Cost-Effectiveness of Stroke Unit Care Followed by Early Supported Discharge

Ömer Saka, MD, MSc; Victoria Serra, MSc; Yevgeniy Samyshkin, MSc; Alistair McGuire, PhD; Charles C.D.A. Wolfe, PhD

Background and Purpose—Stroke places a significant burden on the economy in England and Wales with the overall societal costs estimated at £7 billion per annum. There is evidence that both stroke units (SUs) and early supported discharge (ESD) are effective in treating patients with stroke. This study assesses the cost-effectiveness of the combination of these 2 strategies and compares it with the care provided in SU without ESD and in a general medical ward without ESD. The objective of this study was to model the long-term (10 years) cost-effectiveness of SU care followed by ESD.

Methods—The study design was cost-effectiveness modeling. The study took place in SUs in the coverage area of the South London Stroke Register, UK. The modeled population was incident ischemic stroke cases (N=844) observed between 2001 and 2006. SU care followed by ESD was compared with SU care without ESD and general medical ward care without ESD. Main outcome measures were health service and societal costs and cost per quality-adjusted life-year gained.

Results—Using the cost-effectiveness threshold of £30 000, as commonly used in the UK, SU care followed by ESD is the cost-effective strategy compared with the other 2 options. The incremental cost-effectiveness ratio of SU care followed by ESD is £10 661 compared with the general medical ward without ESD care and £17 721 compared with the SU without ESD.

Conclusion—SU care followed by ESD is both an effective and a cost-effective strategy with the main gains in years of life saved. (Stroke. 2009;40:24-29.)

Key Words: cost ■ cost-effectiveness ■ economics ■ stroke ■ stroke unit

Stroke places a significant burden on the economy in England and Wales with the overall societal costs of stroke estimated at £7 billion per annum. Direct care accounts for 40% of the total costs, informal care for another 35%, and indirect costs for approximately 25%.1

The treatment of patients with stroke in stroke units (SUs) is becoming a standard treatment approach.2 National clinical guidelines for stroke recommend, “Stroke services should be organized so that patients are admitted under the care of a specialist team for their acute care and rehabilitation.”3 SU defined by the Stroke Unit Trialists’ Collaboration includes the availability of a consultant physician with responsibility for stroke, formal links with patient and caregiver organizations, multidisciplinary meetings at least weekly to plan, provision of information to patients about stroke, and continuing education programs for staff. A minimum of 4 of these criteria has to be met for a treatment unit to be classified as a SU. SUs differentiate between acute treatment and rehabilitation. Acute SUs are the care units that admit patients at the acute stage of treatment and follow-up thereafter. Rehabilitation SUs augmented the acute treatment phase with initial follow-up in the hospital. Combined SUs include both of the components.4-6 SU management has been shown to reduce the relative risk of 5-year mortality by 40%7 and is reported to reduce the risk of recurrence.8

The National Sentinel Stroke Audit has shown an increase in the proportion of hospitals in England with stroke units from 79% in 2004 to 91% in 2006 as well as an increase in the size of the units themselves.9 Despite the growth in such care in the United Kingdom, generally there is little health economics research on the cost and cost-effectiveness of SUs.10-12 Existing studies suggest that SU care is more expensive than the alternatives and there is only one study on the cost-effectiveness of SUs, which suggests that such increased costs are justified by the improved outcomes and this results in favorable incremental cost-effectiveness ratios for SU care.12

Despite the recorded benefits of SUs dealing with acute treatment, there is less conclusive information available on the effective management of discharge and follow-up after...
acute SU care. The Royal College of Physicians Stroke guidelines state that “Specialist stroke services should be available in the community as a part of an integrated system of care to facilitate early supported discharge.” The development of early supported discharge (ESD) offers an effective care pathway in which less disabled patients can be discharged early to undergo further rehabilitation at home. This strategy has the obvious benefit of shortening the length of hospital stay and to reduce long-term dependency and risk of further disability after 6 months. It also results in fewer admissions to institutional care, particularly where there are coordinated services across the acute and rehabilitation management of patients with mild to moderate disability. Six months after stroke, the proportion of such patients that are dead or in an institution is significantly lower for those who have undergone properly managed ESD. Furthermore, patients who received ESD have higher recorded independence scores than those receiving conventional care. In summarizing such evidence, a Cochrane Review evaluating the effectiveness of ESD for patients with stroke concluded that appropriately resourced ESD services could reduce long-term dependency and admission to institutional care as well as reduce the length of hospital stay without causing any adverse effects on the mood or subjective health status of patients or caregivers.

