We set out to determine if rehabilitation variables predicted the motor and functional outcomes of stroke patients. Using the Modified Motor Assessment Scale (motor status) and the Barthel Index (functional status), we tested 50 stroke patients ≤3 days, 1 week, and 1 month after their stroke and at discharge from the hospital. Both measures are reliable and valid. We used the Spearman correlation coefficient (r) and stepwise regression analysis to analyze the data. Balanced sitting and bladder control scores at 1 week correlated significantly with motor score at discharge ($r=0.83$), Barthel Index score at discharge ($r=0.82$), and walking score at discharge ($r=0.80$). The combined arm score at 1 month correlated significantly with the combined arm score at discharge ($r=0.94$). Regression equations using the scores at 1 month produced the highest $r^2$ values (range 0.76–0.95) in predicting the Barthel Index, motor, walking, and arm recovery scores at discharge. The correlation coefficients and the regression equations have uses in both research and clinical settings. We suggest that these objective predictors of recovery be used as adjuncts in prioritizing and directing the rehabilitation management of patients with stroke. (Stroke 1990;21:78–81)
Subjects and Methods

We studied patients admitted to the Emergency Department of St. Boniface General Hospital with a diagnosis of stroke between July 1, 1984, and January 31, 1986. Stroke was defined as the sudden onset of a focal neurologic deficit(s) due to local disturbance in the blood supply to the brain. All patients with a probable diagnosis of stroke were reviewed by one of two medical staff members for admission to the study; the patients admitted were ≥18 years of age, were conscious at presentation (i.e., we excluded patients in deep coma and those with an altered level of consciousness and evidence of abnormal brainstem function indicating subarachnoid hemorrhage), did not require intensive care, had no previous stroke or transient ischemic attack, and were admitted no more than 4 days before admission. All patients in the study received a neurologic examination by one of the two medical staff members. Concurrently, ≤3 days after admission to the hospital, each patient was taken to a standardized assessment area and tested by one of two trained physiotherapists not involved with their care. Each patient was tested using the Modified Motor Assessment Scale (MMAS) and the Barthel Index. Testing was repeated 1 week and 1 month after admission and at discharge from the hospital (date discharged into the community or date decision was made for long-term care or nursing home placement).

The patients were managed on medical wards, rehabilitation wards, or both at St. Boniface General Hospital. All patients received physiotherapy, and all but two received occupational therapy. The therapy approach attempted to meet the individual needs of the patients, incorporating reeducation of movement, facilitatory techniques aimed at increasing patient independence, and patient/family education. Speech therapists and social workers were available for those patients requiring their services.

The MMAS measures motor recovery in stroke patients; the maximum score is 48. The eight areas assessed are movement from the supine position to side lying, movement from the supine position to sitting on the side of a bed, balanced sitting, movement from a sitting to a standing position, walking, upper arm function, hand movements, and advanced hand activities. The combined arm score was the sum of the scores on the last three components of the MMAS.

The Barthel Index measures independence in ADL; the maximum score is 100. The Barthel Index has been used frequently in stroke research; Granger et al found it to be reliable and consistent with other stroke evaluations. The 10 ADLs assessed are bowel control, bladder control, personal hygiene, toilet transfer, bathtub transfer, feeding, dressing, wheelchair transfer to and from bed, walking (wheelchair management if patient is nonambulatory), and ascending and descending stairs.

Both the MMAS and the Barthel Index have been tested for intertester and intratester reliability, as have the physiotherapists. The results are highly acceptable for both scales.

The Spearman correlation coefficient (r) was calculated for the MMAS components (sitting, movement from a sitting to a standing position, upper arm function, and combined arm score; for age; and for the Barthel Index components bowel control and bladder control obtained ≤3 days, 1 week, and 1 month after admission versus the Barthel Index score, the MMAS score, and the scores for the components walking, upper arm function, and combined arm score obtained at discharge. We used the Bonferroni adjustment to correct the significance levels for r, taking into account the number of variables correlated. Values ≥0.70 (p<0.0001) are reported. To derive equations that predict recovery, stepwise regression analysis of the same variables was performed.

Results

Fifty-seven patients met our inclusion criteria. Six patients (three men and three women) died during the study period, and we were unable to assess one patient at discharge. Therefore, r values and regression equations were calculated using the results for 50 patients. The mean±SD age at stroke onset was 68±10 (range 44-84) years. There were 28 men and 22 women, 26 with left hemiplegia and 24 with right hemiplegia. The cause of stroke was thrombotic in 43, hemorrhagic in six, and embolic in one patient. The mean±SD initial MMAS score was 16.7±12.8; the mean±SD initial Barthel Index score was 40.1±22.9. The mean±SD length of stay was 59±44 days. The initial and 1-week results were correlated for 50 patients and the 1-month and at-discharge results were correlated for 38 patients (12 patients were discharged <1 month after admission).

