The Stroke Impact Scale
Validation in a UK Setting and Development of a SIS Short Form and SIS Index
Crispin Jenkinson, DPhil; Ray Fitzpatrick, PhD; Helen Crocker, MSc; Michele Peters, PhD

Background and Purpose—The Stroke Impact Scale (SIS) covers 8 dimensions and a composite disability score. This study evaluates the SIS in the UK context, and develops a single index and an 8-item short form.

Methods—Patients with a diagnosis of stroke were recruited through general practices in London and the North-West of England. Patients completed the SIS and the EQ-5D.

Results—Internal consistency of the SIS dimensions and the disability score ranged from \( \alpha = 0.86 \) to 0.95. Complete data were available on 73 questionnaires (48.34%). Factor analysis suggested the 8 domains could be aggregated into a single index. A short-form SIS (SF-SIS) index was created by summing 1 item per dimension. Selected items were those that most highly correlated with their respective domain score (\( \rho \) ranged from 0.77–0.94, \( P<0.001 \)). The SF-SIS index scores were highly correlated with those gained from the parent form (\( \rho = 0.98; P<0.001 \)). The correlation of the SIS index and SF-SIS index with the EQ-5D was identical (\( \rho = 0.83; P<0.001 \)). The disability score, whether scored from the dimensions of the SIS, or relevant items on the SF-SIS, were highly correlated (\( \rho = 0.97; P<0.001 \)).

Conclusions—The SIS covers aspects of health, which are of importance to stroke patients, and the dimensions were found to have high levels of internal consistency in the UK context. The amount of incomplete data suggests that the length of the questionnaire may present a substantial patient burden. In comparison to the parent form the SF-SIS can accurately provide the disability score and overall index score with considerable brevity. (Stroke. 2013;44:2532-2535.)

Key Words: patient-reported outcomes • SIS index • Stroke Impact Scale

Stroke can have substantial adverse effects on functioning and well-being. Despite this, there is no single disease-specific patient-reported outcome measure that is universally accepted for this patient group. Patient-reported outcome measures are questionnaires designed to capture the impact of ill health on a broad range of areas that influence quality of life. To date, clinically assessed functional outcome measures,1 generic2 or adapted generic3 patient-completed measures have dominated in the evaluation of stroke and the impact of rehabilitation programs.4 Use of such measures has continued despite the development of a number of disease-specific patient-reported outcomes in recent years.5 As a result, a structured review of existing scales was undertaken to determine which may be the most appropriate for potential inclusion in a study to evaluate the possibility of collecting patient-reported outcome data from stroke patients via general practices in the United Kingdom.4 The Stroke Impact Scale6 (SIS) was selected as having a well-documented and thorough development history, together with good psychometric properties. Consequently, this study evaluates the SIS, a questionnaire designed in the United States, in the UK context, and furthermore, suggests some scoring algorithms that may lead to (1) simplification in the presentation of SIS data, especially in clinical trials, and (2) reduced patient burden, by selecting a subset of items to create a SIS short form.

Methods
Stroke patients were recruited from general practices in London (n=12) and North-West England (n=7) as part of a larger survey assessing the use of patient-completed questionnaires across a wide variety of conditions. Eleven practices were based in more deprived areas and 8 in more affluent areas. According to the National Statistics Area Classification (2001),1 the area of 8 practices was classed as multicultural city life, 5 as professional city life, 3 as miscellaneous built-up areas, 2 as countryside, and 1 as disadvantaged urban communities. Patients were identified through an automatic remote search of general practice patient databases by a subcontracted IT company according to Read Codes, the standard clinical coding system used in the National Health Service. The aim of the search was to identify \( \approx 50\% \) of the stroke patients on each general-practice database. This meant that respondents were sampled from a larger number of practices, which increased the geographical spread. The search produced a list of patients with a diagnosis of stroke (n=525), which was checked by practice staff to identify and remove any patients who were not deemed suitable to be invited to a research study (n=107), because of severity of illness or mental incapacity. Eligible patients (n=418) were sent a survey by practice staff. The surveys were returned to the research team based at Oxford University. Ethics approval was given by the National...
Research Ethics Service of the Isle of Wight, Portsmouth and South East Hampshire (now the National Research Ethics Service South-Central Committee). As per guidance from the ethics committee, consent was implied by returning the completed questionnaire.

