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Use of early indicators in rehabilitation process to predict functional outcomes in subjects with acquired brain injury

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Background. **The use of Evaluation Scales in ABI is necessary for measure of outcome, but not always they are used as predictor factors for rehabilitation processes and organization.**
Aim. **The aim of this study was to evaluate the effectiveness and efficiency of an inpatient rehabilitation program for patients with traumatic brain injury through the use of selected indicators and to identify predictive factors for functional outcome.**
Design. **This was a retrospective database analysis.**
Setting. Patients admitted to an Intensive Rehabilitation Unit as inpatient (Sacro Cuore-Don Calabria Hospital, Negrar-Verona).
Population. **The population included patients with traumatic brain injury.**
Methods.The study enrolled 175 patients admitted to an Intensive Rehabilitation Unit between 2004 and 2007. Data collected included demographic characteristics, first 24-hours worst GCS, length of acute and rehabilitative stay at admission and discharge FIM, DRS, LCF and GOS. Results. There was a statistically significant recovery over the course of admission for all assessment tools (P<0.000). When patients were subdivided on the basis of admission DRS categories a linear correlation among variables could be observed, with most disabled patients showing the longest acute and rehabilitation stays and the lowest functional gains. Within each DRS category age appeared to affect improvement (P<0.005) while final outcome was influenced not only by age but also by initial functional status (P<0.000) and time from injury to admission (P<0.004).
Conclusions and Clinical Rehabilitation Impact. **Systematic data collection in intensive rehabilitation is of great importance to monitor recovery and plan appropriate programs on the basis of admission functional status.**

KEY WORDS: Brain injuries - Rehabilitation - Outcomes - Evaluation studies.

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Over the past two decades the level of organization of rehabilitation services for people with severe acquired brain injury (ABI) has progressively improved and diversified in increasing its offers and intervention modalities. From models that focused exclusively on in-hospital approaches a more comprehensive management which contemplates outpatient community programs has been developed.[1] This latter modality requires the individualization of goals that are more easily detectable in subjects with mild disability: for this subgroup of patients a shortening of in-hospital rehabilitation, with the aim of rapidly introducing settings that are more favorable for return to community and work, is desirable. At the other end of the scale subjects with severe impairments and considerable nursing necessities

require an inpatient rehabilitation treatment that is substantially longer than average to reach stable clinical conditions and sufficient functional outcomes.

The Italian Health Care System requires rehabilitation treatments for patients with ABI and particularly for those with severe traumatic brain injury (first 24-hours worst GCS ≤8) to be undertaken within special hospital wards called Units for Severe Acquired Brain Injury. Also subjects with milder levels of disability can be admitted to intensive rehabilitation on condition that they present important motor, cognitive and behavioral rehabilitation needs. Our Health Care System provides complete coverage for the whole in-hospital stay and for the subsequent therapies in the outpatient setting. In fact there is no restriction on the length of stay and this can be prolonged for as long as a patient needs rehabilitation. In the current state administration, mechanisms over patients' outcomes and functional gains have not been implemented. Therefore, there is no system comparable to the Function Related Groups. In practice, the majority of Italian centers adopt shared (yet not defined) standards for hospital discharge, while outpatient rehabilitation models differ on a regional basis.

The Rehabilitation Department of the Don Calabria Hospital in Negrar, Verona, has established an autonomous monitoring system in order to better accomplish organizational requirements and rehabilitation planning. For this purpose indicators have been selected to synthesize demographic characteristics, severity of injury and level of functioning at the beginning and end of the rehabilitation course.

The centerpieces of this system are the Disability Rating Scale (DRS) and the Functional Independence Measure (FIM). They include measures of motor and cognitive impairment and overall disability. In particular the DRS derive some items from the Glasgow Coma Scale (GCS), such as indicators of awareness, communication and motor ability.[2] A large number of tools are adopted to assess more specific neurological and neuropsychological aspects (*e.g.*, CT findings, duration of post-traumatic amnesia, motor scales, etc.) but most of them display difficulty in synthesizing patients' characteristics and are inappropriate for analysing large cohorts.

