Costs and Caregiver Consequences of Early Supported Discharge for Stroke Patients

Josephine Teng, BSc; Nancy E. Mayo, PhD; Eric Latimer, PhD; Jim Hanley, PhD; Sharon Wood-Dauphinee, PhD; Robert Côté, MD, FRCP; Susan Scott, MSc

Background and Purpose—Early supported discharge (ESD) for stroke has been shown to yield outcomes similar to or better than those of conventional care, but there is less information on the impact on costs and on the caregiver. The purpose of this study is to estimate the costs associated with an ESD program compared with those of usual care.

Methods—We conducted a randomized controlled trial of stroke patients who required rehabilitation services and who had a caregiver at home.

Results—Acute-care costs incurred before randomization when patients were medically ready for discharge averaged $3251 per person. The costs for the balance of the acute-care stay, from randomization to discharge, were $1383 for the home group and $2220 for the usual care group. The average cost of providing the 4-week home intervention service was $943 per person. The total cost generated by persons assigned to the home group averaged $7784 per person, significantly lower than the $11,065 per person for those assigned to usual care. A large proportion of the cost differential between the 2 groups arose from readmissions, for which the usual care group generated costs more than quadruple those of the home intervention group.

Conclusions—Providing care at home was no more (or less) expensive for those with greater functional limitation than for those with less. Caregivers in the ESD group scored consistently lower on the Burden Index than caregivers with usual care, even caregivers of persons with major functional limitations. For persons recovering from stroke and their families, ESD provides a cost-effective alternative to usual care. (Stroke. 2003;34:528-536.)

Key Words: caregivers ■ cost-benefit analysis ■ rehabilitation ■ stroke

Reducing the cost of health care has become increasingly important in the advent of rising costs,1 and the treatment of stroke is no exception.2 The high morbidity associated with stroke contributes to the economic burden of this condition worldwide,3-5 with hospital costs accounting for 71% of the total stroke care costs.6 In an attempt to decrease the hospital costs associated with stroke without having a negative effect on patient outcomes, early supported discharge (ESD) programs have been developed and evaluated. In these programs, a qualified team provides comprehensive and coordinated services in the patient’s home. Care is initiated as soon as the patient is medically ready for discharge from the acute care setting.

There is growing evidence that providing home-based rehabilitation and nursing care immediately after discharge is effective in reducing hospital stay and yields outcomes similar to those for patients receiving conventional care.7-11 There is, however, less information about the costs associated with ESD programs.12 The type of cost comparison that is pertinent depends on the hypothesized or observed effectiveness. When 2 programs are equally effective, only an examination of costs is required13; this is referred to as cost-minimization analysis. If 1 program is more effective than the other, both costs and outcomes must be considered together; this is referred to as cost-effectiveness analysis. To date, the studies examining costs have been of the cost-minimization type because there were similar outcomes for the ESD and conventional care groups. Four studies from the United Kingdom, Australia, and Sweden also examined the economic consequences for stroke care with ESD compared with usual care.9,12,14,15 Although the time periods varied, all found a trend for lower average costs per person in the ESD groups.

Studies of ESD that have shown a benefit have not yet been subjected to a cost analysis.10,16 A recent study17 in Montreal, Canada, showed evidence of benefit from an ESD program over a 3-month period. The purpose of the present study is to estimate the costs associated with the ESD program compared with those of usual care.
Although there have been no reports of significant long-term negative effects of ESD on caregivers to date,\textsuperscript{10,16,18–21} the extent of impact may be health system dependent. Accordingly, a secondary objective of the study is to estimate the impact of the ESD program on caregiver burden.

**Methods**

**Study Design**

A detailed description of the procedures and clinical outcomes of the Montreal study is given elsewhere.\textsuperscript{17} Briefly, a randomized controlled trial of stroke patients who required rehabilitation services and who had a caregiver at home was conducted. This study targeted persons with persistent motor deficits after stroke who had caregivers willing and able to provide live-in care for the subject over a 4-week period after discharge from hospital. Stroke patients who, by 28 days after stroke, still required the assistance of >1 person to walk were excluded, as were patients with cognitive impairment or with important coexisting conditions affecting their ability to function independently. Because of these criteria, persons selected were relatively high functioning (mean Barthel Index, 84), although the range covered a wide spectrum of stroke disability.