### Patient-Reported Outcome Measures

Participants in the survey were asked to complete 2 patient-reported outcome measures (the SIS and the EuroQol EQ-5D), as well as a number of demographic questions relating to age, sex, employment status, and ethnicity.

The SIS was designed to be a mail-administered outcome measure developed in the United States by Duncan et al.9 and has undergone considerable validation and development. The current version of the SIS (SIS version 3.0) is a 59-item patient-reported outcome measure, covering 8 domains: strength (4 items), hand function (5 items), mobility (9 items), activities of daily living (10 items), memory (7 items), communication (7 items), emotion (9 items), and handicap (8 items). Domains are scored on a metric of 0 to 100, with higher scores indicating better self-reported health. Four of the scales of the SIS can be combined into a composite physical domain (strength, hand function, physical and instrumental activities of daily living, and mobility), with scores also presented on a 0 to 100 metric. Minor changes to wording for use in the UK context were required: the term yard work was changed to garden work (question 5j), take out garbage was changed to take out rubbish (question 5h), walk 1 block was changed to walk 100 yards (question 6e), and pick up a dime was amended to pick up a coin (question 7e). Permission to use the scale was granted by Mapi Research Trust, Lyon, France, on behalf of the copyright holder, the University of Kansas Medical Center, Kansas City, KS.

The EuroQol EQ-5D is a generic measure of health status primarily designed to provide a single-index value, which is intended to represent the utility of specific health states, that is, how given health states are valued by the general population.10 It can be used as a self- or interview-administered survey and takes ≈5 minutes to complete. The EQ-5D was developed by researchers in 5 European countries, with the intention that it would be supplemented by other health-related questionnaires.11 The EQ-5D comprises 5 items, one on each on mobility, self-care, usual activities, pain/discomfort, and anxiety/depression, all of which are scored on a 3-point scale. A single-index value is calculated from the 5 items typically with a score range from 1 (perfect health) to 0 (death) although a small number of scores <0 can be obtained indicating, the developers suggest, states worse than death.

### Data Analysis

Descriptive statistics are used to present domain scores and the range of scores across domains. Data completeness for domains is also presented. Internal consistency statistics (Cronbach α) are presented for each of the domains of the SIS. Higher-order factor analysis and internal consistency reliability statistics are used to determine whether domain scores on the SIS could be meaningfully aggregated to create a single-index figure (SIS Index). Higher-order factor analysis has been used to create summary scores for a number of disease-specific12 and generic13 questionnaires, and involves analysis at the level of dimensions not items. Correlations (Spearman) of items to the domain to which they contribute are calculated to select 1 item per domain to create a SIS short form. Results on the SIS short form are correlated with those gained from the parent form by means of Spearman correlations, and 95% confidence intervals (CIs) around mean scores. Data analyses were undertaken using SPSS version 19.

### Results

Questionnaires were returned by 151 respondents (36.1%), of whom 56 (37.1%) were women, 88 men (58.3%), and 7 did not respond to the question. Four respondents (2.7%) indicated they were in the age range 18 to 44 years, 45 (30.4%) in the range 45 to 64 years, 41 (27.7%) in the range 65 to 74 years, and 58 (39.2%) >75 years. Only 29 respondents indicated they were in full- or part-time work (19.2%). The majority had either fully retired from work (n=84; 55.6%) or indicated they were unemployed because of their health (n=19; 12.6%). The majority of respondents were white British (n=122; 80.8%) and from the North-West of England (n=83; 55.0%). The mean time since their stroke was 7.3 years (SD, 6.1). Respondents reported an average of 2 comorbidities (SD, 1.5), with 18 (11.9%) not reporting any comorbidities, 53 (35.1%) reported 1 comorbidity, and 80 (53.0%) reported 2 or more comorbidities.

