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Patterns of alcohol use 1 year after traumatic brain injury: A population-based, epidemiological study

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Abstract

This study delineated patterns of alcohol use 1 year after traumatic brain injury (TBI) in a large, population-based, epidemiological, nonclinical sample, and identified predictors of heavy alcohol use in these individuals. Participants were 1,606 adults identified by review of a South Carolina statewide hospital discharge data set, on the basis of satisfying the Centers for Disease Control case definition of TBI, and were interviewed by telephone 1 year after TBI-related discharge. Alcohol use in the month prior to interview was classified according to categories from the Quantity–Frequency–Variability Index; heavy drinking was defined as nearly daily use with ≥ 5 drinks at least occasionally, or at least three occasions with ≥ 5 drinks. A polychotomous logistic regression with 3 response levels (heavy, moderate, and abstinent/infrequent/light drinking) was used to identify predictors of heavy drinking. Heavy drinking in the month prior to interview was reported by 15.4% of participants, while 14.3% reported moderate drinking and 70.3% reported abstinence or light/infrequent drinking. Risk factors for heavy drinking included male gender, younger age, history of substance abuse prior to TBI, diagnosis of depression since TBI, fair/moderate mental health, and better physical functioning. There was no association between drinking patterns and TBI severity. (*JINS*, 2005, *11*, 322–330.)

Keywords: Alcohol abuse, Alcohol drinking, Alcoholism, Epidemiological studies, Follow-up studies, Substance abuse, Traumatic brain injury

INTRODUCTION

Alcohol is the predominant risk factor for traumatic brain injury (TBI) (Kolakowsky-Hayner et al., 1999). In clinical samples of TBI patients, pre-injury heavy drinking is more common than in healthy comparison groups (e.g., Corrigan et al., 1995; Silver et al., 2001; van Reekum et al., 1996), with estimates of preinjury alcohol abuse ranging from 16 to 66% (Burnett et al., 2000; Corrigan, 1995; Corrigan et al., 1999; Kolakowsky-Hayner et al., 1999). Pre-TBI substance abuse is also associated with poorer TBI treatment outcomes in clinical samples (Corrigan, 1995; Corrigan et al., 1999; MacMillan et al., 2002; Sherer et al., 1999).

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However, patterns of alcohol use *following* TBI have received surprisingly little attention in the literature. Alcohol abuse/dependence is the second most common Axis I disorder in persons with TBI, after major depressive disorder (Hibbard et al., 1998; Koponen et al., 2002). Studies of clinical samples have shown that, early in recovery from TBI, the rates of moderate and heavy alcohol use decline to levels comparable to those of the general population, with many patients reporting complete abstinence (Corrigan, 1995; Corrigan et al., 1995, 1999; Dikmen et al., 1995; Kolakowsky-Hayner et al., 1999, 2002; Kreutzer et al., 1991, 1996a), but that drinking increases with time since injury (Corrigan et al., 1995, 1998; 1999; Dikmen et al., 1995; Kreutzer et al., 1996a). In a multi-center, 4-year follow-up study (Kreutzer, et al., 1996b), most participants abstained from alcohol at all follow-up periods; most moderate and heavy drinkers remained so over the course of the study;

and 25% of abstinent patients began drinking, with 10% becoming moderate or heavy drinkers. There was some association of greater TBI severity with lower alcohol consumption, possibly because of supervision by others, limited finances, transportation problems, and complex medical problems (Corrigan et al., 1999; Kreutzer et al., 1996b). In another study (Kolakowsky-Hayner et al., 2002), 50% of persons with TBI were abstinent, but of those who used alcohol, 43% were moderate or heavy drinkers. In the Epidemiological Catchment Area study (Silver et al., 2001), 25% of respondents who reported a history of head injury had a lifetime history of alcohol abuse or dependence, compared to 10% of respondents with no head injury, but the proportion of respondents for whom the alcohol abuse predated the TBI was unknown.

Thus, only a handful of studies have addressed patterns of alcohol use following TBI, almost exclusively in clinical samples. Knowledge of such patterns is important because heavy drinking after TBI can contribute to seizures, additional head injury, diminished benefit from rehabilitation, exacerbation of cognitive and behavioral impairments, higher arrest rates, and increased difficulty returning to work (Corrigan et al., 1995; Ellerd & Moore, 1992; Kolakowsky-Hayner et al., 1999, 2002). Clearer delineation of the factors that predict alcohol abuse following TBI would help to identify those patients most at risk for such problems, so that specialized treatments and resources could be directed toward them.