When patients were medically ready for discharge, they were randomized to either the home intervention (n=58) or the usual care (n=56) group. The home group received a 4-week, tailor-made home program of rehabilitation and nursing services. The usual care group followed current practices for discharge planning and referral for follow-up services. These included services such as an extended acute-care hospital stay, inpatient rehabilitation, outpatient care, private care, and home care provided by a local community health service center (CLSC).

Follow-up of study subjects was 3 months after randomization. This yielded 2 relevant time periods to consider outcomes. The first time period was from randomization to the end of the intervention (lasting 4 weeks), and the second time period was from the end of the intervention to 3 months after randomization (1 to 3 months).

The economic analysis was carried out from the perspective of the healthcare system. Thus, costs borne by the healthcare system, including all hospital, physician, and home care services, were ascertained. Private costs, such as those borne by caregivers, were not.

**Outcomes and Service Use Data**

Interviews were conducted on all subjects at the end of each period to ascertain outcomes and use of rehabilitation and home care services. Health professionals who were part of the home intervention team recorded the number of visits with the patients. A total of 11 people in the usual care group missed 1 or both follow-up assessments; 7 refused any evaluations, and 4 others had moved, were institutionalized, or were otherwise unavailable at the 3-month evaluation. There were 7 persons in the home group who were lost by the 3-month assessment: 4 because of refusal, 1 because of illness, and 2 because of death (myocardial infarction and previously undetected cancer).

Data on physician and emergency room attendances and readmissions were obtained from records of fee-for-service billings from the Régie d’assurance maladie du Québec (RAMQ). Study participants consented to having their RAMQ number used for linkage. In the province of Quebec, virtually all residents have an RAMQ number; thus, service use could be ascertained for all subjects, whether they were evaluated or not. Because 1 medical encounter could generate multiple billings, the number of days on which a general physician or specialist visit occurred was selected as the measure of physician service use.

**Effectiveness Assessment**

Although a number of outcomes related to disability and functioning were measured, the primary outcome was self-rated physical health as measured by the Physical Component Summary of the Medical Outcomes Study Short Form-36 (SF-36).\textsuperscript{22} This well-known health-related quality-of-life measure has been validated for stroke.\textsuperscript{23,24} It comprises 36 items organized into 8 scales, and each scale is scored from 1 to 100. Two summary scales are available, 1 for physical health and 1 for mental health. These have been standardized to have a mean of 50 and an SD of 10. Higher scores are associated with better health-related quality of life.

**Cost Assessment**

Costs for each patient were estimated for acute-care hospitalization, readmission, emergency room visits, inpatient rehabilitation, home intervention visits, outpatient visits, and CLSC home visits and were based on estimates of direct, overhead, and opportunity costs.\textsuperscript{25} Costs of physician visits were summed from RAMQ billing records and included billings from all settings combined. (Unlike in the case of visit counts, separate billings from the same encounter were summed to ascertain physician service costs.)

Unit costs for other services were calculated as estimates of average costs, including overhead costs and an allowance for the opportunity cost of buildings and land, because the comparison is between 2 modes of treatment that rely on a different mix of hospital and home care.\textsuperscript{13}

The costs for the intervention services delivered to the home group were calculated on the premise that the health professionals were employed by an acute-care hospital. This assumption was made because if the intervention were to be generalized, it would be preferable for the acute-care hospital to oversee this care as part of total stroke care rather than for the care to be transferred to an outside agency.

Costs for hospitalization, emergency visits, and physician billings were calculated for all subjects regardless of whether they completed the study or not. However, outpatient and CLSC home visits could be ascertained only for subjects who completed the follow-up interviews. To calculate total costs over 3 months, group-specific mean values of outpatient and CLSC costs were added for persons with missing data.

Table 1 provides a summary of cost information. All costs are expressed in Canadian dollars.

**Caregiver Assessments**

To estimate the stress associated with caregiving, caregivers completed the Burden Index.\textsuperscript{26,27} This 22-item measure, designed to assess feelings of anger, frustration, and stress and the burden of being a caregiver, has been used frequently with caregivers of persons who are mentally or physically impaired. Caregivers are asked to rate how often they feel the way described in each question from 0 (never) to 4 (nearly always). Factor analysis of the Burden Index has produced 2 subscales\textsuperscript{28}: the Personal Strain Index (α=0.80), which reflects how personally stressful the experience is, and the Role Strain Index (α=0.81), which reflects the stress resulting from role conflict or overload.