Descriptive statistics for the 8 dimensions of the SIS are reported in Table 1. The Physical Domain mean score was 73.45 (SD, 25.59; 95% CIs, 68.3–78.6; min=14.93; max=100). Internal consistency reliability estimates for each of the 8 dimensions were calculated and ranged from 0.86 to 0.95, suggesting possible item redundancy in a number of the domains measured by the instrument. Dimension totals were calculated in those instances where respondents had answered all items in a scale (ie, no data imputation algorithm was implemented), and hence response rates vary across dimensions (Table 1). Most striking was the fact that complete data, enabling all 8 scores to be calculated, were only available for 73 cases (ie, 48.34% of all those who returned questionnaires).

The 8 dimensions of the SIS were then subjected to higher-order principal component factor analysis. One factor with an eigenvalue >1 was produced, which accounted for 68.76% of the variance. Each dimension of the SIS loaded on this factor (eigen value=5.5). Factor loadings are shown in Table 2. Consequently, all 8 dimensions of the SIS were summed to create a single-index figure (SIS Index). Internal reliability was assessed using Cronbach α and a value of 0.93 was gained for the SIS Index, indicating high levels of internal reliability. The mean of the SIS Index was 74.05 (SD=21.89; min=14.21; max=99.31; 95% CIs, 68.9–79.1; n=73).

### Derivation of Items for the SF-SIS and SF-SIS Index

The high levels of internal consistency of domains on the SIS suggested some item redundancy. Consequently, it was decided to see whether single items chosen from each dimension could replicate results on the Physical Function Domain.

#### Table 1. Cronbach α Statistics and Descriptive Statistics for the 8 Dimensions of the SIS

<table>
<thead>
<tr>
<th>SIS Scales (n)</th>
<th>α</th>
<th>Mean (SD)</th>
<th>95% CI</th>
<th>Min–Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strength</td>
<td>120</td>
<td>0.94</td>
<td>65.32 (27.51)</td>
<td>60.4–70.24</td>
</tr>
<tr>
<td>Hand function</td>
<td>131</td>
<td>0.95</td>
<td>70.11 (32.23)</td>
<td>64.59–75.63</td>
</tr>
<tr>
<td>Mobility</td>
<td>129</td>
<td>0.92</td>
<td>74.81 (25.44)</td>
<td>70.42–79.20</td>
</tr>
<tr>
<td>Memory</td>
<td>137</td>
<td>0.96</td>
<td>78.47 (24.30)</td>
<td>74.40–82.54</td>
</tr>
<tr>
<td>ADL</td>
<td>124</td>
<td>0.95</td>
<td>79.54 (23.70)</td>
<td>75.37–83.71</td>
</tr>
<tr>
<td>Communication</td>
<td>138</td>
<td>0.95</td>
<td>84.21 (22.64)</td>
<td>80.43–87.99</td>
</tr>
<tr>
<td>Emotion</td>
<td>128</td>
<td>0.86</td>
<td>68.40 (18.62)</td>
<td>65.17–71.63</td>
</tr>
<tr>
<td>Handicap</td>
<td>98</td>
<td>0.89</td>
<td>68.30 (31.05)</td>
<td>62.15–74.45</td>
</tr>
</tbody>
</table>

*ADL indicates activities of daily living; CI, confidence interval; and SIS, Stroke Impact Scale.*
and the SIS Index. The derivation of the items of the short- 
form SIS (SF-SIS) is based on selection of the most highly 
correlated item from each dimension to the total score of 
the dimension to which the item contributes. The items selected, 

together with the level of correlation with the dimension score, are shown in Table 3. The Physical Domain score was 
calculated summing the 4 items representing the 4 dimensions 
summed in the parent version. SIS and SF-SIS Physical 
Domain scores were highly correlated (ρ=0.97; P<0.001; 
n=99). When scores for the Physical Domain could be 
calculated both on the SIS and SF-SIS results were found to 
be similar (SIS physical domain: mean=73.45 [SD, 25.60]; 
SF-SIS physical domain: mean=75.10 [SD, 24.34]).

