Attainment of maximal functional capacity and subsequent improved quality of life are important in stroke rehabilitation. However, with limited numbers of beds and increasing costs, it is also important to apply available resources to patients who are likely to obtain the most benefit from comprehensive inpatient rehabilitation. Since individual rates of rehabilitation efficiency and effectiveness vary considerably, the selection of inpatients is important, as is the provision for rehabilitation-related community- or hospital-based welfare services for those unlikely to benefit from inpatient care.

While the general principle of triage operates to select a 'middle-band' of patients for rehabilitation, the proportion of stroke patients who receive comprehensive inpatient rehabilitation varies greatly. Australia has one of the highest rates, with 43% being referred for inpatient rehabilitation, compared with 19% in The Netherlands, 14% at the Mayo Clinic, and 21% in other medical centers in the United States.

Due to methodologic flaws, there is considerable disagreement among the studies that have examined improvement in functional status, function on discharge, and variables predicting outcome measures. Only a few studies have examined the efficiency of rehabilitation gains or the effectiveness of achieving rehabilitation potential. This prospective, multicenter, methodologically sound study examines these factors, as well as the duration of rehabilitation stay, using a population of all patients with a first stroke referred for comprehensive inpatient rehabilitation in Brisbane, Australia.

Subjects and Methods

We used a prospective pretest–posttest study design for patients with first stroke referred for comprehensive inpatient rehabilitation during 1984. Stroke was defined as rapidly developing clinical manifestation of a focal loss of cerebral function lasting >24 hours or leading to death within 24 hours. For 52% of the patients the diagnosis of stroke was based on neuroradiologic investigations and for the other 48%, on the clinical impression of the consulting physician and neurologist. Comprehensive inpatient rehabilitation was defined as the combined and coordinated use of a physical therapist, an occupational therapist, and a rehabilitation nurse in a multidisciplinary team, with the services of speech therapists, social workers, and psychologists available as required. The patients were primarily drawn from the population residing in Brisbane, Australia, which numbered slightly over 1 million in 1984. All seven public hospitals and the four private hospitals in Brisbane that admitted stroke patients participated in our study.
In 1984, 2,676 patients were admitted with a provisional diagnosis of cerebrovascular disease (International Classification of Diseases [ICD] codes 430–437). Of these, 2,676 patients, 1,342 had a diagnosis of stroke (ICD codes 431, 434, 436, or 437). Of the 1,342 stroke patients, 265 (20%) died within the first 2 weeks, 98 (7%) with persistent altered consciousness state were transferred directly to extended-care facilities, and 359 (27%) who were independent in the activities of daily living (ADL) were sent directly home. To minimize potential confounding, we did not consider the 68 stroke patients (5%) with neurosurgical intervention or the 291 patients (22%) with a second or multiple stroke.

There remained 261 patients (19%) who survived their first stroke in 1984 and were referred for comprehensive inpatient rehabilitation following their discharge from acute-care hospitals. The time from stroke onset to rehabilitation commencement ranged from 1 to 79 (mean±SD 17±14.2, median 13) days. Patients were assessed both on admission to and on discharge from rehabilitation. Three patients died during rehabilitation, leaving 258 patients, the total population of survivors of first stroke who underwent comprehensive inpatient rehabilitation during 1984. The patients were discharged from rehabilitation when the multidisciplinary team considered that they had achieved their maximum benefit. Rehabilitation stay ranged from 6 to 276 (mean±SD 61±45.1, median 49) days.

Functional recovery was measured as improvement in the ability to perform ADL and was scored according to the Barthel Index. Neurologic recovery was measured using the Brunnstrom motor recovery scales. A small modification of the Barthel Index was incorporated to improve its sensitivity to small increments. The Barthel Index measures functional independence at one point in time, and the change in Barthel Index score from rehabilitation commencement to discharge can be calculated as one measure of functional improvement. Rehabilitation efficiency is the amount of improvement divided by the duration of rehabilitation stay and can be regarded as the average increase in Barthel Index score per day: rehabilitation efficiency=(discharge Barthel Index score−initial Barthel Index score)/duration of rehabilitation stay. Since the potential improvement for patients with high initial scores is lower than that for those with low initial scores, another way to measure functional improvement is achievement of potential improvement. This is expressed as actual improvement divided by potential improvement, a percentage reflecting the proportion of potential improvement actually achieved during rehabilitation: achievement of rehabilitation potential=(discharge Barthel Index score−initial Barthel Index score)/(100−initial Barthel Index score)×100%. Duration of rehabilitation stay, measured in days, is the time from rehabilitation commencement to discharge, not the time from stroke onset or admission to the acute-care hospital.