A systematic review looking at the economic evidence on rehabilitation concluded that there was some evidence that the mean total cost of rehabilitation per patient in a SU is comparable to care provided in a conventional hospital ward; however, there was no evidence that ESD services do significantly reduce costs compared with the costs arising from the usual care of patients with stroke. There is insufficient evidence on the cost of community-based rehabilitation compared with commonly provided care. There are 2 other studies looking at the effects of ESD strategy together with the costs. However, thus far, no study has attempted to model and calculate the long-term cost-effectiveness of ESD strategies as compared with conventional discharge strategies.

The aim of this study is to evaluate the long-term (10-year) cost-effectiveness of SU care followed by ESD (SUESD) compared with SU care and treatment in a general medical ward with no ESD (SUNESD and GWNESD, respectively). To do so, data were obtained from the South London Stroke Register (SLSR) in England and from a randomized, controlled trial of an ESD scheme for patients with stroke.

### Methods

#### Model

To establish the cost-effectiveness of SUESD, a Markov health state transition model was developed. The decision analytic model was constructed using TreeAge Pro 2007 software (TreeAge Software; Williamstown, Mass).

Data on the service use and health outcomes of a group of patients with stroke registered in the SLSR were used. The SLSR is an ongoing population-based register in a defined area corresponding to 22 wards of the Boroughs of Lambeth and Southwark. Data were used from November 2001 to January 2006 (Table 1), which corresponds to the period when a SU was opened at the only hospital in the SLSR area. The SU has 4 acute beds and 23 rehabilitation beds admitting only patients with stroke. In addition, data from a local ESD trial were used to assess the effectiveness of ESD and the resources used in the process (Table 2).

The health state transition model simulated the care pathways after stroke, starting from the diagnosis of acute stroke and admission to inpatient care. The model structure allows for either the conventional path of discharge from inpatient care and follow-up or ESD and follows the disease progression and costs of care for 10 years (Figure). Patients with acute stroke can be referred to as: (1) SUESD; (2) SUNESD; or (3) GWNESD.

#### Outcome of Care

Postdischarge patients were assumed to be either residing at home or in institutional care (nursing home, residential home). The model did not allow for recurrent strokes given the lack of data on the occurrence of recurrent strokes. Given that the majority of recurrences occur during the first year after the initial stroke and SU treatment actually reduces the incidence of recurrences, this is a conservative assumption.

The main outcome for the model was the combination of death and activities of daily living score as measured by the Barthel Index (BI) (mild: BI score 15 to 20; moderate: BI score 10 to 14; severe: BI score 0 to 9). BI index scores were expressed in health-related quality-of-life values to calculate the quality-adjusted life-years (QALYs) gained from the model using the conversion method developed by Van Exel et al. The transitions in the model were among 3 disability states: mild, moderate, or severe. The most disabled patients older than age 85 were assumed to remain severe for the rest of their lives (Supplemental Figure I, available online at http://stroke.ahajournals.org). The 1-year outcomes from the ESD trial were extrapolated for 10 years and were used as transition probabilities obtained from that trial (Table 3).

SLSR data were used to calculate the average length of hospital stay for patients with stroke in an SU and general medical ward (GMW), the discharge location of patients, and also to identify the disability levels of patients at discharge. The disability levels of the patients at the end of the first year were obtained from the ESD trial. Data on resource use and severity levels of ESD and non-ESD patients were obtained from Beech et al.

#### Costs

Costs were analyzed from a societal perspective, not including the transportation costs for outpatients to the point of care (Table 4).