Principal component analysis of the 8 items produced a single 
factor accounting for 57.25% of the variance (Table 2). Internal 
consistency reliability of the 8 items was high (α=0.89).

Comparison of the SIS Index and the SF-SIS Index
The SIS index was calculated in 2 ways: first, by summing 
the 8 dimensions of the SIS, and then standardizing the score 
on a scale of 0 to 100 (the SIS Index), and second, by sum- 
ing the 8 items of the SF-SIS, and then standardizing the 
score on a scale of 0 to 100 (SF-SIS Index). The mean scores 
gained from these 2 methods were similar and highly correlated 
(ρ=0.98, P<0.001, n=73) and 95% CIs for mean scores

overlapped: the mean of the SIS Index was 74.05 (SD=21.89; 
min=14.21; max=99.31; 95% CI, 68.9–79.1; n=73) and the 
mean SF-SIS Index score was 78.66 (SD, 20.15; min=25.00; 
max=100; n=73; 95% CI, 74.0–83.4). Because of missing 
data the SIS Index could only be calculated on 73 cases, but 
the shorter SF-SIS Index could be calculated for 151 cases 
(mean=71.64; SD, 23.80; min=0, max=100).

The mean EQ-5D score was 0.63 (SD, 0.33; min, –0.035; 
max, 1.00; n=145). The SIS Index and SF-SIS Index score 
correlated with EQ-5D, and produced identical results (ie, 
ρ=0.83 between the EQ-5D and both the SIS Index and 
SF-SIS Index).

Discussion
Stroke can have substantial consequences in terms of impair- 
ment and disability. The SIS is a validated measure that will 
enable the patient perspective of the impact of this condition 
to be quantified. However, the instrument is long, and con- 
sequently may prove to be a burden on people with serious 
illness. The length may also limit its uses in conjunction with 
other instruments. The length may at least partly account for 
the relatively low response rates to this survey and to the high 
levels of missing data within dimensions of the SIS. That 
said, the response rates to this survey are in keeping with 
other general practice surveys in the United Kingdom.14,15 
However, the length of the SIS, and consequent patient bur- 
den, may account for the high level of missing data within 
dimensions of the measure. The SIS short form, however, has 
far less missing data.

The interpretation of multidimensional scales, such as the 
SIS, can be complicated, and consequently the potential value 
of summary scores cannot be underestimated. Higher-order 
factor analysis of the original 8 domains of the SIS was used 
here and supports the derivation of summary index for the 
SIS. This provides substantial evidence that the disease has 
an overall effect on health and well-being, at least in terms 
of the 8 dimensions measured by the SIS. Reliability of the 
summary measure was assessed using Cronbach α and found 
to be high, indicating that the index created by summing the 
8 dimensions is internally consistent and reproducible. The 
convergent validity of the measure was assessed by compar- 
ing the results of the index with those gained from a generic 
patient-reported outcome measure, the EQ-5D, and found to 
be highly correlated.

Table 2. Factor Loadings of SIS Dimensions (n=73) and 
Relevant SF-SIS Items (n=151)

<table>
<thead>
<tr>
<th>SIS Factors</th>
<th>Factor Loadings—SIS Dimensions</th>
<th>Factor Loadings—SIS Items</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strength</td>
<td>0.807</td>
<td>0.650</td>
</tr>
<tr>
<td>Hand function</td>
<td>0.894</td>
<td>0.709</td>
</tr>
<tr>
<td>Mobility</td>
<td>0.910</td>
<td>0.807</td>
</tr>
<tr>
<td>Memory</td>
<td>0.807</td>
<td>0.768</td>
</tr>
<tr>
<td>ADL</td>
<td>0.932</td>
<td>0.858</td>
</tr>
<tr>
<td>Communication</td>
<td>0.744</td>
<td>0.752</td>
</tr>
<tr>
<td>Emotion</td>
<td>0.703</td>
<td>0.730</td>
</tr>
<tr>
<td>Handicap</td>
<td>0.809</td>
<td>0.762</td>
</tr>
</tbody>
</table>

Factor loadings refer to the correlations between each variable (dimension or item) and the underlying unitary factor. ADL indicates activities of daily living; SIS, Stroke Impact Scale; and SF-SIS, short-form SIS.

