Journal of Vocational Rehabilitation 32 (2010) 135–150
DOI:10.3233/JVR-2010-0505
IOS Press

Vocational interventions and supports following job placement for persons with traumatic brain injury

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Revised/Accepted: February 2010

Abstract. Previous research on vocational rehabilitation after traumatic brain injury (TBI) has suggested that coaching and other services provided following job placement are particularly important for successful work re-entry in this population. Methods of defining and measuring these services are needed to estimate more precisely their effects on vocational outcomes. In this study we developed a measure of the type, amount, and location of post-placement interventions that could be completed by treaters in "real time". Treatment was measured prospectively for 6 months after job placement for 65 people with moderate to severe TBI treated at 5 TBI Model System centers. Centers were found to differ substantially in the amount and location of treatment provided following job placement; centers providing more intensive treatment and treatment at the workplace also served more severely impaired clients at a longer interval after injury. Within centers, participants' cognitive speed and emotional distress predicted certain aspects of amount and type of treatment provided. Three-fourths of the sample were still working at the placement job after 6 months. Due to the confounding between case mix and treatment variables, unique effects of treatments on outcomes could not be determined.

Keywords: Traumatic brain injury, vocational rehabilitation, treatment definition

1. Introduction

Traumatic brain injury (TBI) affects primarily young adults in their economically productive years [44]. TBI has impact on diverse social roles, including employment, owing to its characteristic effects on cognitive, behavioral and physical function [23]. The opportunity to work for pay is of great importance to many people with TBI [17], and vocational status is a strong predictor of overall satisfaction with life in this population [4]. Society also has a major stake in returning people with TBI to paid employment, as the loss in productivity for both injured persons and their families, and the costs of continued dependency, are enormous [12].

However, getting and keeping a job remains an elusive goal for many people with disability due to TBI. In a study of people with moderate to severe TBI followed in the TBI Model System (TBIMS) longitudinal project, only 27% were competitively employed at 1 year post injury [20]. This proportion does not improve substantially over succeeding years [18]. A recent systematic review with data pooling across studies suggested an almost identical employment rate (41%) at 1 and 2 years post injury [33]. Even among people with TBI

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who were working at the time of injury, the relative risk of unemployment 3 to 5 years later is five times that of the general population for men, and three times for women [10]. Moreover, people with TBI who do return to work tend to work fewer hours, make less money, and experience more job turnover compared to pre-injury [37].

Despite these grim statistics, many people with TBI do not receive help in obtaining work. Population-based surveys have confirmed that assistance with improving job skills and/or finding paid employment is one of the primary expressed needs of people with TBI, yet is among the most likely to remain unmet [5]. For example, only 3% of Coloradoans [2] and 4% of South Carolinians [25] received vocational rehabilitation services in the first year after a TBI severe enough to warrant hospitalization. People with TBI may have poor awareness of federally funded vocational services [30], and these services are frequently unavailable, inadequately funded, or meted out according to overly stringent criteria [37, 43].

Several treatment models focusing on vocational re-entry have been developed specifically for TBI, including comprehensive/holistic programs that feature work readiness training and sheltered work trials as part of a therapeutic milieu [1, 26], and case coordination systems emphasizing early intervention [21, 22]. Supported employment, which emphasizes on-the-job training and coaching, is an influential model that has been studied in TBI by Wehman et al. [35, 38]. The empirical evidence for all of these approaches remains limited, according to a recent systematic review [11]. That review also noted that comparisons among the three approaches are challenging due to marked differences in case mix, outcome measures, and treatment definition. In particular, since vocational treatment is generally described as "individualized" to some degree, it is difficult to determine from a published article the types and amounts of activities that are actually done for and with participants. This issue is not specific to TBI or vocational treatment, as it has been noted that rehabilitation in general is more concerned with precise measurement of patient characteristics (i.e., case mix variables) and outcomes than with defining and measuring treatments [39]. However, defining and measuring "what is actually done" during various types of treatments is a critical step not only toward describing treatments and comparing them across studies, but critically evaluating what treatment components are most effective, when, and for what kinds of patients.

In previous work attempting to define categories of vocational treatment for TBI, we surveyed 16 TBIMS centers and found a wide variety of treatment models and components represented [16]. However, in that study we did not measure specific vocational treatment components at the level of services offered to individual clients, nor did we examine the case mix characteristics at the various centers. Survey respondents (directors of TBIMS vocational programs) indicated that job coaching and other services provided *after* vocational placement were frequently the most crucial, yet least well funded, interventions for helping people with TBI maintain employment. Thus, we reasoned that it would be useful to decompose and measure services provided after job placement, in part to learn more about the efficacy of specific treatments. One prior study [36] categorized supported employment services for the purpose of determining time spent by the treater in various activities (travel, consumer training, advocacy, etc.). However, there remains no standard way to define and measure vocational treatments provided after clients have begun work. To our knowledge, no studies have examined the relationships among specific treatment components and the vocational outcomes they are intended to bring about.

Given the perceived importance of interventions following job placement, and the lack of definition and measurement of these services to date, a primary objective of the current study was to create a measure of the types and amounts of interventions given to persons with TBI after job placement. We designed this measure based on input from vocational rehabilitation clinicians and field staff who work with persons with TBI on the job. For feasibility of use in future studies, we focused on developing an instrument that could be used in "real time" – that is, at the time of service delivery – with minimal extra demands on treating staff. We then used this instrument to measure actual services received after job placement in 5 TBIMS sites. The treatment data thus collected were used, along with case mix and outcomes data, to address 3 questions:

1. How do post-placement vocational interventions differ across the 5 TBIMS programs, both qualitatively (e.g., type and location of service) and quantitatively (length, duration, number of contacts)?
2. How are treatments related to case mix variables such as injury severity and functional status or presenting problems at the time of job placement? For example,

   a. Do clients with more severe TBI and/or worse functional status at the time of job placement receive more services overall?
   b. How are service locations related to client factors? For example, do clients with worse cognitive impairments receive proportionally more services at the workplace compared to the clinic, as might be done to reduce the need for such clients to generalize treatment across training sites?
   c. How are specific treatments targeted to presenting problems? For example, do clients with worse emotional status receive more counseling focused on emotional issues, and do those with worse cognitive status receive more services targeting cognitive function?
3. How do short-term vocational outcomes differ across the 5 TBIMS sites, and how might outcomes relate to the amounts, types and locations of treatments received?