The aims of the present study were to examine the incidence and level of alcohol consumption after TBI, and to delineate the demographic and clinical predictors of problematic drinking in these individuals. We hypothesized that specific individual characteristics, including age, sex, depression since TBI, and history of pre-TBI substance abuse or other psychiatric disorder, would be associated with greater alcohol use following TBI. We addressed these questions using a representative, population-based sample of individuals 1 year after TBI.

METHODS

Research Participants

This study was approved by the Institutional Review Boards of the Medical University of South Carolina and the Centers for Disease Control and Prevention (CDC). A representative sample of persons with TBI was randomly selected from a South Carolina statewide hospital discharge data set and recruited to participate in a larger follow-up study. State law mandates that all non-federal hospitals report uniform, abstracted billing data to the South Carolina State Budget and Control Board; additional information on pre-existing health conditions and injury variables was acquired through medical record review. All South Carolina residents age 15 and older who sustained a TBI resulting in hospital admission from January 1, 1999 through December 31, 2001 were eligible for the larger study. TBI was defined as any discharge with a primary or secondary diagnosis of injury to the head associated with decreased consciousness, amnesia, neurological abnormalities, skull fracture, or intracranial lesion, in accordance with the CDC case definition of TBI (Thurman et al., 1995).

After excluding out-of-state residents and children younger than 15, a stratified random sample was selected. By design, the sample was constructed to include 67% *more severe* TBI [defined as Abbreviated Injury Scale (AIS; Association for the Advancement of Automotive Medicine, 1990)] scores of 3–6 and 33% *mild* TBI (AIS = 2). Further information on the AIS scoring system is presented in the next section.

From January 1,1999 through December 31, 2002, there were 7,613 South Carolina residents age 15 and older with TBI who were discharged alive from one of the 62 acute care hospitals in the state. Of these individuals, 4,519 were selected for the study using a two-stage stratified random sampling protocol. From this group, 713 (15.8%) were not eligible to participate because they had died since TBI, had moved out of state, did not speak English, were medically unable to participate and had no proxy, or were prisoners. Another 875 (19.4%) could not be located, and 813 (18.0%) chose not to participate, leaving 2118 participants who completed interviews. Thus, the overall response rate was 55.7%. Comparison of participants with non-participants indicated that non-participants tended to be minorities, uninsured, and older than age 65.

Participants were then excluded if they were under 18 years of age, had a proxy respond for them, or gave incomplete or what were judged to be inconsistent answers to the alcohol-related questions. The final sample size of 1606 reflected all of these individuals who gave answers to all of the variables included in the final regression model. A comparison between these 1,606 individuals and the 97 who were excluded for reasons other than age showed that those excluded were more likely to be young, male, uninsured or on Medicaid, have poor SF-36 (Ware, 1993) mental health scores, and have had drug or alcohol treatment prior to TBI. Thus, it is possible that the current data could underestimate alcohol consumption in this population, although the very small number of persons excluded for these reasons indicates that the degree of such underestimation would be very small.

Procedures

Participants were recruited and interviewed by telephone approximately 1 year after hospital discharge. In addition to alcohol use, the interview included standardized measures or other questions to assess general health, post-injury symptoms, employment, life satisfaction, and demographic and other variables. The interview was approximately 45 min long. The data collected through medical record abstraction and interview were validated for internal consistency and predictive value positive.

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Alcohol questions followed the format of those from the 1999 Behavioral Risk Factor Surveillance System (BRFSS; Centers for Disease Control, 2003). They assessed frequency, average quantity per drinking occasion, and number of occasions on which the individual had five or more drinks (termed "binges" in this paper) in the month prior to the interview. Participants also compared their present drinking to their drinking in the month prior to TBI. Drinking was initially categorized into four levels (*abstinent/infrequent*, *light*, *moderate*, and *heavy*) according to two schemes: that proposed by Corrigan et al. (2003), and a modified version of the Quantity–Frequency–Variability Index (QFVI; Cahalan & Cisin, 1968a, 1968b). Although the survey instrument did not provide all of the data required to compute the QFVI, the general descriptions of each QFVI classification level (Cahalan & Cisin, 1968a, 1968b) were applied to the available data. As the two schemes showed excellent agreement (weighted kappa = .89), the modified QFVI was utilized because of its use in prior studies. Outcome was then condensed into three levels: *abstinent/infrequent/light* (the reference level; no drinking in past month, or 1–15 drinking days averaging up to 2 drinks per occasion with no binges); *moderate* (drinking up to daily, averaging more than 2 but less than 5 drinks per occasion with no binges; or more than 15 drinking days averaging from 1 to less than 5 drinks per occasion with no binges; or less than 22 drinking days per month averaging less than 5 drinks per occasion with 1–3 binges); and *heavy* (drinking up to daily and averaging 5 or more drinks per occasion; or 22 or more drinking days with at least one binge; or more than three binges).