**Statistical Analysis**

The estimated cost of each service was aggregated for each subject and then averaged over the group. The total average cost per patient was compared between the 2 groups by use of an independent t test. Even though the distribution of costs was skewed, the t test is a valid method to compare costs because the sample size was large enough to invoke the properties of the central limit theorem. However, a comparison based on a z-score transformation, as recommended by Zhou et al\textsuperscript{29} for log normally distributed data, was also carried out to substantiate the validity of the inference from the t test.

Additional analyses were conducted to examine whether the impact of ESD on costs varied across levels of functional disability. In a regression analysis, inference about the coefficients requires normally distributed error terms. With skewed data, this assumption is violated, and probability values tend to be too low. For these analyses to yield meaningful information, a natural logarithmic transformation was applied to costs to perform a 2-way ANOVA by group and by level of functional disability. The impact on the caregiver was estimated with a generalized linear model for repeated measures.
The analyses of costs included all 114 subjects who were in the original randomized controlled trial: 37 women and 77 men with an average age of 70 years (range, 28 to 89 years). Before randomization, the 2 groups were comparable in terms of demographic characteristics and stroke severity measured with the Canadian Neurological Scale (8.9 ± 2.2 for both groups) and Barthel Index (84.6 ± 14.4 for the home group versus 82.7 ± 13.9 for the usual care group).

### Table 1. Sources of Information on Costs

<table>
<thead>
<tr>
<th>Services</th>
<th>Units of Measurement</th>
<th>Data Sources for Resource Quantities</th>
<th>Unit Cost Estimates (1997–1998), Can $</th>
<th>Data Sources for Unit Cost Estimates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inpatient stay</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Initial acute-care stay</td>
<td>Days</td>
<td>Intervention team</td>
<td>469.20</td>
<td>QHA†</td>
</tr>
<tr>
<td>Acute readmission</td>
<td>Days</td>
<td>RAMQ</td>
<td>469.20</td>
<td>QHA</td>
</tr>
<tr>
<td>Inpatient rehabilitation</td>
<td>Days</td>
<td>Intervention team</td>
<td>233.20</td>
<td>QHA</td>
</tr>
<tr>
<td>Emergency</td>
<td></td>
<td>Intervention team</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Home intervention</td>
<td>Visits</td>
<td>RAMQ</td>
<td>146.06</td>
<td>QHA</td>
</tr>
<tr>
<td>Nurse</td>
<td></td>
<td></td>
<td>71.32</td>
<td>QHA</td>
</tr>
<tr>
<td>PT</td>
<td></td>
<td></td>
<td>73.27</td>
<td>QHA</td>
</tr>
<tr>
<td>OT</td>
<td></td>
<td></td>
<td>73.27</td>
<td>QHA</td>
</tr>
<tr>
<td>ST</td>
<td></td>
<td></td>
<td>78.14</td>
<td>QHA</td>
</tr>
<tr>
<td>DT</td>
<td></td>
<td></td>
<td>73.27</td>
<td>QHA</td>
</tr>
<tr>
<td>CLSC home visits</td>
<td>Visits</td>
<td>Interview</td>
<td>CLSC finance department</td>
<td></td>
</tr>
<tr>
<td>Nursing</td>
<td></td>
<td></td>
<td>77.48</td>
<td>QHA</td>
</tr>
<tr>
<td>PT, OT</td>
<td></td>
<td></td>
<td>73.70</td>
<td>QHA</td>
</tr>
<tr>
<td>Care/housekeeper</td>
<td></td>
<td></td>
<td>47.30</td>
<td>QHA</td>
</tr>
<tr>
<td>Social worker</td>
<td></td>
<td></td>
<td>88.50</td>
<td>QHA</td>
</tr>
<tr>
<td>Outpatient visits</td>
<td>Day-treatment units</td>
<td>Interview</td>
<td>QHA</td>
<td></td>
</tr>
<tr>
<td>PT</td>
<td></td>
<td></td>
<td>46.62</td>
<td>QHA</td>
</tr>
<tr>
<td>OT</td>
<td></td>
<td></td>
<td>55.62</td>
<td>QHA</td>
</tr>
<tr>
<td>ST</td>
<td></td>
<td></td>
<td>71.86</td>
<td>QHA</td>
</tr>
<tr>
<td>DT</td>
<td></td>
<td></td>
<td>82.28</td>
<td>QHA</td>
</tr>
<tr>
<td>Physician billings</td>
<td>Services</td>
<td>RAMQ</td>
<td>As billed</td>
<td>RAMQ</td>
</tr>
<tr>
<td>General practitioner</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Specialist</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

QHA indicates Quebec Hospital Association; PT, physical therapist; OT, occupational therapist; ST, speech therapist; and DT, dietician.