2. Method

2.1. Overview of design

This was a longitudinal, 5-center observational study of persons with moderate to severe TBI. Participants were followed for 6 months after a job placement that was facilitated by an outpatient rehabilitation program. Participants underwent a standardized assessment of cognitive, functional and emotional status near the point of starting their jobs. All clinical interventions they received in support of job performance and job retention were recorded by treating staff using an instrument developed for the study and described below. Interventions were recorded per day of service, starting on Day 1 of job placement and lasting for 6 months, at which point short-term employment outcomes were assessed.

2.2. Participants

Participants were 65 people aged 18–68[1] who received clinical services from one of 5 geographically dispersed TBIMS centers following paid, competitive job placement, either in a new job or one held pre-injury. Inclusion criteria further stipulated a diagnosis of open or closed TBI with at least one of the following: loss or alteration of consciousness attributable to the TBI (e.g., Glasgow Coma Scale score on emergency admission <13, or other medically documented coma or unresponsiveness); prospectively documented disorientation attributable to the TBI and persisting ≥24 h; or a neuroimaging study positive for trauma-related brain abnormality such as contusion, hematoma, or diffuse axonal injury. There was no restriction on time since injury, nor were participants excluded for comorbidities such as psychiatric diagnoses. However, the latter could not be the *primary* reason for clinical services; i.e., participants had to be receiving vocational services primarily due to the TBI. All participants or their legal proxies provided informed consent. Across the 5 TBIMS sites, 83 persons met all of the inclusion criteria and 65 (78%) consented to participate. There were 27, 12, 11, 8, and 7 participants respectively from the 5 sites. Twenty-seven (42%) of the participants were co-enrolled in the TBIMS National Database (NDB), which contains a standard set of variables collected from emergency admission to long-term follow-up [3].

Participants were an average age of 36 years at the time of injury (SD 14.6, range <1–63; one participant was injured as an infant) and 41 years at the time of enrollment (SD 14.1, range 19–68). There were no significant differences by center for age at injury or age on enrollment (both $p > 0.15$; it should be noted that the power for any comparisons is low due to the small sample size). Sixty-three percent of the TBIs were of vehicular etiology, 19% from falls, 9% intentional (gunshot/assault), and 9% other (e.g., sports). As is typical in studies of moderate and severe TBI, the sample included mostly males (77%). The sample overall was 87% white. The proportion of nonwhite participants ranged from 0 to 43% across sites, with the highest in the Northeast and Southern US. Overall, 7 participants (11%) had less than a high school education, 16 (25%) had a high school degree and 42 (65%) had at least some college education. Education did not differ significantly by center (Chi-square $p = 0.14$).

2.3. Measures

Case mix variables were selected for their predictive validity with respect to employment outcome after TBI [6, 24, 34]. *Demographic variables* included employment status at the time of injury, in addition to age at injury and at enrollment, gender, race/ethnicity, and level of education. *Injury variables* included cause of injury. Standard TBI severity indices such as

[1] The original inclusion criteria stipulated ages 18–65 to ensure that the sample was of working age. When a participant who returned to work at age 68 was inadvertently enrolled and followed, his/her data were retained in the study.

depth/duration of altered consciousness could not be gathered for all participants due to varying availability of original medical records. To estimate injury severity, participants were asked to estimate retrospectively the duration of their post-traumatic amnesia using a brief semi-structured interview [15, 32, 40]. Retrospective estimates were found to be correlated at $r = 0.68$ ($p < 0.001$) with prospectively measured PTA duration, in the 35 cases for whom prospective measurement was conducted for the TBIMS NDB.

Current status (i.e., functional status at the time of job placement) was assessed with several measures administered after enrollment. *Global status* was rated using the Glasgow Outcome Scale-Extended (GOSE; [42]). *Neuropsychological status* was measured with a brief battery that included the California Verbal Learning Test, Revised (CVLT-II; [7]) and the Symbol Digit Modalities Test-Written version (SDMT-W; [28]). *Emotional status* was assessed using the Brief Symptom Inventory 18 item version (BSI-18; [8]).

Vocational information gathered for the study included information about the job at which each participant was placed, and its relationship to the pre-injury job: same,[2] different, or not applicable (participant was unemployed at injury). We also recorded up to 4 types of special work conditions, or accommodations, that could have been arranged for each participant's placement job: a reduced work schedule; modified or specially structured tasks; increased training or supervision; or modifications to the physical environment.

Measurement of treatment components. The types, locations, and durations of all interventions were collected for every day that treatment was provided, starting with Day 1 on the placement job and extending for 6 months. The types (categories) of treatment were selected and defined using input from focus groups with vocational specialists and job coaches in 2 of the participating centers. These centers also performed informal pilot testing leading to revision of the treatment definitions before the multi-center study was begun. The 8 categories of treatment in the final measurement tool were all judged to represent important content; to be provided to a non-trivial proportion of clients with TBI; and to be readily distinguishable from one another (i.e., mutually exclusive). The focus groups introduced the important point that for certain categories of treatment (e.g., employer education), the client *need not be present* for productive intervention to occur. The 8 treatment categories and their definitions, as well as the abbreviations to be used in the remainder of this article, are presented in Table 1.

For each of the treatment types provided on a given day of service, the treater also indicated the location(s) of treatment, selecting among the following: the client's Worksite; Other Community location (e.g., the client's home, public transportation, etc.); the treater's Clinic or office; and Phone or email contact. Multiple locations on a single day could be selected.