TBI severity was determined by translating ICD-9-CM codes into ICD/AIS scores using ICDMAP–90 software (Center for Injury Research Policy of the Johns Hopkins University School of Public Health, 1997). The AIS is an anatomical scoring system that ranks injury severity for various body regions on a scale of 1 (*minor*) to 6 (*unsurvivable*), and that has been previously used to relate TBI severity to longer-term outcome (e.g., Massagli et al., 1996). For the present study, only the ICD/AIS score for the head region was considered. TBI was classified as *severe* with an ICD/AIS score of 3–6 (typically corresponding to loss of consciousness exceeding 30 min), or *mild* with a score of 2. Although a *moderate* category corresponding to ICD/AIS score of 3 was initially considered, its discriminatory power was considered unreliable by the study authors and a panel of consultants. (When this *moderate* severity category was included, a univariate analysis of the relationship between severity and drinking patterns did not reveal stronger results than those reported below.) As noted in the preceding section, the sample was constructed by design to include 67% *more severe* TBI and 33% *mild* TBI.

Although Glasgow Coma Scale (GCS; Teasdale & Jennett, 1974) score might have been a preferable index of TBI severity, it was not available for 43.6% of the study cohort, precluding its use in the present study. Unfortunately, GCS and ICD/AIS are not directly comparable since they use different indicators to estimate severity; GCS measures physiological functions (which change over time), while ICD/AIS assesses anatomic damage (which is static). Furthermore, GCS is often measured before or on admission while AIS measurement is based on discharge diagnosis. Thus, scores on the two measures are not expected to be correlated (Association for the Advancement of Automotive Medicine, 1990). In fact, in our sample, the intraclass correlation (weighted kappa) between GCS and ICD/AIS comparing *mild* (ICD/AIS = 1–2 *vs.* GCS = 13–15), *moderate* (ICD/AIS = 3 *vs.* GCS = 9–12) and *severe* (AIS = 4–6 *vs.* GCS = 3–8) was .27.

Physical functioning and mental health were assessed with the SF-36, and scored and categorized based on U.S. population norms according to guidelines of the Medical Outcome Studies (MOS; Ware, 1993). The physical functioning dimension of the SF-36 assesses limitations in physical activities, such as walking and climbing stairs; using norms provided by Ware (1993), scores of 84.2–100 were defined as *excellent/good*, 63.8–84.1 as *moderate*, and less than 63.8 as *fair/poor*. The mental health dimension assesses psychological distress, such as nervousness and depressed mood; using norms provided by Ware (1993), scores of 74.7–100 were defined as *excellent/good*, 50.0–74.6 as *moderate*, and less than 50.0 as *fair/poor*. Questions from the Satisfaction with Life Scale (SWLS; Diener, 1984) were adapted and scored according to the guidelines of Diener (1984; Pavot & Diener, 1993), with scores of 20–35 indicating *satisfaction with life* and 5–19 indicating *dissatisfaction*.

Pre-TBI psychiatric disorder was assessed by the question, "Before your injury, had you ever been treated for a psychiatric problem?" (The term "psychiatric problem" was not further clarified in the standardized interview used in the present study.) Pre-TBI substance abuse treatment was assessed by the question, "Before your injury, had you ever been treated for a drug or alcohol problem?" Post-TBI depression was assessed by the question, "Since your injury, has a doctor told you that you had depression?"

Statistical Analysis

The relationship between drinking levels and the various demographic, clinical, and outcome characteristics was first examined using a chi-square test statistic. Differences within groups were evaluated by constructing 95% confidence intervals (CI) around the proportions. Mean number of drinks per month was compared by various participant characteristics, adjusted for the influence of gender. Chi-squares were also used to compare the characteristics of participants who reported increased drinking after their TBI to the rest of the cohort; the Kruskal-Wallis test was used to compare number of drinks in the month prior to interview among those reporting drinking more, the same, or less than prior to TBI.

Alcohol use was modeled as a function of age, gender, marital status, level of education, insurance status, TBI sever-

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ity, physical functioning, mental health status, satisfaction with life, pre-TBI substance abuse treatment, pre-TBI psychiatric problems, and post-TBI depression, using polychotomous logistic regression (Stokes et al., 1995). Multicollinearity among the independent variables was evaluated by assessing the deviations of the regression coefficients and their standard errors in the fitted univariate and multivariable models (Darlington, 1998). The independent variables were entered simultaneously into the model. An alpha level of .05 was used to decide statistical significance.