*All unit costs include a component for overhead costs (which varies from 32% of direct costs for inpatient care to 16% for home interventions, the percentages having been obtained from the various data providers) and, for facilities-based services, another to represent the opportunity cost of the buildings and land (5% of direct plus indirect costs). Some costs were provided for 1998–1999 rather than 1997–1998 and were adjusted downwards for inflation with the Consumer Price Index.

†Based on a double-weighted average of costs per day for DRG 14 (cerebrovascular affictions excluding ischemia) at McGill University teaching hospitals. (The double weighting takes into account differences in cost according to level of acuity, using numbers of patients by level of acuity at each hospital, and according to hospital, using numbers of admissions in DRG 14 at each hospital.)

‡The hourly wage for each type of professional (which in Quebec is set by provincial labor agreements) was obtained from their respective provincial associations, assuming 4 to 5 years of experience. Each visit was assumed to require 2 hours, including travel and charting time. To this was added 25% to account for downtime. A further 15% was added to the cost to account for other direct expenses including travel expenses, some administration, pagers, etc, and a further 16% to that to account for indirect costs (see above).

### Results

#### Costs

The analyses of costs included all 114 subjects who were in the original randomized controlled trial: 37 women and 77 men with an average age of 70 years (range, 28 to 89 years). Before randomization, the 2 groups were comparable in terms of demographic characteristics and stroke severity measured with the Canadian Neurological Scale (8.9 ± 2.2 for both groups) and Barthel Index (84.6 ± 14.4 for the home group versus 82.7 ± 13.9 for the usual care group).

Table 2 presents for each group the average resource use per person over the 2 periods: during the first month after randomization and during the subsequent 2 months. Because this was a randomized trial, resource use in the time period before randomization was common for both groups. The average time per person in hospital between stroke and randomization was 6.9 days and was not significantly different by group ($P=0.5$). From the time of randomization, resource use for the 2 groups differed. The mean time to discharge for the home group was 3 days compared with 4.7 days for the usual care group.
Although all persons in the intervention group were discharged home, persons in the usual care group could have gone home or to inpatient rehabilitation, according to the usual procedures for discharge planning. Seven patients in the usual care group were discharged to inpatient rehabilitation for an average of 36.4 days each. Apportioning the total number of rehabilitation bed days (255 days) over the entire group of 56 usual care patients yields an average of 2.5 days during the first period and 2.1 days for the second period. One patient in the home group was readmitted as an acute emergency and was subsequently transferred to inpatient rehabilitation for 34 days.

Of the 56 persons in the usual care group, 10 had 11 acute-care readmissions, with an average length of stay of 19.5 days (SD=20.4) per admission. Among subjects in the home care group, there were only 3 readmissions, with an average stay of 11.3 days (SD=10.2). Table 2 gives the readmission stay averaged for each group.

Over the 4-week intervention period, subjects in the home group received, on average, 2.3 nursing visits, 5.5 physical therapy visits, 3.5 occupational therapy visits, 1.3 speech therapy visits, and 0.2 dietician visits. Everyone received at least 1 rehabilitation visit. During the same 4-week period, participants in the usual care group could have received inpatient rehabilitation care (n=7) or sought services as an outpatient (n=19). However, more than one third (17 of 47 interviewed) did not receive any rehabilitation services in the first 4 weeks after discharge.

Once the 4-week intervention period ended, participants in the home group were referred for further rehabilitation as needed (15 of 50). Of 54 of the usual care subjects, 9 did not receive any rehabilitation services during the first 3 months. Other types of physical therapy visits (ie, from day hospital or private care) and other forms of services (ie, stroke clubs, community activity groups) were counted, but there were very few of these visits in either group.
Table 2 shows the average numbers of days on which a visit to a general physician or a specialist was recorded and an average count of emergency room visits. Table 3 presents average costs for each type of service according to group and time period. Costs were based on the resource use presented in Table 2. Not included were the costs associated with the use of other community services because these are not funded through the healthcare system. Also not included in this table are costs incurred before randomization, which averaged $3251 per person. The costs for the balance of acute-care stay, from randomization to discharge, were $1383 for the home group and $2220 for the usual care group.