On the other hand, the DRS and the FIM well describe patients' profiles and can be adopted to establish realistic goals for postacute rehabilitation, understand discrepancies between actual and expected outcomes and compare results from different rehabilitation units. The DRS was originally developed to follow rehabilitative progress from coma through different levels of functioning to return to community and can help identifing patients most likely to benefit from intensive in-hospital rehabilitation.[3]

A well-structured rehabilitation project should help an early estimation of final outcome. This would permit better admission planning, optimize resources employment and define inpatient and outpatient rehabilitation timing. We believe that the length of rehabilitation course should be proportioned to the severity of admission functional state and social and rehabilitative needs in the same manner as in the USA, where patients' functional gains, lengths of treatment, functional status at discharge, costs and disposition location have been demonstrated to differ by Function Related Groups, the modular set of patient classification system.[4]

This is a retrospective analysis of data regarding the phase of inpatient rehabilitation for subjects with traumatic brain injury (TBI). Purposes of the present study were to:

— outline a predictive model of functional change and outcome on the basis of variables available at the beginning of inpatient rehabilitation, such as age, time between injury and rehabilitation admission, GCS and initial functional status;

— verify if subdivision into admission DRS categories identifies homogeneous groups of patient with regard to effectiveness and efficiency of rehabilitation treatments as measured by length of stay, functional gain and efficiency and discharge disposition.

Results on the basis of concrete data, from a large number of patients with TBI homogeneously treated along both acute (intensive and neurotrauma care) and rehabilitative phases would provide valuable guidance on program organization, resources planning and outcome evaluation.

Materials and methods

The Rehabilitation Department of the Don Calabria Hospital includes a 25-bed Intensive Rehabilitation Unit which admits about 90 new patients with ABI each year; of these approximately 40 subjects have suffered a traumatic brain injury and the re-

maining 50 are split between severe strokes and anoxic accidents. Within the unit, 5 beds are reserved for sub-acute care management.

The Rehabilitation Department provides different outpatient programs, including a residential neuro behavioral rehabilitation program that may also last for a lengthy period prior to social/occupational reintegration into the community.

Criteria for admission to our Intensive Rehabilitation Unit are: clinical stability including the patient's capability along with medical judgement in obtaining beneficial rehabilitation treatment. Individualized goals are identified on admission and are periodically monitored by the rehabilitation team. The program provides multidisciplinary team-based services that include physical, occupational, speech and art therapy as well as psychological and social assistance. Demographic, descriptive and functional data are systematically collected for each patient by members of the rehabilitation team, stored in electronic databases and periodically updated and checked.

The current study retrospectively analyses data from patients with TBI admitted to our unit between 2004 and 2007. All patients came directly from acute care wards and they were on their first rehabilitative admission.

The indicators used to measure disability and levels of functioning were: the DRS,[5] the GOS,[6] the Levels of Cognitive Functioning (LCF),[7] and the Functional Independence Measure (FIM).[8] For the purpose of this study only the assessments completed within 72 hours of admission and discharge from in-patient rehabilitation were used.

The FIM score at discharge has been demonstrated to be a predictor of quality-of-life indicators, such as return to work and life satisfaction, one year after TBI.[9, 10]

The LCF scale has been found to be highly correlated to the DRS and the GOS. In the field of rehabilitation it has been proven to be a reliable tool, offering a precise description of the different grades of cognitive recovery of brain injured patients. The DRS shows significantly high reliability, sensitivity and validity. Similarly DRS scores at rehabilitation admission and discharge possess predictive validity in determining discharge disposition, requirement for supervision and return to work.

We have also calculated DRS and FIM daily gain as the difference between admission and discharge scores and FIM efficiency as FIM daily gain divided by length of stay.