### Table 1. Service Provision Characteristics, SLSR25

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>SU (n=571)</th>
<th>GMW (n=581)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>64.2</td>
<td>63.3</td>
</tr>
<tr>
<td>Gender, female</td>
<td>47.3%</td>
<td>48.7%</td>
</tr>
<tr>
<td>Limitation in activities of daily living, mean BI score (SD)</td>
<td>11.27 (7.82)</td>
<td>10.3 (8.2)</td>
</tr>
<tr>
<td>Discharge destination</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Home</td>
<td>402</td>
<td>356</td>
</tr>
<tr>
<td>Institutional care (nursing home, residential home)</td>
<td>156</td>
<td>75</td>
</tr>
<tr>
<td>Deceased before discharge</td>
<td>32</td>
<td>23</td>
</tr>
<tr>
<td>Length of stay, mean (SD)</td>
<td>32.3 (34.2)</td>
<td>35.3 (44.9)</td>
</tr>
</tbody>
</table>

### Table 2. Population Characteristics, ESD Trial23

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>ESD (n=167)</th>
<th>Conventional Care (Non-ESD; n=164)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Limitation in activities of daily living, mean BI score (SD)</td>
<td>11.27 (7.82)</td>
<td>10.3 (8.2)</td>
</tr>
<tr>
<td>Length of stay, mean (SD)</td>
<td>34 (34)</td>
<td>42 (41)</td>
</tr>
</tbody>
</table>
Indirect cost estimates were based on income loss due to mortality and/or morbidity were calculated using the data obtained from the Office for National Statistics on mortality and the mean earnings of UK workers in different age bands for 2003. For both the mortality and morbidity calculations, it is assumed that people aged older than 65 years are retired. The rate of economic productivity and the current unemployment figure as published in the Annual Abstract of Statistics were used to estimate friction costs. The income loss of stroke-related morbidity was then estimated by multiplying the number of certified days off work from stroke with the income per day.

The direct cost estimates were based on the costs of hospital stay and follow-up care where appropriate. The relevant detailed National Health Service service costs were obtained from the Guy’s & St Thomas’ Foundation Trust, Financial Performance Report, 2004/2005 (unpublished data) using a full costing approach with apportioned indirect and overhead costs. The cost of an inpatient stay was calculated using the average length of stay for stroke as documented by the SLSR and the ESD trial for patients with different severity levels and multiplied by the per-diem cost of hospital stay. The per-diem cost of inpatient stays included cost of the hospital bed (including nursing services) and the cost of time of physicians and therapists. The hourly costs of specialists were calculated using the salary schedules of specialists obtained from the stroke unit at Guy’s & St Thomas’ NHS Foundation Trust as well as the per-day cost of hospital stay (including nursing services; Guy’s & St. Thomas’ Foundation Trust, Financial Performance Report, 2004/2005, unpublished data). The amount of time spent by physicians, physiotherapists, occupational therapists, and speech and language therapists per patient per diem is taken from De Wit et al. The resource use data on outpatient services provided by therapists and physicians for each severity group was obtained from the ESD trial. The cost of institutional care was represented by the cost of nursing home care, because the majority of patients classified as