Table 4 summarizes, for the combined time periods, the average total cost per subject according to group. The prerandomization costs, including both an acute-care per diem and physician billings, are included to present a portrait of total stroke care costs. The cost of providing the 4-week home intervention service was, on average, $943 per person. The total cost generated by persons assigned to the home group averaged $7784 per person and by persons assigned to usual care averaged $11,065. The difference ($3281) between the 2 groups was statistically significant (P<0.0001). A large proportion of the cost differential between the 2 groups arose from readmissions, for which the usual care group generated costs more than quadruple those of the home intervention group.

Sensitivity Analysis
A multiway sensitivity analysis was also performed to test the robustness of the unit cost estimates. The lower costs associated with the home group remained even after the overhead rates for unit costs were reduced from the assumed 30% to 20%, 10%, 5%, and 0%. In addition, the t test on untransformed data remained significant.

Effectiveness
The original article by Mayo et al17 reported a significantly higher score on the Physical Component Summary scale of the SF-36 at the 3-month evaluation: the mean score for the home group was 5 points higher than that for the usual care group (see Table 5).

Caregiver Impact
Table 6 presents the scores on the caregiver Burden Index at the 3 evaluations. Caregivers in the home intervention group...
TABLE 4. Summary of Total Costs of Resource Use to 3 Months After Randomization

<table>
<thead>
<tr>
<th>Total Resource Use</th>
<th>Costs for Intervention Group (n=58), Can $, Mean (SD)</th>
<th>Cost for Usual Care Group (n=56), Can $, Mean (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prerandomization</td>
<td>4064.84 (3314.94)</td>
<td></td>
</tr>
<tr>
<td>Acute care (bed days and physician billings)</td>
<td>1383.28 (1599.97)</td>
<td>2220.25 (2321.90)</td>
</tr>
<tr>
<td>Rehabilitation bed days</td>
<td>136.70 (1041.10)</td>
<td>1061.89 (3484.24)</td>
</tr>
<tr>
<td>Readmission bed days</td>
<td>364.03 (1794.84)</td>
<td>1793.01 (5504.66)</td>
</tr>
<tr>
<td>Home intervention</td>
<td>942.87 (505.45)</td>
<td>0</td>
</tr>
<tr>
<td>CLSC visits</td>
<td>124.83 (259.85)</td>
<td>144.76 (280.09)</td>
</tr>
<tr>
<td>Outpatient visits*</td>
<td>381.31 (760.17)</td>
<td>730.70 (947.93)</td>
</tr>
<tr>
<td>ER visits</td>
<td>62.07 (117.93)</td>
<td>61.72 (162.14)</td>
</tr>
<tr>
<td>Physician billings†</td>
<td>539.67 (545.74)</td>
<td>764.96 (724.83)</td>
</tr>
<tr>
<td>Total costs‡</td>
<td>7784.25 (3858.36)</td>
<td>11 065.20 (7504.19)</td>
</tr>
</tbody>
</table>

Abbreviations as in Table 1.

*Outpatient visits to physical, occupational, speech, and dietary therapy among persons with interview data.
†Includes general and specialist physicians, as well billings made from private offices, in emergency and during hospitalization.
‡Group-specific mean outpatient visit costs were added to 18 persons without interview data, and an overall mean physician costs per day before randomization was added for 1 person with no RAMQ number.

The advantage of offering ESD in Montreal likely arose in part because all the persons in the home intervention group scored consistently lower on burden than caregivers in the usual care group, and this difference did not change with time.

Cost-Effectiveness

Because the home intervention proved to be more effective than usual care, reduced caregiver burden, and had lower costs, it is more cost-effective than usual care.

Impact of Functional Status on Costs and Caregiver Burden

Figure 1 shows the observed average (bar) and median (line) costs for each group according to 4 levels of the Barthel Index at baseline. The categories for the Barthel Index were chosen on the basis of known groups for this measure, but it was also important to balance the sample sizes within categories to have a fair comparison of differences across levels of the Barthel Index. Analysis of variance shows that there was a significant effect of baseline functional status on cost but that this did not depend on group ($F_{1,113}=2.63$, $P=0.11$). In other words, providing care at home was no more (or less) expensive for those with greater functional limitation than for those with less. Figure 2 shows the impact of baseline functional status on caregiver burden for each of the 2 groups. Functional status at baseline had a significant effect on burden, but adjusted for baseline functional status, there was no significant effect of group. Although this study was not powered to detect differences in caregiver burden, visual inspection of Figure 2 reveals that the caregivers of persons with major functional limitations assigned to the home intervention group experienced considerably lower burden than did caregivers assigned to usual care. The sample sizes reported in Figures 1 and 2 differ because of differences in the number of patients and caregivers with completed interviews.