Demographic data such as age and gender have been considered. The first-24 hour's worst GCS has been assumed to reflect severity of injury and it has been subdivided into three groups:[11] severe injury (GCS from 3 to 8), moderate and mild injury (GCS from 9 to 12 and GCS from 13 to 15 respectively). Analysis also included time from injury to rehabilitation admission (TIR) and length of rehabilitation stay (LOS).

Discharge disposition was investigated and categorized as "home", with or without outreach support, and "institution". The latter term includes skilled nursing facilities, chronic hospital, long-term residences and special units for vegetative state.

All patients had rehabilitative motor and cognitive treatments as necessary, for three hours a day, five days a week, in accordance with Italian rules about centers for severe acquired brain injury. Rehabilitation of motor aspects follows the Bobath concept and repetitive task training. The treatment planning derives from a medical evaluation and rehabilitation project, which is based both on functional overall evaluation (DRS, FIM, GOS scores) and other specific problems (*e.g.*, speech, dysphagia, behavioral assessment).

Written informed consent was obtained from each patient or their care-givers. The study was notified to our institutional review board as requested by departmental norms about retrospective analysis.

Data were processed using SPSS 13.0.1 for Windows. Parametric and non-parametric statistics were run as appropriate, P≤0.005 was used for these analyses. Parametric statistics were used for TIR and LOS with ANOVA (univariate analysis of variance); not parametric statistics for GCS, GOS, LCF, DRS, FIM with ANOVA.

Results

A total of 178 subjects with TBI were admitted to our Intensive Rehabilitation Unit between January 2004 and December 2007. Three patients died over the course of admission, so that the current study included 175 patients. Sex distribution showed 140 (80%) men and 35 (20%) women. Mean age of the total sample was 40 years (SD=19.25y, range=13-87 y, inter-quartile interval=24-52.5 y). Average time

TABLE I.—*Functioning scores at admission and discharge.*

	Admission	Discharge
GOS	3 IQ 3-4	4 IQ 3-5
LCF	5 IQ 4-7	7 IQ 5-8
FIM	47.14 SD 33.22	80.9 SD 38.93
DRS	13.59 SD 6.81	8.83 SD 6.75

Functioning scores of total sample at admission to and discharge from in tensive rehabilitation. There is a statistically significant improvement for all assessment tools (P<0.000). GOS-LCF are mediana.

from injury to admission was 38.16 days (SD=24.48 d, range=5-216 d, inter-quartile interval=22.5-49 d), average length of rehabilitation stay was 63.57 days (SD=73.12 d, range=2-540 d, inter-quartile interval=17-85.5 d) and mean first 24-hours worst GCS was 6.9 (SD=3.49, inter-quartile interval=4-8).

The functioning scores of the 175 patients at admission to and discharge from intensive rehabilitation are reported in Table I. There is a statistically significant improvement over the course of admission for all assessment tools (P<0.000).

Age grouping shows 103 patients younger than 40 years (59%, group 1), 42 between 40 and 64 years (24%, group 2) and 30 older than 64 years (17%, group 3). Length of acute stay of group 3 was similar to that of younger classes despite showing the highest GCS scores (8.9 *versus* 6.9 and 6.2, P=0.0021). On the other hand group 3 had the shortest rehabilitation stay, with a mean LOS of 46.6 days as opposed to 69.1 and 66.2 days for groups 1 and 2 respectively. However, this difference did not reach statistical significance (P=0.8462) probably because of the different distribution of this variable among groups. Patients over 64 years also showed the highest disability levels both at admission and discharge; this difference resulted to be statistically significant only for DRS ratings at the end of rehabilitation stay (P=0.1900 and P=0.0104 respectively) (Table II).