RESULTS

Sample Characteristics

The sample was 61% male. Mean age was 44 years (SD = 19, range 18–92). Racial composition was 76% Caucasian, 22% African-American, and 2% other. Of the 95% that reported their income in the year prior to their TBI, 64% made $25,000 or less. Nearly two-thirds had less than a college education. Persons who were uninsured, without listed insurance, under Medicaid, or under the Medically Indigent Assistance Program (MIAP) accounted for 28% of the sample. Other demographic characteristics are listed in Table 1. Two-thirds had severe TBI, 10% had had previous treatment for substance abuse problems, and 12% reported treatment for psychiatric problems prior to TBI. Forty-three percent reported poor physical functioning, 26% reported poor mental health scores, and 21% reported having been told by a doctor that they had depression since the TBI.

Patterns of Alcohol Use

Drinking patterns as a function of demographic factors, TBI severity, and other variables are shown in Table 1. Of the entire sample, 15.4% were classified as heavy drinkers, 14.3% were moderate drinkers, and 70.3% were infrequent/light drinkers or abstainers. Heavy and moderate drinking were associated with male gender, age between 18 and 44, having Medicaid or no listed insurance, being single, and excellent/good physical functioning. Heavy drinking was additionally associated with history of substance abuse treatment prior to TBI.

Of those who described their alcohol consumption in the month prior to TBI (99.8%), almost all were drinking about the same or less 1 year later, in the month prior to interview (58% same, 36% less). Almost half of the current heavy (48%) and moderate (47%) drinkers described themselves as drinking less than before their TBI. The 6% of the sample who reported drinking more than before their TBI tended to be young, single, and not insured by Medicare, to report depression since TBI, and to have lower life satisfaction and mental health scores than those drinking the same or less than before their TBI. After removing those who never drank, the median number of drinks in the month prior to interview of those who reported increasing their drinking since TBI (30 drinks), drinking the same amount (one drink), and decreasing their drinking (four drinks) were significantly different ($p < .001$). Median number of drinks was used as a measure of central tendency because the data did not conform to a normal distribution.

Table 2 shows the number of occasions in the month prior to interview on which five or more alcoholic beverages were consumed ("binges"), compared to data for the general population of South Carolina (Centers for Disease Control, 2003). Of those individuals who drank in the month prior to being interviewed, individuals with TBI were more likely to have binged, compared to the general population. Also, of those individuals who drank in the preceding month, individuals with TBI were significantly more likely than the general population to have binged five or more times.

Logistic Regression Analyses

The results from univariate and multivariable (adjusting for all covariates in the model) polychotomous logistic regression analyses are presented in Table 3. The table summarizes the odds of heavy or moderate drinking at the time of interview. Risk factors for heavy drinking included male gender, younger age, history of substance abuse prior to TBI, diagnosis of depression since TBI, fair/moderate mental health, and better physical functioning. There was no association between drinking patterns and TBI severity, level of education, marital status, psychiatric treatment prior to TBI, or overall satisfaction with life. Risk factors for moderate drinking included male gender, fair/moderate mental health, better physical functioning, and being uninsured or on Medicaid.

DISCUSSION

This study assessed patterns of alcohol consumption in a large, population-based sample of individuals who had sustained a TBI 1 year earlier. In contrast to most previous studies, it was not limited to patients undergoing treatment or identified in specific clinical settings. Most (70%) of the sample was classified as light or infrequent drinkers, or abstainers. Risk factors for heavy drinking (15% of the sample) included male gender, younger age, history of substance abuse treatment prior to TBI, diagnosis of depression since TBI, fair/moderate mental health, and better physical functioning. Nearly all participants (94%) reported drinking the same amount as, or less than, before their TBI.

Few previous studies, even of clinical samples, have directly examined the demographic or clinical predictors of alcohol use in persons with TBI. The high proportion of abstainers and infrequent drinkers in our sample is consistent with previous reports (Corrigan, 1995; Corrigan et al., 1995, 1999; Dikmen et al., 1995; Kolakowsky-Hayner et al., 1999, 2002; Kreutzer et al., 1991; Kreutzer et al., 1996a). Abstinence or light drinking shortly after TBI could be due to factors such as decreased access to alcohol, advice by health care providers or others, decreased tolerance for alco-

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Table 1. Characteristics of persons with TBI by alcohol use, expressed as percentage of the sample