We analyzed rehabilitation efficiency, achievement of rehabilitation potential, and duration of rehabilitation stay (each measured as a ratio) as the dependent variables and all medical, rehabilitative, demographic, and attribute variables available at rehabilitation commencement as independent variables. The data were coded and entered into a DEC-10 mainframe computer using the 1022 database system. Analysis was performed using SPSS-X on a VAX 8550 mainframe computer. We obtained both descriptive statistics and initial correlations, and we performed statistical analysis using one-way and multi-way analysis of variance (ANOVA) and stepwise regression (forward selection).

### Results

We excluded data from two patients because their initial Barthel Index scores of 100 prevented our calculating values for achievement of rehabilitation potential and gave nonsensical values for rehabilitation efficiency.

Descriptive statistics for the ordinal/interval variables are presented in Table 1, Table 2 details the frequencies of the attribute variables, and Table 3 presents the results of one-way ANOVAs between the nominal variables and the three dependent variables. Marital status was significantly related to the achievement of rehabilitation potential (p<0.05). Side of paralysis had a significant bearing on rehabilitation efficiency (p<0.05) and achievement of rehabilitation potential (p<0.01). Site of the lesion showed a significant association with duration of reha-
TABLE 2. Attribute Variables Considered in Predicting Rehabilitation Outcome in 256 Patients With First Stroke

<table>
<thead>
<tr>
<th>Variable</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male sex</td>
<td>56</td>
</tr>
<tr>
<td>Ethnicity</td>
<td>16</td>
</tr>
<tr>
<td>Visual confrontation affected</td>
<td>61</td>
</tr>
<tr>
<td>Hypertension</td>
<td>70</td>
</tr>
<tr>
<td>Myocardial infarction</td>
<td>29</td>
</tr>
<tr>
<td>Other ischemic diseases</td>
<td>29</td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td>16</td>
</tr>
<tr>
<td>Congestive cardiac failure</td>
<td>14</td>
</tr>
<tr>
<td>Peripheral vascular disease</td>
<td>8</td>
</tr>
<tr>
<td>Fractured femur</td>
<td>4</td>
</tr>
<tr>
<td>Other associated illness*</td>
<td>55</td>
</tr>
</tbody>
</table>

*Includes any other medical condition not itemized, none of which have individual frequency of >4%.

The relation between initial and discharge Barthel Index scores is not linear due to the maximum discharge score of 100. Patients with high initial scores cannot improve beyond this boundary, so the ratio of improvement relative to the initial score diminishes. Furthermore, patients with very low initial scores tend not to improve greatly, whereas those exhibiting the most improvement appear to be the patients with initial scores of 40–80.12,13

Discussion

The major finding of our study is that all three dependent variables are poorly predicted, with only 17% of the variance in rehabilitation efficiency, only 30% of the variance in achievement of rehabilitation potential, and only 22% of the variance in duration of rehabilitation stay being explained (Table 5). Other research into these dependent variables reveals equally poor, or even worse, prediction,2,15,16 which indicates that there is a lot of unexplained variance that cannot be attributed to the independent variables considered by this and other studies. It is possible that further research into medical, rehabilitation, and demographic factors not considered by this study may explain additional variance. However, unlike many other studies, ours is comprehensive in its determination of important independent variables.1–3,8,10,13 It is therefore likely that the unexplained variance is due to social, personal, and family factors that are unrelated to the rehabilitation process and that affect the decision to refer patients to rehabilitation, especially in a free hospital system.

In Australia, any member of the medical team can recommend rehabilitation referral, in contrast to other countries in which recommendation for rehabilitation is the domain of physiatrists. In Australia,
the allocation of funding to rehabilitation units on a patient-day basis makes it in the interests of the units not to refuse referrals. Consequently, Australia has one of the highest comprehensive inpatient rehabilitation rates in the world (43%), more than double that in other Western countries.5-9 The mass referral to and extended duration of comprehensive inpatient rehabilitation are constraints on the development of more appropriate health care facilities and overburden the available rehabilitation and nursing services.