With regard to severity of injury 135 patients presented with a GCS score between 3 and 8 (77.1%, severe injury), 17 subjects with a score between 9 and 12 (9.7%, moderate injury) and 23 between 13 and 15 (13.1%, mild injury). Patients with severe injury differed from the other groups for all variables, showing the lowest age and the longest acute and rehabilitation stays (P=0.008 and P<0.000). Furthermore, they were placed at the bottom of the functioning scores range both at admission and discharge (P<0.000) (Table III). DRS gain appeared substantially similar in all groups (P=0.9865), albeit FIM gain differed significantly (P=0.0203) (Table IV).

Patients' subdivision into admission DRS categories highlights that the majority part of our patients belonged to classes of considerable disability. Over 82% of subjects were transferred from acute wards with motor, cognitive and behavioural impairments, often coupled with fractures and unstable medical conditions, this configured as severe disability (68%) or vegetative state (14%).

TABLE II.—*Age groups and their characteristics.*

Age groups	<40	40-64	>64
N. of patients	103	42	30
TIR			
Mean and SD	39.7 SD 26.8	38.8 SD 19.3	37.4 SD 22.9
Range	10-216	6-95	5-105
Interquartile interval	21-46.5	25-49.25	22.25-53.75
LOS			
Mean and SD	66.2 SD 84.2[a]	69.1 SD 66.2 [a]	46.6 SD 35.3 [a]
Range	2-540	8-245	7-142
Interquartile interval	13.5-72.5	25.25-98	18.75-61.25
GCS			
Mean and SD	6.2 SD 2.9[b]	6.9 SD 3.7 [b]	8.9 SD 4.1[b]
Interquartile interval	4-7	4-8.75	6.25-13
Admission DRS			
Mean and SD	13 SD 7.2[c]	13.8 SD 6.4 [c]	15 SD 5.5 [c]
Range	2-27	2-25	6-24
Interquartile interval	6.5-20	8-19	10-19.75
Discharge DRS			
Mean and SD	11.3 SD 6.7[d]	8.9 SD 6.5 [d]	8 SD 6.5 [d]
Range	0-27	1-24	3-22
Interquartile interval	3-10.5	4-11.75	5-18
Admission FIM			
Mean and SD	53 SD 37	40.8 SD 27.3	35.8 SD 20.4
Range	18-126	18-112	18-97
Interquartile interval	18.5-82	20-52.5	19-44.75
Discharge FIM			
Mean and SD	87.1 SD 38	79.5 SD 38	61.4 SD 37.7
Range	18-126	18-124	18-120
Interquartile interval	60-119.5	49-115.25	21.25-95

Characteristics of patients are shown following age subdivision. For each variable mean, SD, range and interquartile interval are reported. [a] P=0.8462; [b] P=0.0021; [c] P=0.1900; [d] P=0.0104.

TABLE III.—*GCS groups and their characteristics.*

GCS groups	≤8	9-12	13-15
N. of patients	135	17	23
Age			
Mean and SD	36.5 SD 17.7[a]	51.1 SD 18.5 [a]	52.4 SD 20.9 [a]
Range	13-83	22-79	16-87
Interquartile interval	23-46	39-66	35-70
TIR			
Mean and SD	41.5 SD 25.9 [b]	27.4 SD 16.7 [b]	26.1 SD 11.7[b]
Range	11-216	5-73	10-50
Interquartile interval	25-53	20-30	16-36
LOS			
Mean and SD	72.8 SD 79.1 [b]	41.6 SD 43 [b]	25.5 SD 20.5 [b]
Range	2-540	8-186	4-90
Interquartile interval	21-101	19-34	10.5-32
Admission DRS			
Mean and SD	14.5 SD 6.9 [b]	11.7 SD 5.8 [b]	9.1 SD 4.5 [b]
Range	2-27	3-20	4-21
Interquartile interval	8-20	7-15	6-9.5
Discharge DRS			
Mean and SD	9.7 SD 7 [b]	6.7 SD 5.4 [b]	5.1 SD 3.1 [b]
Range	0-27	2-20	2-15
Interquartile interval	4-16	3-10	3-6
Admission FIM			
Mean and SD	44.6 SD 33.9	49.9 SD 30.8	60.1 SD 28.4
Range	18-126	18-117	18-120
Interquartile interval	18-68	20-65	36-81.5
Discharge FIM			
Mean and SD	75.5 SD 39.7	91 SD 37.1	105 SD 22.4
Range	18-126	19-126	56-126
Interquartile interval	34-112.5	64-119	95-121.5

Characteristics of patients are shown following GCS subdivision. For each variable mean, SD, range and interquartile interval are reported. [a] P=0.008; [b] P<0.000.

The following considerations are with reference to admission DRS categories. Employing to this subdivision we report on the demographic and descriptive characteristics and the functional scores both at admission to and discharge from inpatient rehabilitation (Tables V, VI). All variables show a roughly linear correlation with admission disability levels with the exception of age. The GCS diminishes with increasing initial DRS score a part from patients with mild disability: their mean GCS is lower than 8 and their stay in acute wards is relatively longer in comparison with other DRS categories. Length of acute stay can be prolonged particularly for subjects categorized with very severe disability and severe vegetative state. Similarly time spent on rehabilitation for these subjects exceeds seven months before poor functional gains. Only patients with initial DRS ratings lower than 12 (46%) reached satisfactory functional recovery and independence in terms of FIM scores after a relatively brief in-hospital rehabilitation stay. Figure 1 shows FIM efficiency for each admission DRS category: intermediate categories and particularly the class with partial disability at admission attain the best daily recovery.

Subsequently we have analysed discharge DRS categories to measure the level of recovery in terms of DRS scores. As shown in Table VII there is a variable distribution of recovery which nonetheless tends to be linearly correlated to initial disability levels. The majority of patients remain in the same DRS category as at admission; this is more evident for the most disabled classes (vegetative states) and for mildly disabled subjects.

Within each admission DRS category the grade of recovery appears to be related to some extent to age, initial GCS, LOS, TIR and initial functioning status. To better understand these correlations a logistic regression analysis pseudo R2 was performed using an improvement of two or more DRS categories as the dependent variable and patients' admission characteristics as independent variables (Table VIII).

The age and TIR resulted to be a statistically significant as predictive factor for better outcome (OR=0.97, 95% CI=0.95-0.99, P=0.003); TIR (OR=0.97, 95% CI=0.96-0.99, P=0.004).

LOS (OR=0.99, 95% CI=0.99-1.00, P=0.166,) and the GCS (OR=1.04, 95% CI=0, 94-1.15, P=0.398,) were not statistically correlated.

In an ordered regression model where final DRS score is the dependent variable and patients' admission characteristics are the independent ones, significant predictive factors are represented by initial DRS score (OR=4.82, 95% CI=3.38-6.87, P<0,000), age (OR=0.97, 95% CI=0.95-0.99, P=0.003) and length of stay in acute wards (OR=0.97, 95%CI=0.96-0.99, P=0.004).

Usually in the clinical practice we observe that initial DRS in rehabilitation and TIR are correlated, and also the regression model confirm, considering them as independent value for Final DRS, as predictive factors. Outcome improves with decreasing

TABLE IV.—*DRS and FIM gains.*

DRS gain	GCS 3-8	GCS 9-12	GCS 13-15	FIM gain	GCS 3-8	GCS 9-12	GCS 13-15
Mean	-4.86*	-5*	-4*	Mean	30.86**	41.70**	44.82**
SD	4.39	4.62	2.61	SD	29.23	28.87	23.86
Max. Value	-19	-15	-12	Max. Value	100	98	99
Min. Value	0	0	0	Min. Value	0	1	0

Patients' DRS and FIM gain on the basis of the first 24-hours worst GCS. The negative sign before DRS scores indicates an improvement considering that higher DRS ratings mean worse disability. * P=0.9865; ** P=0.0203.

TABLE V.—*Demographic and descriptive characteristics following subdivision into admission DRS categories.*

DRS classes	N. of patients	Age y	TIR d	LOS d	GCS
>24	7 (4%)	25.4	75.7	222.5	4
22-24	17 (9.71%)	39	58.5	135.4	4.5
17-21	49 (28%)	42.5	41.8	78.2	5.7
12-16	22 (12.57%)	35.6	35.6	50.1	7.5
7-11	48 (27.42%)	41.2	30.6	39.7	8
4-6	26 (14.85%)	32.3	25.1	14.4	8.8
2-3	6 (3.42%)	34.1	31.6	7.3	6.8

Patients' subdivision into admission DRS categories and their demographic and descriptive characteristics. In our sample no patients belonged to mild or no disability category (DRS=0 and DRS=1, respectively).

initial DRS score, younger age and shorter acute stay.

With regard to discharge disposition, 89% of patients returned back home directly or continued with a rehabilitation program as an outpatient. In this subgroup 50% of subjects whom continued as outpatients were younger than 65 years and 10% older. The remaining 11% were submitted to various institutions. In general, the most severe patients were assigned to discharge destinations different from home, while all subjects whose final DRS score was lower than 17 returned to the community.

Discussion

Our first purpose was to explore a predictive model for outcome at the end of intensive in-hospital rehabilitation. In the present sample age strongly affects functional recovery as measured by change of DRS category. Functional status at admission, age and time from admission to injury are significantly correlated to functional status at discharge. These data are consistent with previous studies.[12-15]

Older patients show lower levels of functioning at both rehabilitation admission and discharge, strongly indicating a positive role of younger age in the recovery from brain injury.[12-14] Another salient feature is the smaller variability in the distribution of length of rehabilitation stay among patients over 64 years, in comparison with other age groups: this is probably to be ascribed to the fact that their program is more standardised and predictable from the beginning of intensive rehabilitation: in the case of older patients it is a priority to rapidly reach the best grade of self-sufficiency in the activities of daily living so that a peaceful return home or to nursing facilities is assured. However, noticeable advantages derive from early discharge to a familiar environment. On the other hand, for younger patients there is a much greater variability in the management of rehabilitation programs: in the case of mild to moderate disability it seems more suitable to shorten the in-hospital stay and invest in outpatient rehabilitative programs in order to facilitate return to education and work. In severe cases the social services search for a suitable disposition can noticeably prolong length of stay. With regard to age it is remarkable that the most severe patients' (DRS>24) mean age is decidedly low (25.4 yrs). This is probably due to the

TABLE VI.—*Functioning characteristics following subdivision into admission DRS categories.*

DRS classes	n. of patients	Adm DRS	Dis DRS	Adm GOS	Dis GOS	Adm LCF	Dis LCF	Adm FIM	Dis FIM
>24	7 (4%)	25.7	23.2	2	2.4	1.8	2.4	18	19.4
22-24	17 (9.71%)	22.7	16.7	2.8	3.1	2.2	4.2	18	33.5
17-21	49 (28%)	19.2	12.3	3	3.3	3.8	5.4	21.7	59.1
12-16	22 (12.57%)	14.1	8.4	3	3.3	5	6.5	33.3	76.1
7-11	48 (27.42%)	8.5	4.3	3.4	4.3	6.7	7.6	61.2	106.1
4-6	26 (14.85%)	5.1	3.4	3.9	4.6	7.1	7.7	90.7	117.3
2-3	6 (3.42%)	2.5	2.1	4.3	5	7.8	7.8	120	122.5

Patients' subdivision into admission DRS categories and their functioning characteristics. In our sample no patients belonged to mild or no disability category (DRS=0 and DRS=1 respectively). Adm: rehabilitation admission; Dis: rehabilitation discharge.

fact that mainly young people survive very severe trauma.

In the regression model the level of admission disability results in a statistically significant prognostic factor of discharge functional outcome: virtually 70.86% of patients remain in the same DRS category as at admission or improve to the next category. Several studies have drawn the same conclusions, in terms of DRS, GOS or FIM gains.[12-14] With respect to the DRS scale: its ceiling effects at the end of intensive rehabilitation appear to be negligible: only one patient scored 0 and four patients scored 1 on the discharge DRS.