Discussion

The Montreal study found that home intervention resulted in a shorter length of stay compared with the usual care group. The home group also showed a significantly higher score on the Physical Component Summary scale of the SF-36 by 3 months after stroke, although there were no differences between groups on other functional measures such as the Barthel Index and a timed mobility test. Results suggested that prompt discharge combined with home rehabilitation appeared to lead to better physical health. As reported previously, subjects also reported a higher degree of reintegration without any negative impact on recovery of basic motor and functional skills.

The advantage of offering ESD in Montreal likely arose in part because all the persons in the home intervention group

**TABLE 6. Caregiver Burden at Baseline and 1 and 3 Months After Randomization**

<table>
<thead>
<tr>
<th>Caregiver Burden Index (0–88)</th>
<th>Home Group, n, mean (SD)</th>
<th>Usual Group, n, mean (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>18.7±11.9 (56)</td>
<td>22.8±13.8 (50)</td>
</tr>
<tr>
<td>1 mo</td>
<td>15.6±12.1 (54)</td>
<td>22.4±14.2 (44)</td>
</tr>
<tr>
<td>3 mo</td>
<td>16.4±14.7 (49)</td>
<td>21.7±14.7 (42)</td>
</tr>
<tr>
<td>Estimated effect (SE)*</td>
<td>−5.3 (2.3)</td>
<td></td>
</tr>
</tbody>
</table>

*Estimated effect from repeated-measures analysis of variance, significant effect of group ($P=0.02$).

**TABLE 5. Physical Health at 3 Months After Randomization**

<table>
<thead>
<tr>
<th>Physical Health*</th>
<th>Home Group</th>
<th>Usual Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>42.9</td>
<td>37.9</td>
</tr>
<tr>
<td>SD</td>
<td>10.1</td>
<td>10.6</td>
</tr>
<tr>
<td>Number†</td>
<td>51</td>
<td>44</td>
</tr>
<tr>
<td>Significant effect</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Physical health according to the Physical Component Summary score of the SF-36, which is standardized to have a mean of 50 and an SD of 10.
†Not all subjects were able to complete the SF-36.

**Figure 1.** Group-specific total costs accumulated from randomization to 3 months according to Barthel Index at baseline. Numbers on bars are sample sizes.
received services immediately after discharge, whereas in the usual care group, only a small number of persons received intensive therapy, and many received none. The gains in physical health were not at the expense of increased caregiver burden. Indeed, the caregivers in the home group tended to experience less burden than caregivers in the usual care group (although not statistically significantly less), and interestingly, the greatest benefit of ESD for caregivers appeared to be for those who cared for persons with more severe functional limitations after stroke.

When economic consequences were considered, the results indicated that ESD not only produced better outcomes but also was associated with lower costs of care over the first 3 months after stroke: $7784 for ESD compared with $11,065 for usual care. Although use of virtually all services was less costly in the home intervention group, the main reason for the cost differential was fewer readmissions for a substantially shorter length of stay for the ESD group. Only 2 previous studies included readmissions, and only 1 provided the cost of bed days associated with them.12,15 In contrast to the Montreal study, Holmqvist and associates15 in Sweden estimated that the average cost of readmissions was higher in the ESD intervention group than in the control group, but this was due to a single patient who was hospitalized 134 days for recurrent stroke. Anderson and associates12 also found the average readmission stay to be higher in the ESD intervention group compared with the control group (6 versus 4 days).

There were some striking similarities with previous economic analyses of ESD programs, more than one would anticipate from studies carried out in different countries.9,12,14,30,31 All showed that compared with conventional care, home rehabilitation resulted in a shorter hospital stay, and for up to 1 year after stroke, most showed a lower average cost per person.9,12,14,15 Table 7 gives the costs for the 5 studies that reported this outcome.