The objective of comprehensive inpatient rehabilitation implicit in our research is that rehabilitation should attempt to provide the maximum functional and neurologic recovery for all individuals indepen-
dent of nonmedical factors such as ethnicity, family support, and architectural barriers. However, medical factors, especially level of impairment, age, and associated illnesses, as shown by this and other research, limit the expected outcome and rehabilitation success. While nonmedical and/or social factors do contribute to discharge disposition decision, referral to comprehensive inpatient rehabilitation should not be influenced by these factors. These unmeasured and often unmeasurable social factors reduce the ability of a regression equation to explain a large proportion of the variance in each dependent variable. However, the equations still serve to identify the independent variables that are significant in predicting rehabilitation efficiency, achievement of rehabilitation potential, or duration of rehabilitation stay. The large proportion of unexplained variance due to confounding variables could mask the potential impact of other variables, and analysis of data from another population in which the impact of these confounding variables is less may produce different results.

Of the considered independent variables (Tables 1, 2, and 3), the only four significant predictors of rehabilitation efficiency are age, Brunnstrom arm recovery level, initial Barthel Index score, and initial Barthel Index score squared (Table 5). Each 10 years of age reduces the rehabilitation efficiency (daily increase in Barthel Index score) by 0.1 unit. Since the average rehabilitation stay is 61 days, this amounts to 6 units during rehabilitation. However, older people are likely to have shorter stays, with each additional 10 years of age reducing the duration of rehabilitation stay by 7 days. The Brunnstrom arm recovery scale comprises six levels. The greater the initial level (degree of arm control), the higher the rehabilitation efficiency, with each higher level increasing efficiency by 0.19 units. A quadratic term was required to model the effect of the initial Barthel Index score. Therefore, it is not possible to state the linear increment in rehabilitation efficiency due to changes in initial score. Since the increment varies with the initial score, the effect must be calculated for each individual score.

Six variables significantly contributed to the prediction of achievement of rehabilitation potential. Each 10 years of age reduced the achieved potential by 9%. Every day’s delay from stroke onset to admission to the acute-care hospital reduced the achieved potential by almost 0.5%, and each day’s delay from admission to rehabilitation commencement reduced it by 0.64%. Each level in the Brunnstrom arm recovery scale was worth 7%, with the presence of myocardial infarction reducing achieved potential by 10%. Bladder control, an item in the Barthel Index and measured in this study on a 5-point scale, also contributed to the prediction, with full bladder control (score of 10 points) increasing achieved potential by 12% compared with a similar patient with no bladder control (score of 0).

Five items significantly predicted the duration of rehabilitation stay. Each additional 10 years of age reduced the stay by 7 days. This unexpected finding is related to the fact that older people make fewer rehabilitation gains, so that the benefit from prolonged rehabilitation is less. Older people are also more likely to be recommended for rehabilitation on the basis of nonmedical and nonrehabilitation reasons. The initial Barthel Index score was linearly related to the duration of rehabilitation stay, with every additional point reducing the stay by 1 day. Bladder control significantly predicted length of stay; a patient with full bladder control stays 25 days longer than a similar individual with no bladder control. Patients with limited bladder control are also likely to have low initial Barthel Index scores and low achievement of rehabilitation potential. Their rehabilitation stays are brief because their small gains are made in a relatively short time, and they are likely to benefit little from further rehabilitation. Such patients are often discharged to partial or full care. The presence of peripheral vascular disease and associated complications affected 8% of the study population (Table 2) and increased rehabilitation stay by 22 days due to the increased effort required for maximum benefit to be obtained. The reverse was true for patients with insulin-dependent diabetes.

These results differ considerably from those of other studies. Nevertheless, identification of variables significant in the prediction of rehabilitation efficiency, achievement of rehabilitation potential, and duration of rehabilitation stay are of paramount importance in promoting the efficient use of existing resources and in developing alternative strategies to maximize quality of life for all stroke patients.

References


Key Words • cerebrovascular disorders • rehabilitation • Australia
Efficiency, effectiveness, and duration of stroke rehabilitation.
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