The r values for the assessment variables predicting MMAS score at discharge are given in Table 1. It was common for the 1-week results to correlate better than the initial results. The r values for the assessment variables predicting Barthel Index score at discharge are also given in Table 1. Interestingly, neither upper arm function nor combined arm score achieved an r of 0.70. Results at 1 week and 1 month varied in their ability to predict Barthel Index scores at discharge. Walking at discharge was assessed as a component of both the MMAS (scored as 0-6 inclusive) and the Barthel Index (scored as 0, 5, 10, or 15). The r values for both assessments are also shown in Table 1. Balanced sitting score combined with bowel control and bladder control scores or with only bladder control score at 1 week appeared to correlate best with walking at discharge.

The r values for upper arm function (scored as 0-6) and the combined arm score (three areas scored as 0-6 each) during rehabilitation as predictors of the scores at discharge are given in Table 2. The
results at 1 month correlated better than the initial results or those at 1 week.

The regression equations predicting four of the five stroke outcomes with the highest coefficient of determination \( r^2 \) are presented in Table 3. The best \( r^2 \) values for outcome equations using 1-week scores ranged from 0.62 to 0.83.

**Discussion**

We looked at results obtained not only at admission but also those obtained 1 week and 1 month after admission for their usefulness in predicting stroke outcome scores at discharge. Previous studies have looked at either admission (postonset) results only\(^4\) or at results upon admission to a rehabilitation center,\(^6\) where the time since stroke onset varies greatly. For all assessment variables, the 1-week scores correlated with outcome measures better than did the initial scores. Results on admission may not correlate as well as the 1-week results because the patient may be disoriented by being in a hospital instead of at home; the patient may be overwhelmed by the present situation and therefore may not respond to requests well, or the patient may have had a single case of urinary incontinence on admission that does not recur. The \( r \) value did not reach 0.70 between either upper arm function or combined arm score and Barthel Index score at discharge. In fact, the best correlation for these two assessment variables was 0.63 (1-month combined arm score vs. Barthel Index score at discharge). This validates the statement that stroke patients are able to achieve independence in ADL without a corresponding improvement in arm recovery; that is, the patients may compensate by performing ADLs with one-handed techniques. This finding strengthens the statement that to test the recovery of hemiplegia due to stroke we need assessments of motor recovery that test the return of motor function in the affected side. The arm function scores at discharge correlated reasonably well with the initial and 1-week arm function scores (Table 2), but the highest \( r (0.94) \) occurred with the 1-month score. Possibly, this suggests that little further significant recovery occurs in the hemiplegic arm later than 1 month after stroke onset. Wade et al\(^5\) assessed seven arm function activities in 55 patients \( \leq 3 \) weeks and after 6, 12, and 18 months after stroke onset and found significant recovery of arm function up to 3 months after onset; thereafter, the change was not significant.

The regression equations quantify correlation further by weighing the assessment variables by their relative importance in predicting stroke outcome. \( r^2 \) measures the extent to which changes in one variable can be explained by changes in another.\(^13\) As with the correlation results, equations using 1-week results had higher \( r^2 \) values than equations using initial results, and the regression equations using 1-month results had higher \( r^2 \) values than equations using 1-week results. It must be noted that the equations using 1-month results were calculated for the 38 patients requiring \( \geq 1 \) month of hospitalization and therefore are applicable only to patients in this category.

For the 1-month results, \( r^2 \) ranged from 0.76 to 0.95 (Table 3). Wade et al\(^14\) presented an equation for predicting 6-month Barthel Index score with an \( r^2 \) of 0.38; their equation included scores for urinary incontinence, motor deficit in the arm, sitting balance, hemianopsia, and age. In our study, the equation for Barthel Index score at discharge \((r^2=0.85)\) improved upon that equation, although their equation was for Barthel Index score at 6 months and ours was for Barthel Index score at discharge. Because discharge dates and length of stay are affected by social variables, we suggest that future studies predict recovery at set times after stroke, rather than at discharge.