One likely mechanism through which ESD reduced costs was that the home-care team identified healthcare problems early and dealt with them before they required emergency care or rehospitalization. Additionally, if a problem arose and hospitalization was required, the presence of the team in the home likely facilitated early return to the community, as evidenced by the much shorter length of stay per readmission in the home group. The difference between the groups would have been even more pronounced had it not been for 1 individual in the home group who became extremely ill and spent 41 days in the hospital (7 in acute care and 34 in rehabilitation). The diagnostic codes that related to the readmissions for the 13 admitted patients were (1) dyspnea, (2) stroke, (3) gastrointestinal hemorrhage with esophagitis, (4) cardiac dysrhythmia, (5) coagulopathy and renal failure, (6) gastroenteritis/colicitis, (7) hypertension, (8) pneumonia, (9) heart disease, (10) heart failure, (11) gastrointestinal hemorrhage, (12) diabetes or renal failure, and (13) not specified.

Baseline functional status has been shown to be an important variable predicting costs among persons with stroke. Caro et al6 found a 10% change in costs (0.095 change in log costs) associated with a 5-point difference in early Barthel Index score. A similar association can be seen in our data: 0.120 change in log costs adjusted for group (P<0.0001).

Baseline functional status has been shown to be an important variable predicting costs among persons with stroke. Caro et al6 found a 10% change in costs (0.095 change in log costs) associated with a 5-point difference in early Barthel Index score. A similar association can be seen in our data: 0.120 change in log costs adjusted for group (P<0.0001). Caro et al also found the Barthel Index score to be a stronger predictor of costs than stroke severity.

Only 2 studies examined the impact of stroke severity on cost using functional status as the indicator of severity. McNamee et al14 found for the intervention group that there were higher costs for the most independent patients (Barthel Index, 65 to 100) and lower costs for dependent patients (Barthel Index, 0 to 60). In contrast, Andersen et al12 found that functional status defined by a modified Barthel Index was an independent predictor of cost in the home-based intervention group, with lower costs for those with mild or moderate grades of disability after adjustment for age, co-morbidity, and presence or absence of a caregiver. In our

### Table 7. Comparison of Costs Associated With ESD

<table>
<thead>
<tr>
<th>Authors</th>
<th>Months</th>
<th>n</th>
<th>ESD</th>
<th>Comparison</th>
<th>Cost Reduction for ESD, %</th>
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<tr>
<td>Mayo et al17</td>
<td>3</td>
<td>114</td>
<td>$7784</td>
<td>$11,065</td>
<td>30</td>
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<tr>
<td>McNamee et al14</td>
<td>3</td>
<td>92</td>
<td>£7155</td>
<td>£7480</td>
<td>4</td>
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<td>Anderson et al12</td>
<td>6</td>
<td>86</td>
<td>$8040</td>
<td>$10,054</td>
<td>25</td>
</tr>
<tr>
<td>Roderick et al30</td>
<td>6</td>
<td>140</td>
<td>£6205</td>
<td>£5631</td>
<td>-9</td>
</tr>
<tr>
<td>Beech et al9</td>
<td>12</td>
<td>331</td>
<td>£6800</td>
<td>£7432</td>
<td>9</td>
</tr>
<tr>
<td>von Koch et al29*</td>
<td>12</td>
<td>83</td>
<td>$10,740</td>
<td>$13,650</td>
<td>27</td>
</tr>
</tbody>
</table>

*Costs from the Anderson et al study are in Australian dollars, and those from Mayo et al are in Canadian dollars. Costs from the Koch et al study were presented in Swedish crowns and converted to US dollars using 1993 conversions.
study, higher costs were associated with lower functional status in the usual care group, but in the home intervention group, the association was less distinct, with relatively constant costs across categories of the Barthel Index. Providing care at home was no more (or less) expensive for those with greater functional limitation than for those with less.

A potential limitation of the study was the short follow-up period for estimation of costs. The follow-up period for most other studies ranged from 6 months to 1 year.\textsuperscript{9,12,14,15} However, the stroke literature indicates that recovery of stroke plateaus after 3 months. Most of the difference in resource use should therefore occur during the first 3 months.\textsuperscript{32} A limitation of the administrative data used in this study is that there is only an indication of a billing for acute-care services and the reason for a readmission is not explicit.

Another limitation of the study is the range of costs taken into account. The costs of medications obtained outside the hospital may have been somewhat higher for the ESD group because they were hospitalized less; however, these medications are typically inexpensive. Indirect costs related to caregiver and patients, which would have been included in an economic analysis from a societal perspective, were not measured. The findings of greater clinical effectiveness and reduced caregiver burden associated with the intervention suggest, however, that those costs may also have been lower had they been measured.