Pilot testing indicated that it was not feasible to record the clock time spent in different *categories* of treatment on a single day. For example, a session at a client's worksite could include a blend of cognitive and behavioral strategy training, or a blend of employer education and scheduling logistics, that proved to be very difficult to separate with regard to the time spent on each. In contrast, the time spent *in each location* per day proved to be relatively easy to capture, partly because many clinical billing systems are organized in similar fashion. Treaters were therefore instructed to record the total time spent per day of treatment in each location (across intervention categories) in ordinal increments, as follows: (1) 1–10 min; (2) 11–30 min; (3) 31–60 min; (4) 1–2 h; and (5) more than 2 h (with the actual number of hours specified). Thus, on the record form treaters marked all of the treatment categories they had administered at each location that day, and the total time spent per location.

Vocational outcomes. Objective data on employment outcomes included whether or not the participant was still employed and if so, at the placement job or a different job; or if not, the date and reason for termination. The trajectories of the 2nd and any subsequent placement job were also recorded. We also recorded each participant's employment ratio, calculated as the proportion of weeks since job placement that the participant had worked at least half-time. Subjective outcomes were assessed using 16 items of the Job Satisfaction Survey (JSS; [29]) pertaining to the factors of pay, supervision, nature of the work, and co-workers. These factors were selected as most relevant to short-term vocational outcomes. A total JSS score was calculated as the average of all items.

2.4. Procedures

The study was approved and overseen by the Institutional Review Boards of all 5 centers. Participants were

[2] The placement job was classified as the same as pre-injury if the participant returned to the same employer, even at a lower level of responsibility or fewer hours per week.

Table 1
Treatment categories and their definitions

Category (abbreviation)	Definition
Cognitive/compensatory strategies training or advising (COG)	Developing or training cognitive compensatory strategies that apply across tasks (e.g., notebook/list, beeping watch, etc.); or that are task specific (e.g., sequencing of steps, placement of materials); quality control skills (e.g., self-checking, using feedback); training/reviewing skills/rules and regulations germane to the job
Emotional/behavioral/attitudinal issues training or counseling (EMOT)	Counseling or feedback on social/interpersonal behavior, impulse control; attitudes toward job, work, co-workers, supervisors; coping with issues affecting work; developing realistic self-appraisal
Supervisor/employer training/education (SUP)	Contacts with supervisor, employer, or co-workers for rapport and education about brain injury or job coaching process; reviewing client's performance with supervisor; training person(s) at job site to serve as natural support
Worksite accommodation: Physical environment (PHYS)	Planning/making modifications to physical environment of work site
Worksite accommodation: Tasks/schedule/logistics (SCHED)	Planning/making modifications to work responsibilities/schedule
Life skills training or counseling (LIFE)	Training in life skills as needed for work: transportation, finances, hygiene, time management, shopping
Case management/advocacy (CM)	Contacts (usually with other professionals including VR and other payers, medical rehab staff, community agencies) for team/services coordination
Family/Significant Other intervention (FAM)	Contacts with family/social support network to support work goals; family conference, education and feedback, problem-solving

recruited from consecutive cases who met all inclusion criteria and were newly placed or about to be placed in paid jobs. Following informed consent, injury data were gathered retrospectively from primary or secondary medical records, or from the TBIMS NDB for those who were co-enrolled. Participant interview/testing sessions conducted shortly after enrollment were used to obtain demographic data, medical/social/vocational history, estimated PTA duration, and the neuropsychological measures.

At each site, job coaches and other clinical staff providing services following job placement were oriented to the treatment data forms and definitions. An instruction sheet was provided with examples of typical scenarios and how they were to be coded. Staff were instructed to record interventions that lasted *one minute* or more; the intention was to ensure that interventions were captured that might not be billed, such as brief telephone calls, e-mails, and informal conversations directed to care coordination. Treatment data forms were completed as near to the day of service provision as possible. Forms were collected by a coordinator at each site who monitored completion by contacting the vocational program clinical staff, and by checking clinical or billing records as needed.

Six-month outcomes data were collected from participants by telephone, allowing a window of ± 1 week around the target date calculated from Day 1 of job placement. Outcomes data were gathered by staff who were not involved in treating clients, at all but one of the centers.

2.5. Data analysis

Summary statistics were computed for each variable of interest. Associations among variables were tested for significance using Chi-square for nominal variables, and rank-order (Spearman) correlations for ordinal or interval variables. Kruskal-Wallis tests were used to determine whether the 5 sites showed overall significant differences on each treatment variable. For variables showing significant differences overall, pairwise Mann-Whitney U tests were then used to determine which centers differed from one another. Further details of data analyses relevant to specific questions are included in Results. Because this study was considered exploratory, with the risk of Type II error equally important to that of Type I error, an alpha level of 0.05 was applied to all analyses.

3. Results

3.1. Question 1: Patterns of vocational treatment across TBIMS sites

Treatment data were compiled for each participant to determine the number of days on which any treatment was received during the 6-month study period; the span of treatment (i.e., days between the first and last day of service); and the summed durations, in hours, across all treatments received (i.e., total "dose" of treatment). Treatment types and locations were examined by summing the number of treatments in each category listed

in Table 1 and the 4 possible locations, respectively, across all service days. (On any given day, one or more treatments at one or more locations could be administered, meaning that the number of "sessions" of all treatment types or locations would not necessarily sum to treatment days.) In addition to raw numbers of treatments, the proportions of total treatments administered at each of the 4 locations were calculated.

Table 2 displays the treatment data for all centers. Significant center differences were found for the number of days on which treatments were received during the 6-month study period, as well as the total number of treatment hours. However, the span of treatment (days between first and last service) did not differ across centers. Pairwise tests suggested that center differences were mainly due to one center providing more treatment than most of the others. For the average client, Center A provided significantly more treatment days than centers B and E (with comparison to C approaching significance at $p = 0.06$). Center A also provided more treatment hours than centers B, C, and E (with comparison to D approaching significance at $p = 0.06$).

Comparisons for each of the 8 treatment categories and 4 treatment locations provide more detail on center differences. The categories COG, SUP, and CM showed significant differences by center, as did both Worksite and Clinic among the 4 possible treatment locations. Center A had the highest number of COG sessions, and indeed the similarity in the mean number of sessions involving COG and the total mean number of sessions indicates that most of center A's treatment days (28.5/29.8) included COG. By contrast, for example, Center C had a mean 2.3/9.1 sessions that included COG. Center A also had a higher number of SUP sessions than Centers B or E. In the other treatment categories, center E, with 0 CM sessions, provided significantly less of this service than each of the other centers. A few service categories, such as PHYS, LIFE, and FAM, were found to be used relatively little during the study period (means <2 sessions across all centers) and are not considered further.

The results for treatment locations in Table 2 suggest that Center A, and to a lesser extent Center D, provided more Worksite interventions than the other centers, both absolutely and as a proportion of all interventions. By contrast, both B and C provided more (and proportionally more) treatments at the Clinic than Centers A or D. Treatments administered by Phone or email did not differ across centers with respect to the number of sessions, but Center A's proportion of phone treatments was significantly lower than that of several other centers. Interventions in community settings other than the workplace were seldom used and are not considered further.

These findings suggested substantial differences among the 5 TBIMS centers in the amount, types, and locations of services provided after job placement. A picture emerged in which Center A and D, the "highest dose" sites, also provided the most interventions at the worksite. Centers B, C, and E provided fewer treatment hours overall, but relatively more Clinic treatment. Two of the centers with little worksite intervention did proportionally more treatment via phone/email (B, E).

3.2. *Question 2: Relationship of treatment to case mix variables*

Given the observed variation in services across centers, it was of interest to ask whether the centers also varied in case mix, in ways that would help to account for the differences in treatment, or whether these differences in treatment were related to different treatment philosophies. For example, if Center A were found to treat the most severely injured clients or those with the worst functional deficits, this might help to explain why Center A offered the most services and/or the most treatments located at the worksite. On the other hand, if case mix were similar between Center A and other centers, this might suggest that the greater intensity of services and more workplace services delivered by Center A were driven by a belief that this was the most effective model. With sufficient overlap in case mix across centers, different vocational outcomes could be more confidently attributed to the treatment practices of individual programs. In contrast, if case mix across programs covaried strongly with the services delivered, this would make it difficult to disentangle the influence of client factors from the impact of service factors on vocational outcome.

To examine this question, we analyzed selected case mix variables by Center in a fashion similar to the analysis of treatment components for Question 1. These case mix variables included severity of TBI, measured using retrospectively reported PTA duration (in days); current functional status as measured by the GOSE score; the two cognitive function measures (SMDT-W total score, Trials 1–5 score from CVLT-II), and the emotional function measure (the GSI T-score from the BSI-18). Time (in months) between injury and job placement was also included, as was the status of the pre-injury job relative to the placement job (same, different, or none, in the case of participants unemployed before injury).

Table 2
Vocational treatment characteristics, by TBIMS site

	Overall	By center					Significance test results (overall)	Pairwise center differences at $\alpha = 0.05$
		A	B	C	D	E		
N	65	11	27	7	8	12		
No. of treatment days								
Mean (SD)	12.2 (14.5)	29.8 (22.4)	6.6 (5.1)	9.1 (6.4)	15.1 (18.3)	8.3 (7.2)	$p = 0.016$	A > B, E
Range	1–71	3–71	1–21	1–18	1–56	3–26		A > C ($p = 0.06$)
Span of treatment (days between 1st and last)								
Mean (SD)	87.8 (59.2)	114.5 (52.4)	78.9 (57.4)	84.3 (74.2)	107.9 (71.4)	72.2 (49.0)	NS ($p = 0.30$)	–
Range	0–199	33–186	0–175[a]	0–182[a]	0–199[a]	14–168		
Total treatment hours								
Mean (SD)	23.1 (46.4)	88.4 (64.1)	5.1 (4.6)	5.2 (3.7)	38.5 (67.6)	4.2 (4.8)	$p = 0.001$	A > B, C, E
Range	0.1–194	2–176	0.1–16	0.3–10	0.3–194	1–14		A > D ($p = 0.06$)
No. sessions by treatment type								
COG Mean (SD)	9.2 (14.9)	28.5 (22.2)	3.2 (4.9)	2.3 (3.5)	10.4 (19.4)	8.1 (7.2)	$p = 0.0001$	A > B, C, D, E
Range	0–69	3–69	0–24	0–10	0–56	3–26		E > B, C
EMOT Mean (SD)	4.1 (8.7)	7.3 (10.9)	1.4 (2.1)	4.1 (3.8)	10.5 (19.4)	2.9 (3.3)	NS ($p = 0.10$)	–
Range	0–56	0–29	0–8	0–9	0–56	0–11		
SUP Mean (SD)	3.7 (8.1)	8.1 (7.6)	1.4 (2.1)	2.4 (2.6)	9.4 (19.7)	1.6 (2.5)	$p = 0.02$	A > B, E
Range	0–56	0–22	0–8	0–7	0–56	0–8		
PHYS Mean (SD)	0.9 (8.1)	1.6 (4.2)	0.6 (1.4)	1.3 (1.1)	1.0 (1.4)	0.4 (0.9)	NS ($p = 0.21$)	–
Range	0–14	0–14	0–6	0–3	0–4	0–3		
SCHED Mean (SD)	4.4 (6.1)	7.5 (11.1)	4.1 (3.9)	4.9 (3.9)	1.2 (1.8)	3.9 (6.1)	NS ($p = 0.18$)	–
Range	0–33	0–33	0–13	0–11	0–5	0–17		
LIFE Mean (SD)	1.0 (1.7)	1.5 (2.4)	1.3 (1.9)	0.3 (0.5)	0.5 (0.9)	0.4 (1.2)	NS ($p = 0.29$)	–
Range	0–7	0–7	0–6	0–1	0–2	0–4		
CM Mean (SD)	4.8 (7.8)	4.4 (5.6)	5.4 (4.0)	5.3 (3.9)	10.4 (19.0)	0 0	$p = 0.00005$	A, B, C, D > E
Range	0–56	0–16	1–16	0–10	0–56	–		
FAM Mean (SD)	0.7 (1.7)	1.1 (1.8)	0.7 (1.6)	1.3 (3.4)	0.1 (0.4)	0.3 (0.6)	NS ($p = 0.52$)	–
Range	0–9	0–6	0–7	0–9	0–1	0–2		
Treatment sessions by location								
Worksite: No. of sessions								
Mean (SD)	15.4 (37.6)	52.7 (44.4)	3.3 (7.2)	4.3 (9.6)	36.9 (77.8)	0.2 (0.9)	$p = 0.00005$	A > B, C, E
Range	0–223	0–140	0–29	0–26	0–223	0–3		D > E
% of all treatment at worksite								
Mean (SD)	22.8 (36.8)	77.8 (35.4)	10.4 (21.7)	9.9 (19.1)	34.0 (44.9)	0.4 (1.5)	$p = 0.00001$	A > B, C, D, E
Range	0–100	0–100	0–76	0–52	0–99	0–5		D > C, E
Clinic: No. of sessions								
Mean (SD)	7.0 (9.5)	1.9 (1.9)	8.2 (7.9)	13.3 (12.2)	1.5 (2.7)	9.0 (14.3)	$p = 0.007$	B, C > A, D
Range	0–43	0–5	0–29	0–34	0–8	0–43		

(*Continued*)

Table 2
(*Continued*)

	Overall	By center					Significance test results (overall)	Pairwise center differences at $\alpha = 0.05$
		A	B	C	D	E		
N	65	11	27	7	8	12		
% of all treatment at Clinic								
Mean (SD)	39.9 (37.0)	11.3 (21.5)	51.2 (33.2)	59.0 (37.4)	25.6 (40.6)	39.4 (40.0)	$p = 0.02$	B > A, D
Range	0–100	0–67	0–100	0–100	0–100	0–100		C > A
Other community: No. of sessions								
Mean (SD)	0.7 (4.0)	3.0 (9.6)	0.3 (0.6)	0	0.2 (0.7)	0 0	NS ($p = 0.33$)	–
Range	0–32	0–32	0–2	0	0–2	–		
% of all treatments in other community								
Mean (SD)	1.3 (5.4)	2.6 (8.1)	2.0 (6.5)	0 0	0.4 (1.1)	0 0	NS ($p = 0.31$)	–
Range	0–33	0–27	0–33	–	0–3	–		
Phone/Email: No. of sessions								
Mean (SD)	5.6 (6.7)	2.4 (4.5)	6.3 (8.1)	4.3 (4.3)	4.9 (5.0)	8.4 (6.2)	NS ($p = 0.08$)	–
Range	0–34	0–15	0–34	0–11	0–15	0–21		
% of all treatments on Phone/Email								
Mean (SD)	36.0 (36.2)	8.4 (14.1)	36.5 (33.3)	31.1 (35.4)	40.1 (41.9)	60.2 (40.3)	$p = 0.02$	A < B, E
Range	0–100	0–38	0–100	0–100	0–100	0–100		A < D ($p = 0.06$)

[a] Span of treatment = 0 means that participant received 1 day of treatment.

Results are displayed in Table 3. Only the GOSE scores and the emotional function scores failed to show significant differences by center. Compared to other sites, Centers A and D treated patients at a significantly longer time post injury, more than 2 years on average. In contrast, Centers B and C both provided services at a mean of less than 6 months post injury. Center E was intermediate with a mean of just over a year post injury, a significantly longer interval than Centers B and C. Consistent with its serving clients at a longer time post injury, Center A also placed proportionally more clients in "new" jobs – either jobs that were different from those held at the time of TBI, or jobs for clients who were previously unemployed – compared to two other centers (B, C).

Center A clients also reported significantly longer PTA durations than those at the other centers, except D. With regard to status at the time of placement, Center A had clients with significantly worse cognitive performance on both the CVLT and SDMT compared to 3 and 2 other centers, respectively. Center C, which placed clients primarily in pre-injury jobs at a mean of 4 months post injury, showed worse average memory scores than one other center (B).

Taken together with the treatment findings, these results suggested that the differences in treatments across centers could be related at least in part to disparities in case mix. Most notably, Center A, which offered the most intensive treatment, also treated clients with the longest PTA durations and the worst cognitive function at the time of placement, at the longest interval post injury; placed fewer of them at pre-injury jobs; and treated proportionally more who had been unemployed at injury. Center D also followed this general pattern. By contrast, Centers B, C, and E appeared to deliver a smaller number of interventions to relatively better-functioning clients, who tended to return to pre-injury jobs relatively soon after injury.

Even with this pattern emerging, it was still of interest to determine whether and how the allocation of treatments *within* centers was related to case mix. That is, did more severely injured/worse functioning clients at each Center receive more, or different, treatments than less affected clients at the same Center? Did clients with worse specific problems (e.g., emotional complaints) receive more treatments targeted to those problems? Ideally, one would conduct an analysis with attributes of individual participants nested within Centers, in order to deconfound generic Center differences from individual patient factors that determine service variations. However, this was not possible in the current study because the sample sizes for some of the centers were small, and because overlap between centers on certain patient factors was minimal.

As a feasible, although less powerful way to examine these questions, we rank-ordered scores on both case mix and treatment variables *within centers* and then adjusted the ranks by dividing them by the number of cases at each center (see also [41]). Spearman correlations on these adjusted ranks were then used to examine the associations between selected treatment variables, injury severity (PTA duration), and selected measures of functional level at the time of job placement. Analyses with the scores ranked in this fashion allowed for use of all of the data across centers because all scores were converted to ranks on a comparable scale from 0 to 1. It should be noted that this method emphasizes patient differences within each center, no matter how small, and obscures differences among patients across centers, no matter how large.

Results are displayed in Table 4. Although most correlations were in the expected direction (i.e., worse function associated with more treatment), the only statistically significant findings were found for cognitive speed as measured by the SDMT. This variable was negatively and significantly correlated with number of treatment days and number of treatment hours, such that participants with lower (worse) scores received more treatment. Although participants who scored lower on the SDMT were also more likely to receive a higher proportion of treatments at the worksite, this correlation did not reach significance.

The adjusted ranks were also used to examine whether the amount of treatment in two frequently used categories (COG and EMOT) was differentially related to presenting problems in cognitive versus emotional function. As above, the CVLT and SDMT scores were used as indices of cognitive function and the BSI-18 GSI score served as an index of emotional distress. As shown in Table 5, SDMT was significantly correlated with both COG and EMOT, in the same direction as its correlation with overall treatment. The emotional distress measure was correlated significantly with amount of emotional, but not cognitive, treatment. A *t*-test for dependent correlations confirmed that the GSI's correlation to EMOT was significantly stronger than its correlation to COG, suggesting that emotional dysfunction was correlated not with more treatment in general, but more treatment targeting emotional problems.

Table 3
Case mix variables, by TBIMS site

	Overall	By center					Significance test results (overall)	Pairwise center differences at $p = 0.05$
		A	B	C	D	E		
N	65	11	27	7	8	12		
Time post injury (Mo.)							$p = 0.001$	A > B, C, E
Median	7.4	26.5	4.6	3.8	30.7	13.6		D, E > B, C
Range	1.5–278.2	3.1–157.2	1.5–278.2	1.8–247.9	6.3–162.8	4.7–48.5		
Pre-injury vs. placement job							$p = 0.03$	A ≠ B, C
Same	40 (62%)	2 (18%)	19 (70%)	6 (86%)	5 (62%)	8 (67%)		
Different	19 (29%)	6 (55%)	6 (22%)	0	3 (48%)	4 (33%)		
Unemployed pre-injury	6 (9%)	3 (27%)	2 (7%)	1 (14%)	0	0		
PTA duration (days)								
Median	21	60	21	14	107.5	14	$p = 0.02$	A > B, C, E
Range	0–730	3–547	0.25–365	11–31	0–730	3–90		
GOS-E								
Mean (SD)	6.2 (0.9)	6.3 (1.1)	6.0 (0.6)	6.3 (1.4)	6.1 (0.8)	6.6 (0.9)	NS	–
Range	4–8	4–8	4–8	4–8	5–8	5–8		
CVLT-II trials 1–5 (T score)								
Mean (SD)	52.0 (15.1)	38.5 (11.1)	59.9 (13.5)	45.3 (16.3)	51.5 (11.4)	52.5 (13.7)	$p = 0.001$	A < B, D, E
Range	13–81	22–60	31–81	13–65	32–69	24–73		C < B
SDMT-W							$p = 0.02$	A < B, E
Mean (SD)	46.5 (13.6)	37.5 (12.0)	51.2 (12.0)	41.4 (12.4)	40.6 (14.5)	51.2 (13.6)		
Range	17–85	18–55	23–85	17–56	20–64	23–80		
BSI-18 GSI							NS	–
Mean (SD)	52.3 (7.8)	51.7 (7.7)	52.7 (7.9)	48.9 (10.9)	53.5 (6.9)	53.4 (6.7)		
Range	36–71	36–63	42–71	36–68	48–65	47–63		

Table 4
Correlations among treatment and case mix variables

	No. of treatment days	No. of treatment hours	% of Treatment at worksite
PTA Duration	0.14	0.24	0.17
Functional Status (GOSE)	–0.20	–0.15	–0.06
Cognitive Status			
Memory (CVLT)	–0.05	0.02	0.11
Speed (SDMT)	–0.33*	–0.44*	–0.19
Emotional Status			
(BSI-18 GSI)	–0.16	–0.07	–0.24

*$p < 0.05$.

Table 5
Correlations among specific treatments and presenting problems

	# COG treatments	# EMOT treatments	Difference between correlations
Cognitive status			
Memory (CVLT)	0.08	0.08	NS
Speed (SDMT)	–0.28*	–0.30*	NS
Emotional status			
(BSI-18 GSI)	–0.09	0.26*	$t = 3.41$ (df 59), $p < 0.005$

*$p < 0.05$.

3.3. *Question 3: Pattern and correlates of short term vocational outcomes by center*

Two participants were lost to follow-up, leaving a sample of 63 participants with 6-month outcomes data. Outcomes were compared across centers using analyses similar to those described for Questions 1 and 2. As shown in Table 6, neither the proportion of participants who were still employed at the placement job 6 months later, nor Job Satisfaction Scale scores, showed statistically significant differences across sites. However, the employment ratio differed by site, with mean ratios at Center E significantly higher than those of Centers A and C.

The small sample size, combined with the observed confounding between case mix and treatment variables, did not allow for a multivariable analysis (e.g., multiple regression) to determine predictors of vocational outcome in any meaningful way. For example, it was not possible to estimate the effects of treatment controlling for the effects of baseline cognitive status or injury severity, because both of those case mix variables were confounded with amount of treatment received. We explored the correlates of outcome grossly by comparing participants who had remained at the placement job throughout the study ($n = 48$) with those who had experienced at least one job turnover ($n = 15$). Mann-Whitney U tests showed that these two groups did not differ significantly as to the number of days they had received treatment ($p = 0.64$), the total number of treatment hours ($p = 0.52$), or the proportion of treatment administered at the worksite ($p = 0.20$).

4. Discussion

Despite the stated importance of vocational re-entry after TBI and the high need for vocational help perceived by consumers, relatively few persons with TBI get help to find or maintain employment [5]. Research is essential to establish the efficacy of vocational services so that more such services may be provided, but research in this complex area is hampered by both logistic and scientific challenges. More precise definitions of treatment components, and ways to measure them, are needed in every area of rehabilitation [14]. Recent systematic reviews have emphasized the importance of specifying treatment ingredients in areas of intervention that are frequently individualized, such as vocational rehabilitation [11].

In previous work examining treatment components of vocational rehabilitation within the TBIMS network [16] we found much variation among centers, from no services at all to comprehensive programs offering job readiness, job placement and supported employment. In the current study, we examined more closely and measured treatment components within one phase of services considered to be particularly crucial for people with TBI: services provided after job placement. To our knowledge, this is the first study to measure the treatment components that are considered important by job coaches and other staff involved in vocational treatment of TBI, such as the development of cognitive compensatory strategies and counseling on emotional issues, in "real time" as treatments are administered.

Table 6
Case mix variables, by TBIMS site

	Overall	By center					Significance test results (overall)	Pairwise center differences at $p = 0.05$
		A	B	C	D	E		
N	63	11	27	6	7	12		
Employment ratio							$p = 0.05$	E > A, C
Mean (SD)	0.75 (0.33)	0.61 (0.36)	0.75 (0.33)	0.55 (0.44)	0.83 (0.21)	0.90 (0.26)		
Range	0–1.0	0.04–1.0	0–1.0	0–1.0	0–1.0	0.11–1.0		
Job satisfaction scale							NS ($p = 0.12$)	–
Mean (SD)	4.7 (56)	5.0 (0.43)	4.6 (0.49)	4.5 (0.79)	4.4 (0.75)	4.9 (0.49)		
Range	2.8–5.5	4.2–5.0	3.7–5.5	3.8–5.4	2.8–4.9	4.1–5.5		
No. of (%) employed at placement job	48 (76%)	9 (82%)	21 (78%)	3 (50%)	6 (86%)	9 (75%)	NS ($p = 0.58$)	–

Even restricting our focus to 5 TBIMS centers that provided these post-placement services, we found a surprising degree of variation in the amount and types of interventions provided to study participants, and in the locations where treatments were delivered. In the 6 months following job placement, for example, the mean hours of treatment varied from 4 to 88 across centers, and the mean proportion of treatment delivered at the workplace ranged from less than 1% to more than 50%. Centers fell roughly into two clusters representing intensive treatment that included services at the workplace (2 centers) and less intensive treatment provided in a clinic setting, supplemented by phone contact (3 centers). Even within these clusters there was variation between centers. For example, one of the intensive/workplace treatment centers appeared to focus mostly on cognitive strategy training; the other provided equal amounts of cognitive and emotional/behavioral treatment, and used more case management than other centers. However, there was also considerable variation within each center, no doubt determined partly by the needs and situations of specific participants. Examination of the treatment variable ranges in Table 2 reveals that every center provided at least *some* treatment at the workplace, some at the clinic, and some by phone or email. Moreover, with one exception, all 8 categories of treatment were used for at least some participants at every center.

The observation that in general, centers clustered as to more or less intensive treatment might have provided a natural experiment for testing the effects of treatment intensity on outcomes. If case mix had proved to be similar across centers, then different outcomes might have been attributable to different mixes of treatment. However, we found that the centers providing less intensive treatment (and less treatment at the workplace) also tended to serve less impaired clients much closer in time to the injury, and mostly returned them to pre-existing jobs rather than engaging in job development. Thus, case mix variables were largely confounded with treatment. A model of less intensive, clinic-based treatment may be "sufficient" for clients with milder injuries and existing jobs, whereas the intensive treatment programs may have evolved to meet the needs of a more chronic and more severely injured clientele.

As with the differences in treatment type and location, the center differences in case mix were not absolute: inspection of Table 3 confirms that all centers served clients at a fairly wide range of time post injury, and all but one center helped at least some clients find new employers. Within centers, participants who demonstrated worse cognitive speed prior to job placement tended to receive more treatment overall, and more treatment in both cognitive and emotional/interpersonal domains. In contrast, greater emotional distress prior to job placement predicted amount of emotional/interpersonal treatment received, but not cognitive or overall amount of treatment. These findings suggest that assessment at the point of job placement might help predict the amount and, in the case of emotional complaints, the types of treatment necessary to promote early job success. Interestingly, new learning ability as measured by the CVLT-2 was not associated with either treatment type or amount. Our findings with regard to cognitive speed support previous work suggesting that cognitive speed is a particularly important neuropsychological factor in return to employment after TBI [19] whereas memory impairment has generated mixed evidence [6].

Given the confounding between client characteristics and treatments, and the apparent lack of relationship between outcomes and treatments, the differences in vocational outcomes across centers are difficult to interpret. For example, the center with the highest mean employment ratio (>90%) also treated clients whose neuropsychological test scores were higher than the overall sample mean, and whose PTA durations were shorter than the overall average. Another factor affecting the interpretation of outcomes is that participants were only followed for 6 months after job placement. Longer term outcomes are also important to study in TBI because problems may arise only when changes occur on the job, including turnover in supervisors, coworkers or other natural supports, and/or when the job coach or counselor is no longer available to troubleshoot [27].

Other limitations of this study must be borne in mind when interpreting results. The sample size was quite small, especially considering the samples from single centers, and it is entirely possible that different findings by center could emerge after a different sampling period. Future studies with a larger sample size might permit statistical adjustment for confounding between case mix and treatment, of the type used in large-scale observational studies examining treatment effects in rehabilitation [13]. Moreover, there were indications that the current sample may not be representative of people with TBI who need help to find or maintain employment. Our sample was well educated, with 65% having attended at least some college, compared to about 1/3 of the TBIMS sample overall [31]. The majority were not only employed at the time of injury, but

were returning to pre-injury employers. People with TBI with more limited education and employment history may be at higher risk of chronic unemployment post injury, but may also have difficulty accessing vocational services [30].

The measurement of treatment components was also limited in several ways that could influence the results. First, by design we examined only vocational services that were provided after job placement. In most cases, this meant examining only a portion of the services received by participants during a course of vocationally oriented treatment. Further research is needed to measure and examine the impact of the whole continuum of clinical services including pre-placement treatments such as job readiness training, job development, protected work trials, etc. Secondly, while the treatment form developed for the study was pilot tested and informed by clinical expertise, it was not systematically validated using external sources of data. Treatment forms were cross-checked where feasible against billed services, but there was no way to confirm that treaters recorded brief, unbilled contacts accurately, or that such contacts were being remembered and recorded equally consistently across centers. In addition, while we attempted to standardize how treaters assigned the treatment categories by providing definitions and brief training, we cannot be certain that different treaters were assigning categories in exactly the same way. Finally, there was no external validation of the content of the categories, such as an observer spot-checking to confirm that a session contained cognitive strategy training, schedule management, co-worker education, etc. Future research should focus on the external validation of the use of the various treatment categories and on more extensive evaluation of the completeness and accuracy of data recording.

Within these limitations, the descriptive findings on categories of treatment are of interest and should be followed up with further study. Overall, the most frequently used treatment categories were cognitive compensatory strategy training, case management, and worksite accommodations having to do with scheduling and responsibilities. The greater use of the last category compared to physical accommodations at the worksite confirms the observation that for TBI, cognitive limitations often contribute to restrictions in participation at least as much as physical difficulties [9]. Other treatment categories with more than 3 episodes per client on average included emotional/behavioral intervention and supervisor or employer education. The light use of the family intervention category (<1 session or contact per client, on average) was somewhat surprising given that involvement of the family or other social support network is considered by many clinicians to be important to vocational success in this population. Perhaps only limited family involvement was needed in this sample because many were returning to pre-injury jobs, thus necessitating less adjustment in the family system. Alternatively, funding or staffing limitations in the participating centers may have limited involvement of the family in the vocational treatment plan. Future research on a larger sample from a varied set of treatment providers is needed to assess whether family involvement and support services are indeed only a small component of supported employment. In addition, it would be useful in further research to examine the types and intensities of services as they relate to the degree of job modification afforded to different participants. Different patterns of treatment could well be needed to support jobs that are essentially identical to competitive jobs (e.g., because they are not modifiable or clients are not considered to need significant modifications) versus jobs that can be "sculpted" in various ways to offer reduced hours, lesser responsibility, etc.

The findings of this study have clinical implications, especially if they are confirmed by other studies using larger samples. The disparity in treatment components across clinical sites – even those with a long-term specialization in TBI treatment – strongly suggest that specific interventions such as on-site coaching or case management cannot be assumed to be available for clients referred for vocational services after placement. Another clinical implication concerns the suggestion that reduced cognitive speed is associated with higher treatment intensity – presumably due to higher need for services. While any neuropsychological impairment (or combination of impairments) may be important considerations when creating a treatment plan, clinicians may wish to devote particular attention to assessing cognitive speed, educating employers about the consequences of slowed information processing, and developing strategies for helping clients compensate for this problem on the job.

Further research to specify and define rehabilitation treatments, so that they can be reliably measured, is important for both research and clinical practice. For the clinic, having agreed-upon definitions of treatment that define the scope of practice is an aid to communication among treaters from different sites and disciplines, and an important tool for planning and monitoring the use of clinician time. For research, measurement of treatment is essential to the goal of linking treatments to

outcomes, i.e., determining which treatments "work" for which clients. Future research on the effectiveness of specific treatment models may help to standardize the treatments offered so that clients with TBI are more likely to receive evidence-based services that will meet their needs.

As with most areas of brain injury rehabilitation, it is unlikely that one treatment model is optimal for patients with varied patterns of deficits and strengths. Indeed, as mentioned, the evolution of different types of programs at different sites may have been driven, at least in part, by perceptions of the clinical needs of clients "typical" of each site. Ultimately, the field can benefit from more explicit guidance regarding how to select the optimal mix of available services for an individual client based on cognitive, physical, emotional, and pre-injury characteristics. Arriving at this type of treatment assignment algorithm will require large scale studies that allow examination of the interaction between client features and program features.

5. Summary

Specification of treatment components and their active ingredients is important for all areas of rehabilitation. Both experimental and observational studies must measure treatments so as to estimate their effects over and above case mix factors known to affect outcomes. In this observational study we designed an instrument to measure vocational services delivered after job placement for persons with moderate to severe TBI, and examined some correlates of amount and types of treatments. The 5 centers involved in this study differed substantially as to the types and locations of vocational interventions they provided over a 6-month period; these differences were largely confounded with case mix factors such as severity of injury, time post injury, and placement on a new versus existing job. Within centers, cognitive speed and emotional distress predicted certain aspects of amount and type of treatment provided. Further research with larger samples is needed to examine the specific effects of treatment on vocational outcomes.

Acknowledgements

This work was supported by Grants #H133A020505, H133A070040, H133A020501, H133A020508, H133A020518, and H133A070033 from the National Institute on Disability and Rehabilitation Research, U.S. Department of Education. We thank Caron Morita, Rebecca Hardin, Aaron Scrol, Joyce Leverenz, Eileen McLaughlin, Clare Morey, Rosanne Sevinsky, Jean Tyler, Jennifer Cotter, and the staff of the TBI Model System National Data and Statistical Center for assistance in data collection and management. Mark Sherer, Mark Hirsch, and Eugene Komaroff provided helpful input at various stages of project and manuscript development. Megan Bartlett assisted with manuscript preparation.

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