<table>
<thead>
<tr>
<th>Classification</th>
<th>BI Score</th>
<th>Health-Related Quality-of-Life Values</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mild</td>
<td>15–20</td>
<td>0.69</td>
<td>0.55–0.8</td>
</tr>
<tr>
<td>Moderate</td>
<td>10–14</td>
<td>0.38</td>
<td>0.33–0.44</td>
</tr>
<tr>
<td>Severe</td>
<td>0–9</td>
<td>0.046</td>
<td>0–0.14</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Component</th>
<th>Unit Cost</th>
<th>Unit</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>SU per patient</td>
<td>£165</td>
<td>Per diem</td>
<td>*</td>
</tr>
<tr>
<td>GMW per patient</td>
<td>£115</td>
<td>Per diem</td>
<td></td>
</tr>
<tr>
<td>CT</td>
<td>£85</td>
<td>Per test</td>
<td>*</td>
</tr>
<tr>
<td>MRI</td>
<td>£400</td>
<td>Per test</td>
<td></td>
</tr>
<tr>
<td>Echocardiography</td>
<td>£101</td>
<td>Per test</td>
<td></td>
</tr>
<tr>
<td>Outpatient drugs</td>
<td>£35.6</td>
<td>Per month</td>
<td>SLSR</td>
</tr>
<tr>
<td>Cost of stay in a nursing home</td>
<td>£570</td>
<td>Per week</td>
<td>35</td>
</tr>
<tr>
<td>Cost of stay in a residential home</td>
<td>£513</td>
<td>Per week</td>
<td>35</td>
</tr>
<tr>
<td>Cost of stay in a sheltered home</td>
<td>£234</td>
<td>Per week</td>
<td>35</td>
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<tr>
<td>Cost of caregiver</td>
<td>£9</td>
<td>Per hour</td>
<td>31</td>
</tr>
<tr>
<td>Minimum wage</td>
<td>£5.52</td>
<td>Per hour</td>
<td>31</td>
</tr>
<tr>
<td>Average income</td>
<td>£90</td>
<td>Per day</td>
<td>31</td>
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</table>

<table>
<thead>
<tr>
<th>Component</th>
<th>Resource Use</th>
<th>Unit</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time available per specialist</td>
<td>Physician</td>
<td>3.31</td>
<td>Hours per week</td>
</tr>
<tr>
<td></td>
<td>Physiotherapist</td>
<td>7.35</td>
<td>Hours per week</td>
</tr>
<tr>
<td></td>
<td>Speech and language therapist</td>
<td>1.35</td>
<td>Hours per week</td>
</tr>
<tr>
<td></td>
<td>Occupational therapist</td>
<td>4.06</td>
<td>Hours per week</td>
</tr>
</tbody>
</table>

residing in an institutional care center were living in a nursing home. Cost of care at home and in an institutional care center were assumed to be the same across patients with different disability levels.\textsuperscript{35} All costs were adjusted to 2005 to 2006 prices\textsuperscript{36} with an annual discount rate of 3.5\% applied to both costs and effects.\textsuperscript{37}

Incremental cost-effectiveness ratios (ICERs) were calculated as cost per QALY to assess the cost-effectiveness of the different strategies. Univariate deterministic and stochastic sensitivity analyses were performed to illuminate the importance of the assumptions made for the baseline case and to test the robustness of the model.\textsuperscript{38} Parameters analyzed for the univariate sensitivity analysis included the cost multipliers, probabilities of death, hospital length of stay, distribution of patients across the functional outcome groups, cost of medication management, outpatient physician visits and durable equipment, health usefulness weights, and discount rates. The effect of varying individual parameters was examined using plausible ranges of values from the literature, 95\% CIs, or by varying estimates by 20\% in each direction.

Deterministic sensitivity analysis is useful for understanding key parameters that determine cost-effectiveness and for examining the range of a variable, which results in the ICER falling below a certain threshold level. However, the likelihood of achieving an ICER that falls below that threshold value cannot be inferred from such analysis.\textsuperscript{39} Available information may be used to perform a Monte Carlo simulation and estimate the probability of cost-effectiveness. For the probabilistic sensitivity analysis, a Monte Carlo simulation method was used to vary model parameters simultaneously using distributions.\textsuperscript{40} The parameters varied were the cost, length of stay, and health-related quality-of-life variables. It was assumed that parameter estimates followed a lognormal distribution for cost multipliers and for length of stay in the hospital. A normal distribution was assumed for the QALY values. The Monte Carlo simulation was run 10 000 times to achieve stability of results. The sensitivity analyses were applied to all 3 arms of the decision model.

**Results**

The GMWNESD option was used as the base case for the initial run of the model. When SU options were compared with the GMW option, they were more cost-effective with an ICER of £10 661 and £11 615 per QALY for SUNESD and SUESD options, respectively (Table 5). A comparison of the 2 SU strategies showed that SUESD is the most cost-effective with an ICER of £17 721 (Table 5). All ICER values fall below the National Institute for Health and Clinical Excellence’s cost-effectiveness threshold level of £30 000 per QALY gained.\textsuperscript{41}

A univariate sensitivity analysis of the base case scenario was conducted by varying the model variables used in the calculations by 20\% below and above their default value. The only exception to this was the discount rate, which was varied between 0\% and 10\% after the conventional use of discount rates.\textsuperscript{42} We used all the variables in the one-way sensitivity analysis (Supplemental Figures I and II).