According to statistical analysis the GCS does not seem an influential factor on patients' improvement and final outcome. Among 93 patients whose discharge FIM was higher than 91.64 subjects had an initial GCS ≤8 (and 10 of them were with GCS=3). A lack in predictiveness of this parameter has already been highlighted, particularly if the GCS is considered alone and not along with other variables, such as age.[16] Older patients showed higher mean GCS scores, albeit their length of stay in acute wards was similar to that of younger patients, probably because of the presence of both pre-existing and concomitant medical problems.

Our analysis underlines a significant correlation between greater TIR and lower functional gains: this may reflect a time-related decrease in spontaneous recovery or the presence of medical problems that postponed admission to intensive rehabilitation. Furthermore, acute length of stay may constitute an indirect measure of injury severity.[17]

In other studies examining the relationship between time before rehabilitation admission and rehabilitation length of stay, longer periods of acute hospitalization appeared to be associated with longer rehabilitation stays.[15]

Our second purpose was to examine homogeneity in descriptive and functional characteristics of admission severity-groups. Our analysis was exploratory and results are suggestive rather than conclusive. As already underlined in the previous section almost all variables are linearly correlated to admission DRS scores. In particular there are some aspects which can be assumed as indirect indicators of effectiveness and efficiency of interventions, like LOS, FIM efficiency and discharge disposition.

LOS can be affected by many variables in a publicly funded system, such as the availability of suitable discharge locations. This is the case of subjects with considerable disability: rehabilitation and social

TABLE VII.—*Discharge DRS distribution.*

disDRS / adDRS	0 (N. 1)	1 (N. 4)	2-3 (N. 38)	4-6 (N. 50)	7-11 (N. 34)	12-16 (N. 14)	17-21 (N. 26)	22-24 (N. 5)	>24 (N. 3)
>24 (N. 7)							**2 (28.5%)**	**2 (28.5%)**	3 (43%)
22-24 (N. 17)			**1 (5.9%)**	**1 (5.9%)**	**3 (17.6%)**		**9 (53%)**	**3 (17.6%)**	
17-21 (N. 49)		**1 (2%)**	**2 (4%)**	**7 (14.3%)**	**12 (24.5%)**	**12 (24.5%)**	**15 (30.6%)**		
12-16 (N. 22)			**1 (4.5%)**	**4 (18.2%)**	**15 (68.2%)**	**2 (9%)**			
7-11 (N. 48)		**1 (2.1%)**	**15 (31.2%)**	**28 (58.3%)**	**4 (8.3%)**				
4-6 (N. 26)	**1 (3.8%)**		**15 (57.7%)**	**10 (38.5%)**					
2-3 (N. 6)		2 (33.3%)	4 (66.7%)						

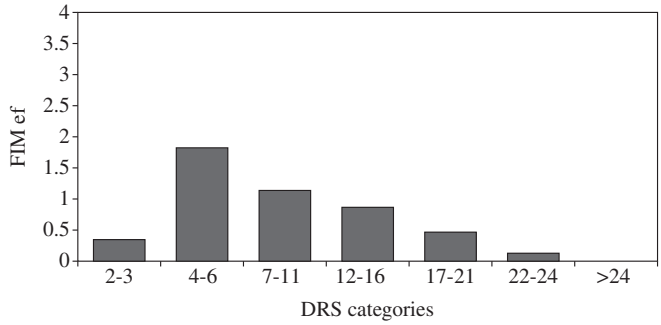
Discharge DRS distribution following subdivision into admission DRS categories.

problems mix together and length of stay can be particularly long, in one case of ours up to 540 days. Particularly, patients whose final disposition is different from home, show the longest rehabilitation stays and the lowest functional gains. This explains why a longer rehabilitation admission does not necessarily imply a better outcome: severe disability points out the delicate problem of a suitable discharge disposition and this is inevitably reflected by length of stay.

