightly point out several limitations that need to be kept in mind, the most important of which is limited generalizability given the known differences in stroke care patterns across countries. Another important limitation not mentioned is that different methods of eliciting health state preferences yield different estimates of QALYs for equivalent health states, and such differences need to be kept in mind, considering the authors used only the EuroQol (EQ-5D) as a preference measure and imputed the baseline values.2 This article, however, is important for several reasons.

First, it demonstrates that cost and cost-effectiveness information can be collected, analyzed, and interpreted in the context of stroke treatment trials. To date, the majority of cost-effectiveness analyses for stroke-related interventions have been performed using decision-analytic modeling or have been methodologically limited economic evaluations piggy-backed onto cohort studies or clinical trials.3–4 Obtaining cost and effect data from the same population, as in this clinical-economic trial, has several advantages compared with obtaining cost and effects data from different sources as is often done in decision-analytic modeling, and one of the biggest advantages is that it allows one to understand the correlation between the costs and effects, including a measure of uncertainty in the cost-effectiveness estimates.

Second, it provides detailed descriptive information on the lengthy list of potential cost categories that should be considered in deriving a total cost estimate, and emphasizes the importance of initial hospital costs and informal care costs (ie, direct nonmedical costs) during the first year after a stroke. In fact, the initial hospital costs account for more than 50% of the first-year total direct medical costs, and the informal care costs ranged from approximately 30% to 151% of the total direct medical costs, depending on the methods used to estimate informal care inputs.
Third, it introduces a method of analysis that allows one to place cost-effectiveness results in a more meaningful perspective by plotting acceptability curves for multiple policy alternatives. The curves simultaneously compare the 3 treatment strategies and plot the probability that each strategy is the cost-effective alternative relative to all others. Rather than comparing each alternative to a single, perhaps arbitrarily chosen, policy, or prematurely eliminating a policy based on dominance or extended dominance, each policy is evaluated relative to all alternative policies simultaneously, and the level of uncertainty in each is appropriately addressed.

Fourth, because the curves plot the probability of cost-effectiveness for different valuations of a QALY, ranging from £0 to £100 000 for an additional QALY gained (analogous to a 1-tailed test probability value), decision makers can determine the probability that an intervention is cost-effective or welfare-enhancing based on their own specified threshold of cost-effectiveness (or ceiling ratio). Societal thresholds differ and current threshold values per QALY in the United Kingdom are estimated to be approximately £30 000 per additional QALY, whereas in the United States recent proposals have recommended that the societal threshold for considering a new technology to be cost-effective should be $200 000 per QALY. It should be kept in mind that domiciliary care is actually a strategy of care where initial care is provided in the home with hospital admission if clinically indicated. Because domiciliary care is the least costly alternative, it is the preferred policy when QALYs are not valued, as indicated by the probability points on the far left of Figure 1 in the article by Patel et al.1 As society’s value of a QALY increases, policies with larger QALY gains (ie, stroke unit) have larger net social welfare improvements and, consequently, increases in the probability of being the preferred policies. At the same time, however, the uncertainty in the net social welfare statistics increases rapidly, resulting in convergence of the probabilities (at 0.33 with 3 alternatives) as the value of a QALY becomes large. In this way, acceptability curves summarize important information about both the uncertainty in the estimates and the relative strength of the point estimates. Therefore, based on the information and the analysis presented, we would conclude that domiciliary care is the most cost-effective alternative, but there is not enough evidence to reject the alternative at any level of a QALY value.

This study moves us in the right direction, but more phase III and IV stroke trials should include an economic component. Stroke trialists should become familiar with study designs and methods to perform and appraise cost-effectiveness research, and collaborative partnerships should be strengthened with health economists, quality-of-life researchers, and health policy researchers. Only then will cost-effectiveness information regarding stroke treatments stand beside clinical information to help guide decisions to improve the quality and efficiency of stroke care.

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Stroke. 2004;35:196-203; originally published online December 18, 2003;
doi: 10.1161/01.STR.0000105390.20430.9F

The online version of this article, along with updated information and services, is located on the World Wide Web at:
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