Discount rates and health-related quality-of-life value of a mild stroke had the greatest impact on the ICER values when 2 competing strategies were compared at any one time; however, the ICER values never went over the £30 000 threshold. Variation of the cost per day for both the SU and the GMWs also had an impact on the results. Variations in the length of stay appeared to have some effect on the ICER values as well.

The comparison of SUESD with GWNESD produced robust results. ICER values never exceeded £30 000 and stayed well within the limits (maximum ICER £14 200). The ICERs did not exceed £30 000 when SUESD and SUNESD were compared either; however, highest ICER value was closer to the National Institute for Health and Clinical Excellence threshold (£25 000). In the comparison of SUESD with SUNESD, outcomes and different length of stay variables had a greater impact on the results. Health-related quality-of-life measures for patients with mild disabilities had some impact on the ICER values in this comparison.

The timing of the outcomes and effects had a large influence on the results in both the comparisons as reflected in the sensitivity of the results to discount rates. This result was expected because high and low values for discounting costs and effects (no discounting versus 10\% per annum) were simulated. Neither of the variables mentioned had a significant enough impact on the results to either allow one strategy to dominate the other or increase the cost per QALY to levels higher than £30 000.

Finally, we carried out a probabilistic sensitivity analysis of health-related quality-of-life measure and length of stay variables. We did not include the cost variables because we had no data on the distribution of unit costs.

When we compared SUESD with GWNESD, we found that only 1.8\% of the time the willingness to pay the threshold of £30 000 is exceeded, and the ICER stayed under this level 97.1\% of the time. A total of 1.1\% of the time, the SUESD option dominated the GWNESD option (Table 5). ICERs did not exceed £30 000 when SUESD and SUNESD were compared either; however, highest ICER value was closer to the National Institute for Health and Clinical Excellence threshold (£25 000). In the comparison of SUESD with SUNESD, outcomes and different length of stay variables had a greater impact on the results. Health-related quality-of-life measures for patients with mild disabilities had some impact on the ICER values in this comparison.

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The results appeared to be robust when SUESD was compared with SUNESD as well. SUESD option dominated SUNESD 3.6\% of the time and the ICER value was below the threshold 96.4\% of the time. Therefore, the willing-to-pay threshold levels were never exceeded by the incremental cost-effectiveness ratios.

**Table 5. A 10-Year Projection of Cost-Effectiveness of Treatment Options**

<table>
<thead>
<tr>
<th>Strategies</th>
<th>Average Cost per Patient in 10 Years, £</th>
<th>Incremental Cost, £</th>
<th>Effectiveness QALY Gained per Patient</th>
<th>Incremental Effectiveness</th>
<th>Cost per QALY, £</th>
<th>Incremental Cost-Effectiveness, £</th>
</tr>
</thead>
<tbody>
<tr>
<td>GWNESD as the base case scenario</td>
<td>40 500</td>
<td>1 679</td>
<td>21 020</td>
<td>24 095</td>
<td>10 661</td>
<td>17 721</td>
</tr>
<tr>
<td>SINESD</td>
<td>45 500</td>
<td>2 151</td>
<td>21 150</td>
<td>10 661</td>
<td>11 615</td>
<td></td>
</tr>
<tr>
<td>SUESD</td>
<td>46 900</td>
<td>2 230</td>
<td>21 020</td>
<td>10 661</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SUNESD as the base case scenario</td>
<td>45 700</td>
<td>2 151</td>
<td>21 268</td>
<td>17 721</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SUESD</td>
<td>47 300</td>
<td>2 230</td>
<td>21 220</td>
<td>17 721</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Discussion
This is the first study that modeled the long-term cost-effectiveness of UK SUs and ESD policies with care in a GMW and with conventional discharge policies using unbiased data collected by the SLSR. The study demonstrates that integrated provision of SU care followed by ESD is likely to lead to improvements in treatment outcomes in a cost-effective manner. This was demonstrated through a comparison of the SUESD option with SUNESD and GWNESD alternatives. Our analysis suggests that SUESD offers the best results in terms of effectiveness with an additional cost, which is within accepted reasonable cost-effectiveness levels the majority of the time. The GWNESD strategy, although less expensive than the other 2, appeared the least effective of all 3 strategies, which confirms the trial evidence on SUs.