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**Table 1. Predictors of Stroke Outcome by Spearman Correlation Coefficients**

<table>
<thead>
<tr>
<th>Assessment variables</th>
<th>MMAS score</th>
<th>Barthel Index score</th>
<th>Walking component</th>
<th>MMAS score</th>
<th>Barthel Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>Balanced sitting</td>
<td>Initial</td>
<td>0.70</td>
<td>NS</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1 week</td>
<td>0.81</td>
<td>0.72</td>
<td>0.71</td>
<td>NS</td>
</tr>
<tr>
<td></td>
<td>1 month</td>
<td>0.74</td>
<td>0.72</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>Sitting to standing position</td>
<td>Initial</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1 week</td>
<td>0.75</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td></td>
<td>1 month</td>
<td>0.77</td>
<td>0.77</td>
<td>0.71</td>
<td>NS</td>
</tr>
<tr>
<td>Combined arm score</td>
<td>Initial</td>
<td>0.80</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td></td>
<td>1 week</td>
<td>0.80</td>
<td>0.81</td>
<td>0.74</td>
<td>0.81</td>
</tr>
<tr>
<td></td>
<td>1 month</td>
<td>0.90</td>
<td>0.87</td>
<td>0.81</td>
<td>NS</td>
</tr>
<tr>
<td>Balanced sitting, bowel control, bladder control</td>
<td>Initial</td>
<td>0.78</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td></td>
<td>1 week</td>
<td>0.83</td>
<td>0.82</td>
<td>0.74</td>
<td>0.80</td>
</tr>
<tr>
<td></td>
<td>1 month</td>
<td>0.78</td>
<td>0.77</td>
<td>NS</td>
<td>NS</td>
</tr>
</tbody>
</table>

MMAS, Modified Motor Assessment Scale; \( NS=r<0.70; p<0.0001. \)

**Table 2. Predictors of Stroke Outcome (Arm Function) by Spearman Correlation Coefficients**

<table>
<thead>
<tr>
<th>Assessment variable</th>
<th>Upper arm function</th>
<th>Combined arm score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial</td>
<td>0.70</td>
<td>NS</td>
</tr>
<tr>
<td>1 week</td>
<td>0.84</td>
<td>0.81</td>
</tr>
<tr>
<td>1 month</td>
<td>0.91</td>
<td>0.87</td>
</tr>
<tr>
<td>Combined arm score</td>
<td>1 week</td>
<td>NS</td>
</tr>
<tr>
<td></td>
<td>1 month</td>
<td>NS</td>
</tr>
</tbody>
</table>

\( NS=r<0.70; p<0.0001. \)
The equation with the greatest $r^2$ predicted combined arm score at discharge from the 1-month results. Wade et al also used regression analysis to study arm recovery after stroke and found the most important variable for predicting arm function at 12 months was the degree of initial motor deficit in the arm tested ≤3 weeks after onset. We suggest that this information has potential applications in stroke rehabilitation regarding planning and prioritizing treatment programs.

It is important to point out the limitations to these equations; they are the product of analyses of results from a defined group of stroke patients. Therefore, the equations should be used only with patients who meet the criteria of our study and are not applicable to the total stroke population. The assessments that we used for testing our patients are objective and have demonstrated both interrater and intrarater reliability; therefore, this cause for error in the results has been minimized. Also, our results should be validated in another group of similar patients at another center to improve the confidence in our predictor equations.

The correlations and equations outlined here have uses in both the clinical and research realms of rehabilitation. Clinically, this objective method of predicting stroke outcome could be used as an adjunct in prioritizing and directing the focus of rehabilitation of such patients. Also, the assessments measure the patient’s present status and the equations predict the patient’s future status. The results can be used by therapists working with individual patients to set appropriate goals regarding motor, functional, walking, and arm recovery and can help the patient and family to realistically plan for the future. From a research perspective, the results predict outcome based on objective testing. These predicted outcomes can be compared with actual outcomes of patients treated with a new regimen to evaluate the efficacy of a new treatment protocol.

### References
7. Ad Hoc Committee of the National Institute of Neurological and Communicative Disorders and Stroke: A classification and outline of cerebrovascular diseases II. *Stroke* 1975;6:565–566

**Acknowledgment**

We wish to acknowledge Mary Cheang, MMath (Stat), statistical consultant, University of Manitoba, for performing the statistical analysis involved in this study.

**Table 3. Regression Equations Predicting Stroke Outcome (At-Discharge Scores)**

<table>
<thead>
<tr>
<th>Equation</th>
<th>$r^2$ (1 month)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MMAS score = 21.9 - 0.23 (age) + 2.15 (balanced sitting score) + 1.6 (combined arm score)</td>
<td>0.85</td>
</tr>
<tr>
<td>BI score = 62.8 - 0.68 (age) + 2.97 (balanced sitting score) + 1.44 (combined arm score) + 4.08 (bowel control score)</td>
<td>0.85</td>
</tr>
<tr>
<td>Walking (BI) score = 0.38 + 0.78 (balanced sitting + walking [MMAS] + bowel control scores)</td>
<td>0.76</td>
</tr>
<tr>
<td>Combined arm score = 0.63 + 1.02 (combined arm score)</td>
<td>0.95</td>
</tr>
</tbody>
</table>

MMAS, Modified Motor Assessment Scale; BI, Barthel Index.

**Key Words**
- cerebrovascular disorders
- rehabilitation
- stroke outcome
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S C Loewen and B A Anderson

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