Characteristics (chi-square *p*-value)	Alcohol use			Total (N = 1,606)
	Heavy drinking (n = 247)	Moderate drinking (n = 230)	Infrequent/ abstainers (n = 1,129)	
Age group ($p < .001$)				
18–24	32.4	32.2	18.8	22.8
25–44	44.9	40.0	28.3	32.6
45–64	20.2	22.2	28.6	26.4
65 and older	2.4	5.7	24.3	18.2
Gender ($p < .001$)				
Male	87.5	69.6	53.7	61.2
Female	12.6	30.4	46.3	38.9
Level of education ($p = .209$)				
No high school diploma	25.7	22.2	27.6	26.8
High school diploma	37.7	36.1	35.2	35.7
Some college	25.5	29.1	23.4	24.5
College graduate	9.3	12.6	13.8	13.0
Marital status ($p < .001$)				
Not married/single	50.6	46.1	28.1	34.1
Separated/divorced	23.1	19.1	18.0	18.9
Widowed	2.0	2.6	9.9	7.7
Married	24.3	32.2	44.0	39.3
Insurance status ($p < .001$)				
Uninsured/medicaid/indigent care	37.7	37.0	24.6	28.4
Commercial private insurance	56.3	57.8	51.1	52.9
Medicare	6.1	5.2	24.3	18.7
Severity of TBI ($p = .116$)				
Severe (ICD/AIS 3–6)	72.1	70.0	65.9	67.4
Mild (ICD/AIS = 2)	27.9	30.0	34.1	32.6
Pre-TBI psychiatric treatment ($p = .025$)				
Yes	17.4	10.9	11.3	12.2
No	82.6	89.1	88.7	87.8
Pre-TBI alcohol/drug treatment ($p < .001$)				
Yes	20.2	10.4	7.5	9.9
No	79.8	89.6	92.5	90.1
Post-TBI depression ($p = .004$)				
Yes	27.1	14.8	21.4	21.3
No	72.9	85.2	78.7	78.7
Satisfaction with life ($p = .009$)				
Dissatisfied	42.1	28.7	36.7	36.4
Satisfied	57.9	71.3	63.3	63.6
Physical functioning (score) ($p < .001$)				
Poor (0–63.7)	27.1	27.8	50.2	43.5
Fair/moderate (63.8–83.9)	14.6	19.1	16.0	16.3
Excellent (84.0–100.0)	58.3	53.0	33.8	40.3
Mental health status (score) ($p = .069$)				
Poor (0–49.0)	26.7	22.6	26.1	25.7
Fair/moderate (50–74.6)	31.2	28.3	23.8	25.6
Excellent (74.7–100.0)	42.1	49.1	50.0	48.7

Note. Levels of significance refer to chi-square analyses for each variable.

hol, or a tendency to rethink one's lifestyle following a major trauma (Dikmen et al., 1995).

A history of substance abuse prior to TBI was one of the strongest predictors of heavy drinking one year after TBI. Perhaps this finding is not surprising; many respondents who currently reported heavy drinking had also done so prior to their injury. (Even so, nearly half of the heavy drinkers reported decreasing their alcohol consumption since their TBI.) This finding highlights the need to provide substance abuse treatment services for those persons with TBI

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Table 2. Number of occasions in the past month on which five or more alcoholic beverages were consumed

		Number of occasions of five or more alcoholic beverages in past month					
Source	Measure	0*	1	2*	3	4	5 or more*
SCTBIFR	%	52.0	12.5	9.5	4.3	6.0	15.7
	CI	(48.5–55.5)	(10.2–14.8)	(7.4–11.6)	(2.9–5.7)	(4.3–7.7)	(13.1–18.3)
	n	398	96	73	33	46	120
BRFSS	%	70.0	9.2	5.2	3.1	3.6	8.8
	CI	(67.0–72.9)	(7.2–11.1)	(3.8–6.5)	(1.9–4.2)	(2.4–4.7)	(6.8–10.7)
	n	1017	123	71	47	40	107

*Independent samples *t* test; $p < .05$.
Note. Results of the South Carolina TBI Follow-Up Registry (SCTBIFR) from the present study are compared with those of the Behavioral Risk Factor Surveillance System (BRFSS; Centers for Disease Control, 2003) for the general population of South Carolina.

who require it. It would appear that more consistent assessment and follow-up is needed for persons with comorbid TBI and history of substance abuse, as these individuals are at high risk for continuing substance abuse.

Heavy drinking was also strongly associated with a diagnosis of depression since TBI. On the basis of our data, it cannot be determined whether depression was primarily a result of heavy drinking for some individuals, or whether heavy drinking was a way of self-medicating depressive symptoms. Most probably both types of relationships were represented in our sample. In any event, the result indicates the importance of thorough assessment of depressive symptoms following TBI, both for the treatment of depression itself and because it may be associated with other disorders such as substance abuse.

It is uncertain why better physical functioning was associated with heavy drinking. