

Substance Abuse as a Mediating Factor in Outcome From Traumatic Brain Injury

John D. Corrigan, PhD

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• A review of recent research addressed two questions: how common are problems of substance abuse in traumatic brain injury (TBI), and to what extent does alcohol and other drug use mediate outcome? Studies showed alcohol intoxication present in one third to one half of hospitalizations; data for other drug intoxication were not available. Nearly two thirds of rehabilitation patients may have a history of substance abuse that preceded their injuries. Intoxication was related to acute complications, longer hospital stays, and poorer discharge status; however, these relationships may have been caused by colinearity with history. History of substance abuse showed the same morbidity, and was further associated with higher mortality rates, poorer neuropsychological outcome, and greater likelihood of repeat injuries and late deterioration. The effect of history may be caused by subgroups with more severe substance abuse problems. Implications for rehabilitation are discussed, including the potential negative impact of untreated substance abuse on the ability to document efficacy of rehabilitation efforts.

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Alcohol and other drug abuse in our society results in a significant cost in human life and financial resources. There is growing recognition that substance abuse among persons with disabilities is as prevalent as in the general society, if not more so.¹ Knowledge about substance abuse among persons with disability is lacking, however, and unique aspects of intervention are still largely unaddressed.²

Among disability groups with unique issues of substance abuse are individuals who have experienced traumatic brain injury (TBI). Before publication of the White Paper on substance abuse and head injury by the Substance Abuse Task Force of the National Head Injury Foundation,³ the relationship between intoxication and TBI was recognized, but there was little mention of substance abuse as a mediating factor in rehabilitation outcomes. Recent studies have sensitized the rehabilitation community to substance abuse in this population;⁴⁻⁷ there are, however, significant gaps in our understanding of the incidence, impact, and secondary prevention of substance abuse after TBI.

We reviewed recent research reports to address two salient questions for rehabilitation professionals who work with persons with TBI. First, how common is substance abuse in this population, especially among those receiving rehabilitation? Second, to what extent does alcohol and other drug use mediate outcome from TBI? Our purpose was to improve the effectiveness of rehabilitation outcomes, as well as the long-term quality of life for this population.

From the Department of Physical Medicine and Rehabilitation, The Ohio State University, Columbus, OH.

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Reprint requests to John D. Corrigan, PhD, Dodd Hall, 480 W. 9th Ave, Columbus, OH 43210.

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INTOXICATION AND HISTORY OF SUBSTANCE ABUSE

Table 1 summarizes 11 research reports, published mostly in the last 5 years, that examined either alcohol intoxication, or a history of substance abuse among persons who experienced TBI. We attempted to include any studies of North American samples that examined the incidence or effects of either intoxication or history. A Medline search was conducted of any pairing of the words "alcohol intoxication," "alcohol abuse," "drug abuse," "substance abuse," or "alcoholism," with the words "brain injury," or "head injury." Because the alcohol or other drug findings from epidemiologic studies of TBI may not have been noted in the title, abstract or key words, prospective studies of North American samples were reviewed also. Several studies mentioned substance use as a causative factor, but could not be included because they lacked sufficient information on study methods. For instance, Desai and colleagues⁸ reported that 54% of patients with TBI admitted to Cook County Hospital in Chicago had been using alcohol, but the method of detection, particularly of the blood alcohol content, was not reported. For this review, we limited studies of intoxication to those that relied on contemporaneous measures of blood alcohol content. Several articles investigated the incidence or effect of substance use in trauma populations, but did not separate out TBIs. For instance, Jurkovich and coworkers⁹ described the effects of both intoxication and a history of substance abuse in a prospective sample of 2,559 admissions to a trauma unit, but did not report, nor separately analyze, the proportion that were TBIs. Trauma center admissions often include half or fewer TBIs; thus, the current review was limited to samples of patients reported to have incurred TBI.

Sampling Methods

Three studies collected data on consecutive acute hospital admissions. Gurney and coworkers¹⁰ conducted a prospective study of admissions to the trauma unit at Harborview

Table 1: Intoxication and Substance Abuse Associated With TBI

Authors	Sample	BAL 100 mg/dL (%)	BAL Tested (%)	History of Substance Abuse (%)
Gurney ¹⁰	520 trauma center admits (≥ 18 years old, CHI only, hospital stay > 1 day)	37%	(75%)	Not reported
Kraus ¹¹	2,649 residents of an urban county hospitalized for, or died of, TBI in 1981 (≥ 15 years old)	49%	(43%)	Not reported
Sparadeo ¹²	85 trauma center admits (18 to 60 years old, not DOA)	51%	(83%)	Alcohol 25% (reported in medical record)
Rimel ¹³	737 trauma center admits (not severe, CHI only, not SCI, 93% ≥ 11 years old)	47%	(85%)	Alcohol 16% (patient or family interview on admission)
Ruff ¹⁴	664 cases in the Traumatic Coma Data Bank (≥ 15 years old, not GSW, not DOA)	36%	(61%)	Alcohol 44%, Drug 13% ("regular" or "excessive" used reported by a relative)
Gordon ¹⁵	325 cases in the TBI Model Systems database (≥ 16 years old)	51%	(62%)	Not reported
Kaplan ¹⁷	129 consecutive admits to a TBI rehabilitation unit (15 to 55 years old)	38%	(68%)	Not reported
Drubach ¹⁶	322 consecutive admits to a TBI rehabilitation unit (average age 34.7 years)	Not reported		Alcohol 62%, Drug 37% (clinical interview)
Wong ¹⁸	498 consecutive admits to a TBI rehabilitation unit (≥ 18 years old)	Not reported		Alcohol 37%, Drug 9% (reported in medical record)
Kreutzer ¹⁹	74 clients referred for supported employment (average age 30.9 years, average time post 6.4 years)	Not reported		Alcohol 66% Pre-injury, 28% Postinjury (Moderate/Heavy QFVI) Drug 36% Pre-injury, 40% Postinjury ("yes" to "use" on GHHQ)
Kreutzer ²⁰	87 patients seen in outpatient medical clinic (average age 31.6 years, average time post 4.0 years)	Not reported		Alcohol 58% Pre-injury, 20% Postinjury (Moderate/Heavy QFVI)

Abbreviations: CHI, closed head injury; DOA, dead on arrival; SCI, spinal cord injury; BAL, blood alcohol level; GSW, gunshot wound; QFVI, Quantity Frequency Variability Index.

Medical Center in Seattle. As in most of the studies reported, a minimum age was established; in this case, subjects were 18 years of age or older. The sample was based on 16 months of data collection, and was restricted to closed head injuries with lengths of stay longer than one day. Kraus and colleagues¹¹ collected data on all residents of San Diego County, CA who were hospitalized for, or were dying from, TBI in 1981. A minimum age of 15 years was set for this sample. Sparadeo and Gill¹² conducted a retrospective study of 85 admissions to a large trauma center in Rhode Island during a 1-year period. The sample was restricted to persons 18 to 60 years old and those who were not dead on arrival.

Two studies reported findings based on trauma center samples with restricted ranges of TBI severity. Rimel and colleagues¹³ reported 199 cases of moderate TBI (Glasgow Coma Scale 9 to 12 at 6 hours postinjury) admitted to the University of Virginia Medical Center during a 20-month period. The authors also provided comparisons to a series of 538 minor TBIs admitted during the same time period (and in some instances, comparisons were made with 260 severe TBIs from their database). These samples had no age restrictions, though adolescents and adults comprised the majority of patients. Patients with penetrating injuries or concomitant spinal cord injury were excluded. Ruff and coworkers¹⁴ reported substance abuse characteristics of cases drawn from the Traumatic Coma Data Bank, a four-center project that collected data over 7 years on more than 1,000 severely head injured patients. Their study was restricted to persons 15 years of age and older, and it excluded patients with gunshot wounds and persons who were dead on arrival at the hospital. Because this database focused on patients with TBIs severe enough to result in coma, this sample may be similar to patients in rehabilitation settings than other acute hospital samples previously described.

Four studies examined populations receiving acute rehabilitation for TBI. Gordon, Mann, and Willer¹⁵ provided data on 325 cases from the National Institute on Disability and Rehabilitation Research, TBI Model Systems database. Included were individuals who were treated in one of the participating rehabilitation facilities and were at least 16 years old. Drubach and coworkers¹⁶ conducted a prospective study of 322 patients admitted over a 4-year period to a specialized brain injury rehabilitation unit serving Baltimore, MD. Although the age range was not reported, the average age of this sample suggests that children were not routinely admitted. Kaplan and Corrigan¹⁷ and Wong and coworkers¹⁸ conducted retrospective studies based on consecutive admissions to specialized brain injury rehabilitation units serving Columbus, OH, and Toronto, Ontario, respectively. Kaplan and Corrigan studied 129 consecutive admissions between 15 and 55 years old. Wong¹⁸ studied 498 consecutive admissions aged 18 years and older.

Two additional studies used in this portion of the review were based on samples drawn from persons receiving services after acute rehabilitation. Kreutzer and coworkers¹⁹ reported on 74 clients who experienced TBI and were referred to a supported employment program at the Medical College of Virginia. This sample had an average age of almost 31 years, and averaged slightly more than 6 years postinjury. Kreutzer and colleagues²⁰ reported on 87 patients seen in an outpatient medical rehabilitation clinic, with an average age of more than 31 years, and averaging approximately 4 years postinjury.

Intoxication at Time of Injury

To examine the coexistence of substance use and TBI, the studies were first reviewed for the incidence of intoxication at time of injury. Intoxication was limited to alcohol,

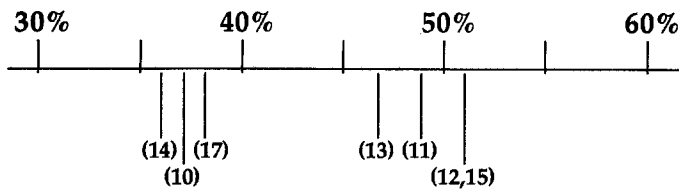


Fig 1—Distribution of findings for alcohol intoxication.

as no studies reported screening for other drugs. In each study, intoxication was defined as a blood alcohol level equaling or exceeding 100mg/dL, which is the legal limit for intoxication in most states in the United States. Figure 1 shows the distribution of reported incidence of intoxication in the seven studies that evaluated this variable. Results ranged from 36% to 51% and suggested a bimodal distribution. Three of the studies clustered just above 35%, and the remaining four clustered at 50%.

There was no apparent explanation for this bimodal distribution. Kraus and colleagues¹¹ suggests that systematic bias in the percentage of intoxication found can be caused by the percentage of persons tested. In their sample, they observed a tendency for persons with more severe injury not to be tested for blood alcohol content; thus, the true incidence rate may be underestimated. Table 2 shows the percentage of patients tested for blood alcohol content and the percentage found to be intoxicated in each study reviewed here. No systematic effect is apparent. Rimel and coworkers¹³ tested the highest percentage (85%), and found 47% intoxicated; Kraus and colleagues¹¹ tested the lowest percentage and found 49% intoxicated. Between these extremes, no systematic effect for percent was found.

A second hypothesis for the bimodal distribution asked whether results found for samples of acute hospital admissions differed systematically from rehabilitation hospital and traumatic coma samples. Gurney¹⁰ found 37%, whereas the three other acute hospital samples clustered in the 50% range.¹¹⁻¹³ The traumatic coma sample,¹⁴ and Kaplan and Corrigan's rehabilitation sample,¹⁷ also found just over 35%; whereas results from the TBI Model Systems rehabilitation sample were in the higher range.¹⁵ These findings did not indicate a systematic difference between samples from acute and rehabilitation hospitals.

Other characteristics of the samples and settings, including age restrictions, inclusion of penetrating injuries, multicenter versus single center samples, and sample size, did not explain the bimodal distribution. Unique characteristics of the populations served by specific facilities could not be evaluated from the research reports, nor could regional differences in alcohol consumption be isolated for comparison. Thus, the answer to the question, "How many adolescents and adults hospitalized after TBI are intoxicated at time of injury?" is equivocal. From one third to one half of persons hospitalized are intoxicated by alcohol, and there were no data about those under the influence of other drugs.

History of Substance Abuse

The second part of evaluating the coexistence of substance use and TBI was to examine the history of alcohol or other

drug abuse in this population. Less research has been conducted on this aspect of substance use, though 7 of the 11 studies reported some findings. Two of the studies of hospital admissions^{12,13} investigated a history of alcohol abuse, and the research from the Traumatic Coma Data Bank examined both alcohol and other drug abuse histories.¹⁴ Four of the studies of rehabilitation populations^{16,18-20} studied the history of alcohol abuse, with three of the four also examined other drug abuse.

The method for detecting a history of substance abuse varied greatly among the studies. Ruff and coworkers¹⁴ posed two questions to close relatives of patients early in their hospitalization following traumatic coma. Relatives indicated whether the injured person's use of alcohol and/or other drugs was "none," "occasional," "regular," or "excessive." Responses of "regular" or "excessive" were considered indicative of a history of alcohol or other drug abuse. Sparadeo and Gill¹² and Wong¹⁸ reviewed medical records for notations of abuse. Rimel¹³ apparently used patient or family interviews to extract information about history of alcohol abuse, but the procedure was not described. It is not clear whether the interview was part of the standard history and physical, whether a specific inquiry was made, or what criteria were used to determine the presence of abuse. In the Drubach and coworkers¹⁶ study, history of alcohol and/or other drug abuse was determined prospectively by an experienced neuropsychologist using clinical interview and review of the medical record and social history taken from a family member. Kreutzer and colleagues²¹ used an adaptation of the Quantity-Frequency-Variability Index (QFVI) completed by a relative to judge preinjury alcohol consumption.^{19,20} The QFVI inquires as to the frequency of drinking occasions, quantity consumed, and variability of quantity consumed from occasion to occasion. This information allows classification of use by abstinence, infrequent, light, moderate, or heavy categories, and can be compared with national norms. Patients in the moderate and heavy categories were considered to have had an alcohol history. Kreutzer and coworkers¹⁹ also reported the incidence of a history of other drug abuse based on an affirmative answer to a question about the use of illicit drugs.

In the four studies that investigated the history of other drug abuse, results ranged from 9% found by retrospective medical record review to 37% identified through clinical interview.^{14,16,18,19} The Traumatic Coma Data Bank found that 13% of relatives reported regular or excessive use of other drugs by their injured family member,¹⁴ a finding similar to Wong¹⁸ Kreutzer and colleagues^{14,19} found 36% of relatives reported any illicit drug use, comparable data from

Table 2: Percent Tested and Percent Intoxicated

	Tested (%)	Found (%)
Rimel ¹³	85	47
Sparadeo ¹²	83	51
Gurney ¹⁰	75	37
Kaplan ¹⁷	68	38
Gordon ¹⁵	62	51
Ruff ¹⁴	61	36
Kraus ¹¹	43	49

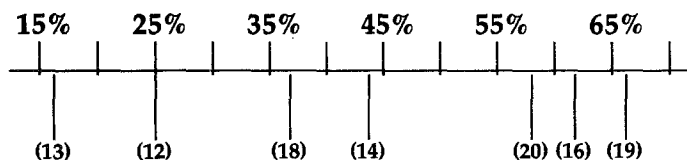


Fig 2—Distribution of findings for prior history of alcohol abuse.

the Traumatic Coma Data Bank indicated that 21% of relatives reported any use. Little can be derived from these studies because of their small number, differences in methods of detection, and variability in the findings.

Figure 2 shows the distribution of findings for the seven studies that investigated history of alcohol abuse. Again, significant variability was evident as results ranged from 16% to 66%. However, sources of systematic bias may have been evident. Two of the three lowest percentages of alcohol abuse history were found in studies that used retrospective medical record review, ie, Sparadeo and Gill¹² and Wong and colleagues.¹⁸ In the third and lowest, it could not be determined whether the method used was any more sensitive than relying on medical records.¹³ Stigma and denial can have a strong influence on whether a history of substance abuse is spontaneously revealed to a health care professional, particularly by the patient. Lack of experience in assessing substance use can result in undetected or underestimated judgments of its presence.

The remaining four studies used prospective methods with explicit inquiry, usually of a family member only or a family member and the patient. Findings from these studies ranged from 44% to 66%, substantially less variance than that found when less reliable methods are included. The three highest rates were found in rehabilitation samples, Drubach and coworkers inpatient rehabilitation study and Kreutzer and colleagues two posthospitalization samples.^{16,19,20} The data suggests that 50% to 66% of people hospitalized for TBI have a history of alcohol or other drug abuse. While there is only one study of acute rehabilitation admissions,¹⁶ results from this study and those by Kreutzer and colleagues^{19,20} suggest a higher incidence among rehabilitation populations.

EFFECT ON OUTCOME

Whatever the prevalence of the problem, the effect of substance abuse on outcome is a salient issue. Table 3 summarizes major findings regarding intoxication and history of substance abuse as mediating factors in outcome from TBI. Risk ratios were calculated when possible to provide a comparison of the extent to which intoxication or substance abuse history increased the likelihood of a related event or condition. Three studies of hospital admissions,¹⁰⁻¹² as well as the findings from the National Traumatic Coma Data Bank,¹⁴ examined the relationship between intoxication and mortality and morbidity. In the latter study, the mediating effect of history of substance abuse was also investigated.¹⁴ Morbidity generally included the development of complications, hospital length of stay, and functional status on discharge from the acute hospital. Sparadeo and Gill¹² also examined the relationship with duration of agitation.

Three of the four studies of brain injury rehabilitation

admissions examined the effects of substance abuse on indicators of injury severity, including Glasgow Coma Scale score, length of posttraumatic amnesia, and acute and rehabilitation hospital lengths of stay.¹⁶⁻¹⁸ Lehmkuhl and coworkers²² examined these measures in the TBI Model Systems sample studied by Gordon, Mann, and Willer.¹⁵ Kaplan and Corrigan¹⁷ also tested the relationship between intoxication at time of injury and neuropsychological performance on clearing posttraumatic amnesia. In addition to indicators of morbidity, Wong and colleagues¹⁸ and Drubach and colleagues¹⁶ provided descriptive information regarding cause of injury and history of substance abuse, including likelihood of previous TBI.

Two additional studies investigated substance abuse as a mediating factor in outcome from TBI. Dikmen and coworkers²³ studied the neuropsychological functioning of 412 subjects admitted to Harborview Medical Center. History of substance abuse was defined using the Short Michigan Alcohol Screening Test (SMAST).²⁴ The SMAST is a 13-item, self-administered abbreviation of the 25-item MAST,²⁵ one of the most widely used screening instruments for alcohol abuse. On the SMAST, abusers were those who responded in the problem direction for three or more items. Subjects represented the full range of severity of brain injuries and received neuropsychological assessments at 1 month and 12 months postinjury. A comparison sample of subjects without brain injury was assessed twice as well, with an 11-month interval between assessments.

Dunlop and coworkers²⁶ studied 34 subjects who showed evidence of emotional and functional deterioration 6 months or more following TBI. Subjects were drawn randomly from 193 TBI cases “. . . included in the application files of a large federal disability program.” Demographic and injury-related data were extracted from case files and rated by psychiatrists or psychologists for the mental disorders, and by neurologists or neurosurgeons for neurological disorders. Deterioration was defined as an increase of two or more points on a modified version of the Neurobehavioral Rating Scale.²⁷ The 34 consecutive cases showing deterioration were compared with 34 cases matched for severity of initial neurobehavioral impairment but showing improvement after 6 months.

Intoxication at Time of Injury

Table 4 summarizes findings from these 11 studies by categorizing the results into the presence or absence of an effect on outcome for intoxication and history. This compilation is considerably less satisfying than meta-analytic procedures; however, the differences among the available studies in sampling methods, criterion variables, and statistical analyses did not allow objective methods of summarization. Studies of intoxication were almost evenly split between those finding a relationship with poorer outcomes, and those finding no relationship. Gurney and coworkers¹⁰ found that those intoxicated were more likely to require intubation, develop pneumonia, and have respiratory distress. Kraus¹¹ found greater neurological impairment at discharge among those intoxicated, whereas Sparadeo and Gill¹² found those intoxicated had longer duration of agitation, and lower Rancho Level of Cognitive Functioning at acute hospital discharge. Finally, Kaplan and Corrigan¹⁷ found longer duration

Table 3: Intoxication, Substance Abuse, and Outcome From TBI

Authors	Findings
Gurney ¹⁰	Intoxicated patients more likely to require intubation (RR = 1.3), develop pneumonia (RR = 1.4), and have respiratory distress (RR = 1.8). Within subgroups of patients with complications, intoxicated had longer LOS.
Kraus ¹¹	Intoxication more likely among 25 to 44-year-olds (RR = 1.3), those involved in MVAs (59%) or assaults (50%). Injury severity and mortality inversely related to intoxication.
Sparadeo ¹²	Among more severe injuries, intoxication associated with neurological impairment at discharge (RR = 1.4). Intoxication associated with longer duration of agitation, lower cognitive status at discharge.
Dikmen ²³	Intoxication and alcohol history highly related (RR = 9.7). Alcohol history more likely in those ≥ 40 years old (RR = 3.0). Men with lower educational level more prevalent in substance abusers; more severe substance abuse associated with lower income and pre-existing psychiatric condition.
Rimel ¹²	Main effects but no interaction between traumatic brain injury and substance abuse on neuropsychological performance. Effect on substance abuse on neuropsychological performance less when age, education, and gender differences accounted for. Posit subgroup of low education, severe substance abuse, and neuropsychological impairment.
Ruff ¹⁴	Alcohol history associated with lower SES and less education Greater likelihood of alcohol history among moderate versus minor injuries (RR = 3.4). Intoxication related to history of excessive alcohol use (RR = 1.9). No apparent relationship between drug use and outcome. History of excessive alcohol use increased mortality (RR = 2.3), increased likelihood of mass lesion (RR = 1.7), decreased likelihood of GOS "Good" outcome (RR = 2.9).
Lehmkuhl ²⁴	No apparent, independent relationship between intoxication and outcome. No relationship between intoxication and severity. Controlling for severity, no relationship between intoxication and either acute care or rehabilitation LOS.
Kaplan ¹⁷	Patients without BAL tested had 16 days longer acute LOS and 15 days longer time to rehabilitation admit. Intoxicated patients had 15 days longer PTA (though difference not statistically significant, $p < .05$). Time to rehabilitation admit 10 days longer for intoxicated patients.
Drubach ¹⁶	No differences in neuropsychological performance for intoxicated group. 47% with alcohol history also had other drug history; 78% with other drug history also had alcohol history. History of drug abuse associated with younger age, less education, more likely injured by intentional violence (RR = 2.1). No difference between those with substance abuse history and those without on initial GCS, length of PTA, acute LOS, or rehabilitation LOS.
Wong ¹⁸	Patients with substance abuse history more likely to have previous TBI (RR = 2.1). History of alcohol and drug use associated. Men (RR = 2.5), men aged 30 or older (RR = 1.9), unemployment (RR = 1.9), and less than 12th grade education (RR = 1.6) associated with alcohol abuse history.
Dunlop ²⁶	Patients with previous TBI more likely to have alcohol histories (RR = 1.7). Gender by alcohol history by cause of TBI interaction: falls in men more likely to be substance abuse related (RR = 2.1). SSI/SSDI applicants who deteriorated after at least 6 months postinjury more likely to have alcohol history (RR = 2.0), TBI caused by assault (RR = 3.4), skull fracture (RR = 1.7), and left parietal lesion (RR = 3.2) when compared with a group matched for severity without deterioration. Agitation/hostility (RR = 6.8), lability of mood (RR = 8.8), emotional withdrawal (RR = 7.3), depression (RR > 28.0), loss of insight (RR > 23.0), and disinhibition (RR > 17.0) most likely to worsen in deterioration group.

Abbreviations: RR, risk ratio; MVA, motor vehicle accident; PTA, posttraumatic amnesia; GOS, Glasgow Outcome Scale; BAL, blood alcohol level; LOS, length of stay; GCS, Glasgow Coma Scale; SES, socioeconomic scale; SSI, Social Security Income; SSDI, Social Security Disability Insurance.

from injury to rehabilitation admission, as well as a trend for longer posttraumatic amnesia among those intoxicated when compared with those without alcohol present.

Ruff¹⁴ and Kraus¹¹ found no relationship between intoxication and mortality, and the former study found no relationship with morbidity. Kraus¹¹ reported greater neurological impairment at discharge for those intoxicated, though this same study found that indices of both mortality and severity were inversely related to the presence of intoxication. Lehmkuhl²⁴ found no relationship between intoxication and severity of injury; within severity groups, no relationships to acute or rehabilitation hospital lengths of stay were evident. Kaplan and Corrigan¹⁷ found no difference between those intoxicated and those without alcohol present on neuropsychological testing conducted on clearing of posttraumatic amnesia.

History of Substance Abuse

In contrast to the findings for intoxication, Table 4 shows only one study that reported the absence of an effect on

outcome for history of substance abuse. This is in contrast to the findings for intoxication. Drubach¹⁶ found no differences on indices of injury severity between rehabilitation patients with and without a history of substance abuse. However, the Traumatic Coma Data Bank study¹⁴ found a significant relationship with mortality, presence of complications, and functional outcome at discharge. In this study, the effects were caused by a subgroup of those positive for a history of substance abuse who seemed to be more severe abusers. Subjects reported to have "excessive" use histories (versus those "regular" or "excessive") showed greater mortality, greater likelihood of mass lesion, and less likelihood of attaining a "good" outcome on the Glasgow Outcome Scale at discharge.¹⁴ Dikmen²³ found a poorer neuropsychological performance at both 1 month and 1 year testing for those with a substance abuse history. Much of the effect was attributable to subjects who had higher SMAST scores and showed more chronic patterns of abuse.

Rimel¹³ found a higher incidence of a history of alcohol abuse among moderate versus minor TBI groups (as well as those with severe versus moderate injuries). These groups

Table 4: Alcohol as a Mediating Factor in Outcome From TBI

Intoxication	History
Effects outcome	“Excessive” use related to mortality, likelihood of mass lesion, unlikely GOS “Good” outcome ¹⁴
More likely to require intubation, develop pneumonia, have respiratory distress ¹⁰	
Among more severe, intoxicated had greater neurological impairment at discharge ¹¹	Poorer neuropsychological performance 1 month and 1 year post, especially subgroup of most severe abusers ²³
Longer agitation, lower RLCF at acute hospital discharge ¹²	More likely to have multiple TBIs ^{16,18}
Longer time to rehabilitation admit, trend for longer PTA ¹⁷	More likely to show deterioration after 6 months ²⁶
	Greater likelihood of alcohol abuse history among more severely injured ¹³
Does not effect outcome	No difference in initial GCS, length of PTA, acute LOS, rehabilitation los ¹⁶
No relationship to mortality or morbidity ¹⁴	
Mortality and severity inversely related ¹¹	
Not related to severity. Within severity groups, not related to acute or rehabilitation los ²⁴	
No effect on neuropsychological performance on clearing PTA ¹⁷	

Abbreviations: RLCF, Rancho Los Amigos Levels of Cognitive Functioning; PTA, posttraumatic amnesia; GOS, Glasgow Outcome Scale; GCS, Glasgow Coma Scale; LOS, length of stay.

also showed differences in pre-injury education, employment, and socioeconomic status, with greater severity associated with lower premorbid status. Dunlop²⁶ found that those deteriorating after 6 months postinjury were more likely to have had a history of substance abuse. Resumption of substance use may have been responsible for this difference although, another possible source of mediating effects could be impairment caused by re-injury. Two studies of rehabilitation samples found that those with a history of substance abuse were more likely to have had multiple TBIs.^{16,18}

Intoxication at time of injury and history of substance abuse have been found to be significantly related, raising the question whether the effects that have been observed between intoxication and outcome are caused by the effect of substance abuse or vice versa. Ruff¹⁴ reported a significant coexistence. Sparadeo and Gill¹² reported that 95% of their subjects with a history of alcohol abuse also showed positive blood alcohol levels (though not necessarily intoxicated levels). In the only study that investigated the relationship to outcome of both history and intoxication, the results were clear. Ruff¹⁴ found no relationship between intoxication and mortality or morbidity, whereas significant effects of history were observed. These results suggest that the mixed findings for intoxication as a mediating factor in outcome may be caused by its colinearity with history of substance abuse. Further, persons with a history of substance abuse, particularly more severe histories, may be more likely to have worse outcomes following TBI, at least in terms of the short-term indicators of outcome reviewed here. To the extent that history of substance abuse influences disability, greater weight may need to be given to the earlier suggestion that persons

with TBI treated in rehabilitation settings may have a higher incidence of prior substance abuse history than that found in acute hospital samples.

IMPLICATIONS FOR REHABILITATION

Adequate studies have not been conducted to formulate definitive conclusions regarding the relationships among intoxication, history of abuse, and outcome from TBI. Differences in samples, methods, and analyses do not permit meta-analytic comparisons of the results that are available. Still, certain findings have heuristic value. Between one third and one half of people who incur TBIs will be intoxicated at time of injury. The number of persons under the influence of illicit drugs cannot be estimated from the available data. A disproportionate number of those intoxicated will be younger, will be men, will have been injured in moving vehicle accidents or assaults, and will have a history of substance abuse preceding the injury. Those with substance involvement will have had more complications and longer acute hospital stays, though those with a history of substance abuse may have been more susceptible to greater morbidity and mortality than those who were intoxicated but had no such history.

Approximately two thirds of patients admitted to brain injury rehabilitation units will have a history of alcohol or other drug use that can be characterized as abusive, at least. Patients with histories will be more likely to be men over 30, have less education and lower socioeconomic status, and have been intoxicated at time of their injury. A portion of those admitted will have had more severe histories of abuse and, concomitantly, may have more severe functional limitations. Some who are admitted with histories of abuse will have had previous injuries that may contribute to functional limitations. Although the effects studied in the research reviewed here were generally short-term when compared with the issues of community integration and long-term quality of life, mediating effects on later outcomes for those with a history of abuse could be expected given more severe functional limitations and possible greater likelihood of deterioration after initial recovery. The data reviewed here do not rule out the possibility of poorer long-term outcomes caused by intoxication.