When both SUESD and SUNESD strategies were compared with the GWNESD option, the results were favorable for the SU care options. Both univariate and probabilistic sensitivity analysis results confirmed this conclusion.

The results appeared to be also cost-effective when SUESD was compared with SUNESD, the ICER value being £17,721. When a univariate sensitivity analysis was performed varying parameter values by 20%, ICER values did not exceed the £30,000 per QALY National Institute for Health and Clinical Excellence threshold. The results of the probabilistic sensitivity analysis gave rise to a wider range of outcomes, however, possibly due to the wide distribution of values used for the health-related quality-of-life variables. Also, for some ESD cases in this probabilistic sensitivity analysis, the length of stay values were comparable to the non-ESD patients despite the fact that mean length of stay for ESD is 8 days lower than for conventional care. Another factor that could have an impact on these cost-effectiveness results could be that the average cost per day for SU and GMW inpatient stays were used for all types of patient, although the cost per day for a more severe patient would be higher than for a milder patient. This might have increased the costs of the less severe cases and increased the costs for SUESD strategy.

There are a number of issues, which might have an impact on our results. First, the ESD trial we used, although it is the largest trial carried out on ESD to date, is a 1-year follow-up study mainly looking at resource use and is limited in its approach to measuring outcomes. In particular, functional ability scores had to be converted to the preferred outcome measure, QALYs. It was also necessary to extrapolate the results of the trial to 10 years poststroke, which inherently assumed that the advantages provided by the ESD in the first year were persistent. The few long-term SU studies, although they have small sample sizes, suggest that the positive impact of SUs on the outcome of care is sustainable for 5 to 10 years. Therefore, we believe that this is a fair assumption given the lack of long-term data on ESD.

Also, the ESD services observed in the trial were provided by a specialized stroke team in our location, which may not be replicated elsewhere. The difference between the effectiveness of SUESD and SUNESD is based on the differences between the disability levels of the patients in the ESD trial. Beech et al, using the same trial data, report the resource use and cost differences between ESD and no ESD strategies but not the differences in effectiveness. However, the study argues that, “When set alongside the previously reported clinical implications of the intervention, the results indicate that the early discharge strategy is cost-effective, with the same achieved at lower average costs.” This suggests that even if an ESD strategy does not provide a health-related quality-of-life advantage over no ESD strategy, it should lead to an improvement in health services if not by increasing effectiveness, then by decreasing overall costs.

The ESD strategy analyzed is a specific ESD strategy, which was used by the clinical trial from which the data were drawn. Different stroke care institutions could be using different strategies with different patterns of resource use involved, which could in the end alter the overall effects and the costs.

The model did not account for recurrent strokes; therefore, the inherent assumption was that the recurrence rates for either of the treatment options were the same. However, there is some evidence in favor of SUs in reducing recurrent strokes. Therefore, this simplifying assumption in the model could only have led to our results being more conservative when estimating the cost-effectiveness of the SU options.

This study is the first economic analysis evaluating the cost-effectiveness of SU care followed by ESD and provides important evidence for understanding the economic implications of different discharge policies. The cost savings that can be generated by the reduction in the average hospital length of stay is partly offset by the increase in the ESD rehabilitation costs. However, the increase in costs remains within reasonable limits when compared with the increase in effectiveness. Therefore, SUESD is a cost-effective strategy with respect to the other 2 strategies discussed.

Conclusion
SU care followed by ESD provides a cost-effective option to conventional care provision methods for patients with stroke. However, future research is needed to obtain long-term outcome data.

Acknowledgments
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Disclosures
None.

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