Table 3. Items Selected for the SIS Short Form and Levels of Correlation (Spearman ρ) With the Dimension Total to Which They Contribute in the Original SIS (P<0.001)

<table>
<thead>
<tr>
<th>Item number</th>
<th>Item description</th>
<th>ρ</th>
</tr>
</thead>
<tbody>
<tr>
<td>Item 1c</td>
<td>In the past week, how would you rate the strength of your leg that was most affected by your stroke?</td>
<td>0.94</td>
</tr>
<tr>
<td>Item 7e</td>
<td>In the past 2 weeks, how difficult was it to use your hand that was most affected by your stroke, to pick up a coin?</td>
<td>0.94</td>
</tr>
<tr>
<td>Item 6f</td>
<td>In the past 2 weeks, how difficult was it to walk fast?</td>
<td>0.93</td>
</tr>
<tr>
<td>Item 2f</td>
<td>In the past week, how difficult was it for you to think quickly?</td>
<td>0.93</td>
</tr>
<tr>
<td>Item 5h</td>
<td>In the past 2 weeks, how difficult was it to do light household tasks/chores (eg, dust, make a bed, take out the rubbish, do the dishes)?</td>
<td>0.90</td>
</tr>
<tr>
<td>Item 4b</td>
<td>In the past week, how difficult was it to understand what was being said to you in a conversation?</td>
<td>0.92</td>
</tr>
<tr>
<td>Item 3d</td>
<td>In the past week, how often did you feel that you have nothing to look forward to?</td>
<td>0.77</td>
</tr>
<tr>
<td>Item 8b</td>
<td>During the past 4 weeks, how much of the time have you been limited in your social activities?</td>
<td>0.90</td>
</tr>
</tbody>
</table>

Item number refers to the position of the question in the original parent SIS. SIS indicates Stroke Impact Scale.
The success in creating a single index from the 8 domain SIS led to our search for a briefer tool that could be used to provide the index alone (ie, not designed to provide 8 dimension scores). To this end, the most strongly correlated item to each dimension total was extracted and summed to create an index. The new 8-item questionnaire is referred to in this study as the SF-SIS, and the single index as the SF-SIS Index.

The evidence of the data reported here indicates that the SF-SIS provides a very similar numeric indication of subjective severity of disease as that gained from the SIS parent form. The results for the single index were highly correlated when calculated from the original parent form and the short form. Furthermore, the brevity of the SF-SIS increases the likelihood that all items are completed. Predictably data completeness is far higher for the SF-SIS than for the SIS. Furthermore, the SF-SIS replicated the Physical Dimension score by summing just 4 items as compared with the summed 4 dimensions of the parent form SIS.

The SF-SIS seems a useful measure in studies where a short instrument providing a summary index of physical disability and an overall index of self-perceived health in stroke are required. A similar procedure has been used to create a Parkinson’s Disease Questionnaire short form (Parkinson’s Disease Questionnaire-8)\(^\text{[16]}\) from the 39-item parent measure (Parkinson’s Disease Questionnaire-39)\(^\text{[17]}\) and has gained widespread use.\(^\text{[18]}\) Results reported here suggest that the SF-SIS can reliably replicate scores from the parent form assessing Physical Disability and the Single Index summary score with considerable economy and reductions in patient burden. Further research in other contexts and other countries is needed to confirm the widespread application of the measure.

Acknowledgments
We thank the Primary Care Research Networks in London and the North-West of England, all the practice staff who helped with the recruitment of practices and patients, and all the patients who participated.

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Disclosures
None.

References
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