This study did not compare ESD with another type of organized and coordinated rehabilitation program. It may be that the organization and coordination were partly responsible for the better outcome. However, the cost of the home intervention, less than $950 per person (see Table 4), was lower than the costs of usual care in Montreal. The costs of alternative programs would likely be higher; offering 4 weeks of inpatient rehabilitation would cost about $7500 per patient. Outpatient care would be less expensive but not practical for the vast majority of stroke patients and their families. Although it may be desirable to carry out further research comparing other rehabilitation programs, there may be many reasons why inpatient or outpatient therapy is not the optimal choice for all. In contrast, there are few contraindications for home care. It would seem more sensible to reserve inpatient care for patients who have no other option for care and offer home care to the remaining persons until they have recovered sufficiently to attend outpatient care or to resume their usual activities.

Even with these limitations aside, the results from the log-transformed costs should be interpreted with caution. Cost data are often skewed because of a small percentage of patients who incur very high costs relative to other patients.\textsuperscript{29} Although not ideal statistically, this distribution reflects the variability in the general patient population. The total cost in the usual care group ranged from $115 to $32 530 compared with $419 to $18 857 in the home group. When subjected to log transformation, the range was greatly reduced, 4.74 to 10.4 (log dollars) in the usual care group and 6.0 to 9.8 (log dollars) in the home group. For purposes of policy making, it may be appropriate to minimize the weight of outliers; generalizability of the results to the general stroke population, however, is clinically debatable. It was not unexpected that statistical testing after a log transformation and nonparametric tests resulted in a nonsignificant difference between groups. The impact of the home intervention was to provide more comprehensive services at predictable costs; this was evident from the lower variability of costs for the home group compared with those for the usual care group.

Results of a sensitivity analysis also indicated that the cost results were not affected by the assumptions incorporated into the analysis.\textsuperscript{33} Differences in average costs continued to favor the home group even after the unit costs were varied. In fact, it was not possible for the difference to reverse itself (ie, the average cost for the home group to be higher than the usual care group) by varying the overhead assigned to an acute-care bed day and the home-based services.

Although the cost results were robust, the generalizability of the cost results is affected by 2 factors: the patient population involved in the study and the cost data used in the analysis.\textsuperscript{9} Patients who did not need services after stroke, who were not medically ready for discharge by 28 days, or who still needed 2 people to assist in walking and those who did not have a caregiver were excluded. The largest excluded group was made up of those who did not have a caregiver at home; however, many of these individuals were discharged home anyway, and they may have benefited in a similar way from the intervention had they been included.

The second factor affecting the generalizability of the results is related to the fact that cost data may not be representative of other healthcare systems.\textsuperscript{9} However, the units of service use are provided, permitting a projection of the potential for cost savings with other unit costs. In the United States at least, there is evidence that the cost of a hospital day is higher in general than in Canada, which could further accentuate the cost-effectiveness of the home care intervention.\textsuperscript{33}

In this study, ESD was a cost-effective alternative to conventional hospital procedures for stroke patients. This cost-effectiveness arises primarily from a reduction in use of inpatient care. In the typical Canadian setting, the reductions in admissions and length of stay associated with home care would simply free up beds that would be used by other patients, so the impact on annual hospital expenditures would be minimal or even nil. Indeed, the provision of home care as an additional service could increase the overall costs of care. Nonetheless, we have found that home care is cost-effective: Fewer resources are expended to obtain a better clinical result, freeing up resources for other patients.

In conclusion, ESD resulted in better outcomes for many reasons. Some were related to the effects of tailoring the rehabilitation program to the patient’s actual needs as observed and realized in his or her natural home environment. Some may have been due to the effects of empowering the family and patient to take charge of the rehabilitation. These positive effects may have directly influenced costs alone or in combination with components of ESD that themselves affect cost. One advantage of having a stroke team in the home is that health issues can be identified and managed early before they led to an emergency visit or hospitalization. If a hospitalization was necessary, the presence of the team in the home facilitated discharge. With demonstrated benefits and...
lower costs, ESD provides a cost-effective alternative to usual care.

References

Costs and Caregiver Consequences of Early Supported Discharge for Stroke Patients
Josephine Teng, Nancy E. Mayo, Eric Latimer, Jim Hanley, Sharon Wood-Dauphinee, Robert Côté and Susan Scott

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doi: 10.1161/01.STR.0000049767.14156.2C

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