FIM efficiency shows an obvious curvilinear relationship with admission DRS category, mainly due to ceiling effects in the case of patients with mild disability. The extremely low recovery rate of more disabled subjects underlines the need for early social support activation and alternative dispositions for patients with persistent vegetative state.

In Italy the reality is that the high percentage of discharges home, depends on factors not really correlated to final outcome or severity of disability, it reflects above all, cultural and social reality, good family capacity, and propensity to welcome persons with disabilities and adequate public organization, which can be classed as favouring factors. There is also lack of long-term residences and resources as negative aspects which increases discharges home. Indeed ageing of population, changes in social and demographic characteristics, family structure and economic resources use may reverse this witnessed trend. This is what has already been observed among subjects with non-traumatic brain injury (vascular and anoxic damage), in reality only 45% of them return home after intensive rehabilitation.

The findings of our study should be interpreted within the context of a number of methodological limitations: firstly it explored only a few of the factors that may affect outcome. Our intention was to analyse some main, robust variables: we believe that



FIMeff	0.340909	1.835106	1.13064	0.853128	0.477445	0.115067	0.006418

Figure 1.—FIM efficiency. FIM efficiency following subdivision into admission DRS categories. FIMeff: FIM efficiency is the daily recovery.

their immediate availability and ease of use, interpretation and communication make them suitable both to delineate a predictive outcome model and to describe functional profile of large cohorts of patients. .

A precise relationship between rehabilitative processes and outcome would require exact quantification of the different amounts of motor, speech and occupational therapy, which is not our aim in this paper. However, there was a homogeneous level of care as far as the total number of hours of treatment and use of rehabilitative techniques.

Furthermore, it must be taken into account that DRS categories do not consider comorbidity and social and environmental factors.

Finally, our analysis only describes inpatient rehabilitation. It is extremely important to underline that further functional improvement continues after hospital discharge even in patients with severe disability.[18-20] A more complex follow-up of the whole course of care through in-hospital phase and community programs would clarify the needs for different rehabilitation timing, strategies and settings.

Conclusions

Knowledge of characteristics of patients with TBI and prediction of long-term outcomes at the beginning of rehabilitation provide essential information for priority setting for the limited resources in intensive rehabilitation. Our study aims to represent a conceptual model to organize the rehabilitation process based on different levels of severity.

TABLE VIII.—*Ordinal logistic regression pseudo R2=0.200.*

Variable	Odds ratio	P>z	[95% CI]
DRSin	4.82	0.000	3.38-6.87
Age	0.97	0.003	0.95-0.99
TIR	0.97	0.004	0.96-0.99
LOS	0.99	0.166	0.99-1.00
GCS	1.04	0.398	0.94-1.15

Data collection through the systematically use of indicators suitable to monitor patients' level of disability and rehabilitation processes primarily intends to improve otherwise empirically based clinical practice. The use of electronic databases and statistical analysis facilitates the evaluation of effectiveness and efficiency of interventions in favour of specific patients' subpopulations. In the case of patients with traumatic brain injury, identifying predictive factors for outcome makes it possible to estimate length of rehabilitation stay and plan outpatients' programs from the beginning of inpatient rehabilitation. In fact, as we saw the length of stay is not always correlated with outcome, though it depends on severity at admission.

The observation of relatively low functional gains among patients with severe admission disability should direct our attention toward social more than rehabilitative problems. On the other hand, functional improvements, noted among younger patients with milder levels of disability at admission, underline the need for further outpatient rehabilitative pathways.

Nevertheless, it is necessary to remember that the recovery process of patients with severe acquired brain injury continues over time.[18-21] Several studies have demonstrated that progresses can occur until five years after injury and are to be correlated with patients' age and discharge DRS.[22]

More studies are needed to demonstrate what type (as inpatient *vs.* community programs) and timing of rehabilitation work for whom.

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