There are few studies of the effect on outcome of postinjury substance use and abuse. At least one study²⁶ found a relationship between a history of abuse and deterioration after the injury. One hypothesis as to the agent of deterioration would be that these individuals resumed use or abuse following their injury. Even without deterioration, it would seem viable to hypothesize that those individuals who resume use or abuse do not attain the same recovery as those who do not. One mechanism of healing in the brain is the reestablishment or proliferation of the dendritic network among those neurons that have survived.²⁸ At least one effect of alcohol on the brain may be to compromise dendritic networking,²⁹ thus, it does not seem overly speculative to posit that the resumption of alcohol and other drug abuse, if not use, could have a deleterious effect on long-term outcome from TBI.

Solomon and Malloy³⁰ recently reviewed the literature on

the relationships among alcohol, head injury, and neuropsychological functioning. These authors concluded that neuropsychological deficits in alcoholics cannot be accounted for solely by the extent of their alcohol abuse, suggesting that TBI may interact with abuse to cause neuropsychological impairment. The basis for this interaction included the relationship between alcohol abuse and risk of TBI, and a possible enhancement of the immediate effects of TBI for alcoholics. Alterman and Tarter³¹ explored the relationship between familial alcoholism and TBI and found an almost 2 to 1 greater incidence of TBI in persons with a family history. They posited that TBI may be one of several possible factors that mediate greater neuropsychological deficits but are not caused by the neurotoxicity of the alcohol itself. Genetic influences, the presence of fetal alcohol syndrome, and impulsivity and hyperactivity in children who become alcoholics were also cited as potential predisposing factors in the development of neuropsychological deficits.³² Etiology aside, these works based on studies of substance-abusing populations are in concordance with the conclusions suggested in this review, ie, persons with both TBI and substance abuse problems can be expected to have greater functional limitations.

To enhance sympathetic feelings and facilitate the therapeutic alliance, many rehabilitation professionals prefer to view their patients as victims of circumstance. The use of alcohol and other drugs in relation to TBI is discordant with this preferred perception. To the extent that a person's injury is viewed as use-related, it may be easier to hold them responsible for its occurrence. Likewise, the resumption of alcohol or other drug use after injury is inconsistent with the professional's expectation that patients do everything in their power to recover. These threats to the patient-professional relationship may make it easier to ignore the role of alcohol or other drugs in a patient's life, or to conclude that simply advising against its use is sufficient. It is clear that substance abuse is a complex behavior for which amelioration is rarely accomplished through advice alone.

As a legal substance in our society, normal use of alcohol may be sufficient to have a deleterious effect on recovery from TBI. Kreutzer and colleagues,²⁰ as well as Corrigan,³³ found that people who had experienced TBI drank significantly more alcohol before their injuries than their same age peers; whereas post injury use was comparable to peers. Fifty-eight percent of these same age peers, however, were consuming enough alcohol to experience intoxication at least once a week, with as many as 18% intoxicated daily.³⁴ When many young people feel the pressure to regain normalcy after their injury, it should be expected that "normalcy" would include a highly visible social behavior such as alcohol consumption.

Professionals involved in the rehabilitation of persons with TBI may not be able to afford to think of alcohol and other drug abuse as a problem for which their only response is to refer the patient. With no fewer than half, and as many as two thirds, of persons receiving rehabilitation potentially at risk of compromising their recovery, substance abuse can have a significant role in attenuating the ability to document effectiveness of rehabilitation. In a marketplace that is increasingly scrutinizing the efficacy of health care procedures,

TBI rehabilitation professionals cannot afford to have a significant proportion of patients showing poor long-term outcomes as a result of their alcohol and other drug use.

As others have suggested,^{7,35,36} secondary prevention of substance abuse must be integrated into the fabric of rehabilitation, much as issues of family functioning or premorbid psychological characteristics have been subsumed in the multidimensional effort of rehabilitation. Minimally, such integration should include specific assessment by knowledgeable professionals, as well as systematic efforts to educate both patient and family as to the potential negative effects of alcohol or other drug use. Additionally, it seems paramount that viable options be developed for effective postacute treatment of persons with substance abuse problems following TBI. Although both micromodels of intervention^{4,37} and macromodels of service delivery^{36,38,39} have been proposed, it seems to be more the exception than the rule that either secondary prevention or intervention systematically occur for persons who have experienced TBI and are at risk of compromising their outcomes through their use of alcohol or other drugs.

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