EXECUTIVE SUMMARY
At the Halvar Jonson Centre for Brain Injury in Ponoka, Alberta data reflecting patient performance profile at intake and discharge have been collected in various formats since the inception of this slow stream rehabilitation centre for moderate to severe brain injury. The goal of this study was to generate a statistical predictive model using the patient records to forecast the likely outcome of a patient's rehabilitation through the Halvar Jonson Centre, given their present profile of strengths and challenges. The performance measures, Functional Independence Measures (FIM™) and Functional Assessment Measures (FAM) are evaluated at intake and discharge from the Halvar Jonson Centre.

These measures were combined to form eight more global outcome variables. Using these global outcome variables, prediction equations were developed to forecast how well a patient would do at discharge from our facility based upon their performance at intake. These predictions are to be used to counsel patients and their families as to expectations following rehabilitation at the Halvar Jonson Centre and to assist in discussions with patients and their families about discharge planning.

RESEARCH OVERVIEW

Objective(s)
The objective of this study was to develop a predictive model that will forecast the likely outcome of a patient’s rehabilitation through the Halvar Jonson Centre, given their present profile of strengths and challenges.

Background
The Halvar Jonson Centre for Brain Injury (HJCBI) is a residential rehabilitation facility for patients who are slow to recover after having sustained moderate to severe head injuries or strokes. Patient stays typically range from 6-18 months. While ample anecdotal information exists to relay to prospective patients and their families regarding improvements others have made, there is no evidence based quantitative information that can predict patient performance at time of discharge from our facility. Outcome measures from patients admitted to HJCBI have been collected since its inception in 1994. Gray and Burnham (2000) evaluated expected total Functional Independence Measures (FIM™) plus Functional Assessment Measures (FAM) gains in this program up to and including 1999, but did not look at the change expected in individual areas of function. As such, it has not been evaluated to assess the typical benefits that can be expected based upon each individual patient’s initial profile of strengths and challenges. This type of slow to recover rehabilitation for moderate to severe brain injuries is unusual and similar programs tend to treat small numbers of clients. Thus, there is little quantitative information available in the literature to illustrate the benefits of such a program. It is desirable to have information to relay to patient admission coordinators as well as to patients and their families, to assist them in making the decision of whether admission to the Halvar Jonson Centre would be beneficial. Furthermore, discharge planning needs to be started at the time of admission. A prediction of the functional level of the patient that is likely at the end of rehabilitation can assist in this process. An additional benefit would be a contribution to the literature illustrating outcomes from rehabilitation for this slow to recover client population.
**Approach and Methods**

Retrospective patient records encompassing performance at intake, discharge, and at 3 month intervals have been collected in a number of data files and in various formats since the inception of HJCBI. Patient functional performance measures are collected by all members of the treatment team which encompasses physiotherapists, occupational therapists, psychologists, speech-language pathologists, dysphagia therapists, recreational therapists, education specialists, nurses, and social workers. Records on all 1,030 patients admitted to the program between January 1994 and June 2012 were amalgamated in a single database and completed by filling in missing information from the original patient charts. This original database is stored on a secure Alberta Health Services system with access restricted as per their guidelines consistent with the practice for all of their records. A second data file was then created with all patient identifying information removed.

The performance measures were assessed for their distributional properties. The outcome measures, FIM (Keith, Granger, Hamilton, & Sherwin, 1987) and FAM (Hall, Hamilton, Gordon, & Zasler, 1993) are a series of 30, 7-point Likert scale variables that cover six areas of function: self-care, sphincter control, mobility, locomotion, communication, and social cognition. The score for each variable indicates the amount of assistance required to perform each skill with ‘1’ indicating ‘total assistance’ required and ‘7’ indicating ‘total independence’. These functional measures are evaluated at intake and discharge from the Halvar Jonson Centre as well as at regular intermediate intervals.

Most parametric statistical analyses require that the outcome measures be continuous random variables. This is not true of Likert scale variables (especially with small numbers of categories) which are ordinal, but not rational. One way of dealing with these ordinal variables is to combine them to produce a variable that approximates a continuous random variable. General statistical wisdom maintains that “a nine-point Likert is continuous for all intents and purposes” (Fahey, 2011). To this end, a selection of the FIM/FAM items were combined to form eight outcome variables as follows:

1. **Eating** combines ‘Feeding’ and ‘Swallowing’ measures;
2. **Self-Care** combines ‘Grooming’, ‘Dressing Upper Body’ and ‘Dressing Lower Body’, as well as ‘Toileting’;
3. **Sphincter** combines both ‘bladder management’ and ‘bowel management’;
4. **Transfers** combine ‘Bed to chair/wheelchair transfer’, ‘Tub or Shower transfer’, and ‘Toilet transfer’;
5. **Locomotion** combines ‘Walking/Wheelchair mobility’ and ‘Stair mobility’;
6. **Verbal Communication** combines ‘auditory comprehension’ and ‘verbal expression’;
7. **Written Communication** combines ‘reading’ and ‘writing’;

As each of these aggregate variables is formed by 2 or more 7 point Likert-scale variables, the new resultant variables are also Likert, but with a minimum of 13 levels. Using these aggregate outcome variables, prediction equations were developed to forecast how well a patient would do at discharge from our facility based upon their performance at intake.

Multiple predictive models were considered. In all cases the dependent variables were the 8 aggregate variables described above measured at time of discharge from the Halvar Jonson Centre. Gray and Burnham (2000) found that age at admission, functional status at admission and time from injury to admission and length of stay all correlated with functional improvement as measured by total FIM/FAM change. As length of stay information is unavailable at time of admission, it could not be included in the predictive model, but all other variables were included. In addition, etiology expressed as stroke vs. acquired brain injury (ABI) was also considered. Initial predictive models generated quantified functional status at admission in terms of the 8 aggregate variables described above. As the predictive models were refined, the aggregate variables were parsed into their constituent 7 point FIM/FAM variables; if encoded correctly, it is unnecessary for the dependent variables to be continuous. It was important that the prediction equations be intrinsically logical. To this end, some categories were merged so that the equations were monotone increasing with increasing FIM/FAM
score when this was deemed to be appropriate.

**Key Findings**

**Regression Analysis**

Age, time from injury to admission and functional performance at time of admission all accounted for variation in level of functioning at time of discharge. As such, these were included in every model. There was no significant difference in the discharge functional performance for stroke vs. ABI, once these covariates are accounted for. These findings are consistent with Gray and Burnham’s findings (2000). In all cases, expected gain in functional performance decreases with increasing age and with increasing days to admission. The latter statistics would be related to both severity and rate of recovery. While these decreases with time are statistically highly significant, the decrease is only a fraction of a FIM/FAM point per decade and per year respectively.

The specific functional performance measures at admission, which explained significant variation in functional performance at discharge varied greatly for each of the 8 aggregate variables. These performance measures are enumerated below:

**Eating**

This aggregate variable is explained by the aggregate variables of *Eating* and *Self-Care* at admission. When each are broken down into their constituent FIM/FAM variables, the ability to self ‘Feed’, ‘Swallow’, ‘Groom’ and do ‘Upper Body Dressing’ are all predictive of *Eating* at discharge. The predictive equation with these variables along with the covariates of age and time from injury to admission explains 45% of the variation in this variable (adjusted $R^2$). *Eating* ranges from 2 to 14 and the standard error of the estimate from the equation is ±2.4 FIM/ FAM points.

**Self-Care**

This aggregate variable is explained by the aggregate variables of *Eating*, *Self-Care*, *Sphincter*, *Transfers*, and *Locomotion*. When each is broken down into their constituent FIM/FAM variables, the scores for ‘Feeding’, ‘Grooming’, ‘Upper Body Dressing’, ‘Bed Transfer’ and ‘Tub/Shower Transfer’ each are significant predictors of *Self-Care* at discharge. The predictive equation with these variables along with the covariates of age and time from injury to admission explains 54% of the variation in this variable (adjusted $R^2$). Interestingly, the ability to do ‘Lower Body Dressing’ and ‘Toileting’ care at admission are not significant predictors of ability to perform *Self-Care* at discharge. *Self-Care* ranges from 4 to 28 and the standard error of the estimate from the equation is ±6.7 FIM/FAM points.

**Sphincter**

This aggregate variable is predicted by the aggregate variables of *Sphincter* and *Self-Care* at intake. When these are parsed into their constituent FIM/FAM variables, both ‘Bowel Management’ and ‘Bladder Management’ at admission are significant predictors, however of the *Self-Care* FIM/FAM variables, only ‘Upper Body Dressing’ and ‘Toilet’ are significant predictors of *Sphincter* control at discharge. In the case of *Sphincter* control the prediction equation with these variables along with the covariates of age and time from injury to admission accounts for only 33-35% of the variation in contrast with 45-54% for the other aggregate variables. It is possible that there is significantly reduced variation at discharge, in that many patients arecontinent, and the reasons for poor continence are often associated with sensation which is a domain not adequately captured by the FIM/ FAM scale. *Sphincter* ranges from 2 to 14 and the standard error of the estimate from the equation is ±3.6 FIM/FAM points.

**Transfers**

This aggregate variable is predicted by the aggregate measures of *Transfers*, *Self-Care* and *Eating*. When each was broken down into their constituent FIM/FAM variables, the ability to independently do ‘Grooming’ and ‘Upper Body Dressing’ as well as perform ‘Bed Transfer’, ‘Toilet Transfer’ and ‘Tub/Shower Transfer’ are all significant predictors of *Transfers* skill at discharge. The predictive equation with these variables along with the covariates of age and time from injury to admission explains 51% of the variation in this variable (adjusted $R^2$). When the FIM/FAM variables are entered into the model sequentially, neither of the variables which constitute *Eating* are significant predictors.
Transfers ranges from 3 to 21 and the standard error of the estimate from the equation is ±4.2 FIM/FAM points.

Locomotion
This aggregate variable is significantly explained by the aggregate measures of Locomotion, Transfers and Eating as measured at admission. When each was broken down into their constituent FIM/FAM variables, then Locomotion variables of independent mobility by ‘Walking/ Wheelchair’ and ability to do ‘Stairs’ as well as the skills of independence with ‘Feeding’, ‘Bed transfer’ and ‘Tub/Shower transfer’, are all significant predictors of Locomotion ability at discharge. The predictive equation with these variables along with the covariates of age and time from injury to admission explains 50% of the variation in this variable (adjusted R²). Locomotion ranges from 2 to 14 and the standard error of the estimate from the equation is ±2.5 FIM/ FAM points.

Verbal Communication
This aggregate variable is significantly predicted by the Verbal Communication at admission or, when broken down into FIM/FAM variables, by ‘Auditory Comprehension’ and ‘Verbal Expression’ at time of admission. No other domains are predictive of progress with Verbal Communication. The predictive equation with these variables along with the covariates of age and time from injury to admission explains 46% of the variation in this variable (adjusted R²). Verbal Communication ranges from 2 to 14 and the standard error of the estimate from the equation is ±2.0 FIM/ FAM points.

Written Communication
This aggregate variable is predicted by the aggregate variables of Written Communication and Verbal Communication upon intake. When these are parsed into their constituent FIM/FAM variables, as expected, both ‘Reading’ and ‘Writing’ ability are significant predictors, but while ‘Verbal Expression’ is a significant predictor, ‘Auditory Comprehension’ is not. The predictive equation with these variables along with the covariates of age and time from injury to admission explains 47% of the variation in this variable (adjusted R²). Written Communication ranges from 2 to 14 and the standard error of the estimate from the equation is ±2.0 FIM/ FAM points.

Cognition
This aggregate variable combines ‘Problem Solving’, ‘Memory’, ‘Attention’ and ‘Orientation’ is significantly predicted by the aggregate variables of Cognition and Sphincter at time of admission. Interestingly, when these are broken down into their constituent FIM/FAM variables, cognition is best predicted by ‘Memory’, ‘Orientation’ and ‘Attention’ at time of admission as well as if the patient is total continent for ‘Bladder Management’ (level 7) or not (levels 1-6). The predictive equation with these variables along with the covariates of age and time from injury to admission explains 49% of the variation in this variable (adjusted R²). Neither problem solving ability at time of admission nor between the other levels of bladder management (levels 1-6) were not statistically different, and were not a significant predictor of Cognition at time of discharge. Cognition ranges from 4 to 28 and the standard error of the estimate from the equation is ±4.6 FIM/ FAM points.

Conclusions
The regression equations that were developed form a clear basis for prediction of patient improvement following a course of rehabilitation at HJCBI. They are unusual in that they look at recovery in specific domains rather than total change in FIM/FAM measures. This allows recovery to be described in a much more concrete manner. The equations and the standard error of the estimates highlight both the predicted level of improvement and the variation in that prediction that is unexplained and unforeseen at time of admission. Both of these factors are important information for patients and their families.

Implications for Policy or Practice
The possible changes for practice fall into two major areas. The first will be in how expected functional performance at time of discharge is discussed with patients and families. At the time of admission, it is typical for patients and family members to expect a full recovery to pre-injury/ pre-stroke functioning. This
method of looking at expected functional change and the variation in that change will form a quantitative basis for a discussion that will hopefully realign expectations. This will happen fully only once the final step in this research project is completed (see directions for further research).

The second implication was not considered at the initiation of this research project. Patients have recently been streamed according to etiology: stroke vs. acquired brain injury. The results of this analysis would suggest that it might be more appropriate to stream patients according to initial severity rather than etiology.

**DIRECTIONS FOR FURTHER RESEARCH**

Staffing levels did not allow for completion of this entire project in the time frame originally foreseen. The final step in the project remains to be completed. This will be to liaise with our project partners, primary patient referral sources, on the best way to inform patients and their families what they might expect to gain from an admission to the HJCBI. The challenge will be to communicate the typical results achieved by patients with similar performance profile as the patient in question, while at the same time recognizing that every patient is different and variation around that, both exceeding and failing to meet average expectations, is inevitable. Thus, it will be necessary not only to communicate the typical performance of similar patients, but also the range of performance outcomes that might be representative. The predictive equations that have been developed will form the basis for this work. Contingent upon restoration of staffing levels, it is hoped that this part of the project will be completed by the end of the year.

Upon completion, the predictive equations will also be made available to facility clinicians, so that they can evaluate their practice efficiency and compare it to the norm for the facility. The equations and methodology will be provided to other facilities using similar functional outcome measures so that they too can evaluate their relative effectiveness. Finally the outcomes will also validate the effectiveness of rehabilitation for these slow to recover patients.

**KNOWLEDGE DISSEMINATION AND TRANSLATION ACTIVITIES**

Most of the information gained from this study will be disseminated after the final stage (see ‘Directions for further research’).

1. **Prospective patients, people with stroke or acquired brain injury, their families or guardians:**
   Prospective patients and their families are generally referred for rehabilitation by other healthcare providers. These healthcare providers are usually those who are working in acute care or in acute rehabilitation and they will be one of the main vectors for the information gathered in this study to be disseminated to this target group. This information will be reiterated by physicians when they assess the patient for admission suitability and discuss admission with the patients and their families prior to approval.

2. **Primary referral sources that provide information to the above individuals:**
   The information generated by the final stage of this study is designed foremost to be a tool to be provided to this target group. Our current primary referral sources have been identified and it is they who have been recruited as team partners to help us design the presentation of the information based upon this prediction tool. The dissemination of information to this group will be a dynamic one, as they provide information to us concerning their needs and we adapt the information we have to a form that is useful to them. Once developed, it will be provided to new referral agencies and organizations as they are identified or as they present themselves.

3. **Healthcare providers assessing client suitability for admission:**
   Client admission to the Halvar Jonson Centre for Brain Injury is performed by an admissions committee who decide on the suitability of clients for admission based on criteria ranging from client suitability to facility resources. This tool will give them another resource to assist in prioritizing clients based upon their potential to benefit from admission.
4. Clinicians reviewing their own practice efficacy and other rehabilitation facilities using similar functional outcome measures:

Clinicians in the Halvar Jonson Centre will be presented with the prediction tool, both in equation form and as it is designed to be presented as a tool for primary referral sources in a similar fashion to those coordinating admissions. It will also be available to administrators who may wish to use it as a baseline against which to compare future outcomes of the facility. For those clinicians working outside of the facility, the information will be made available through publication and presentation at relevant professional conferences.

**Principal Applicant (Team Leader)**

<table>
<thead>
<tr>
<th>Name</th>
<th>Position Title</th>
<th>Topics of interest</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alanna Kerr, MSc., R.SLP</td>
<td>Speech Language Pathologist</td>
<td>Outcome Measures for Rehabilitation,</td>
</tr>
<tr>
<td></td>
<td>Halvar Jonson Centre for Brain Injury</td>
<td>Speech-Language and Dysphagia</td>
</tr>
<tr>
<td></td>
<td>Centennial Centre for Mental Health</td>
<td>Rehabilitation after Stroke and</td>
</tr>
<tr>
<td></td>
<td>and Brain Injury</td>
<td>Acquired Brain Injury</td>
</tr>
<tr>
<td></td>
<td>Ponoka, Alberta</td>
<td></td>
</tr>
<tr>
<td>Russell Hemingson</td>
<td>Unit Manager</td>
<td>Chair Outcome Measures Committee</td>
</tr>
<tr>
<td></td>
<td>Halvar Jonson Centre for Brain Injury</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Centennial Centre for Mental Health</td>
<td></td>
</tr>
<tr>
<td></td>
<td>and Brain Injury</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ponoka, Alberta</td>
<td></td>
</tr>
</tbody>
</table>

**Project Partners (Team Members)**

<table>
<thead>
<tr>
<th>Name</th>
<th>Position Title</th>
<th>Role</th>
</tr>
</thead>
<tbody>
<tr>
<td>Douglas Gross Ph.D.</td>
<td>Associate Professor</td>
<td>Coordinator Analytical Support</td>
</tr>
<tr>
<td></td>
<td>Department of Physical Therapy</td>
<td>Rehabilitation Research Centre</td>
</tr>
<tr>
<td></td>
<td>Faculty of Rehabilitation Medicine</td>
<td>University of Alberta</td>
</tr>
<tr>
<td></td>
<td>University of Alberta</td>
<td></td>
</tr>
<tr>
<td>Mary Roduta Roberts, Ph.D.</td>
<td>Assistant Professor</td>
<td>Analytical Support</td>
</tr>
<tr>
<td></td>
<td>Department of Occupational Therapy</td>
<td>Rehabilitation Research Centre</td>
</tr>
<tr>
<td></td>
<td>Faculty of Rehabilitation Medicine</td>
<td>University of Alberta</td>
</tr>
<tr>
<td></td>
<td>University of Alberta</td>
<td></td>
</tr>
</tbody>
</table>

**About the Alberta Addiction and Mental Health Research Partnership Program**

The *Alberta Addiction and Mental Health Research Partnership Program* is comprised of a broad-based multi-sectoral group, representing service providers, academic researchers, policy-makers and consumer groups, working together to improve the coordination and implementation of practice-based addiction and mental health research in Alberta.

The mission of the Research Partnership Program is to improve addiction and mental health outcomes for Albertans along identified research priority themes, by generating evidence and expediting its transfer into addiction and mental health promotion, prevention of mental illness, and innovative service delivery.

The Research Partnership Program sets out to increase Alberta’s excellence and output of addiction and mental health research findings, and to better translate these findings into practice improvements.
References


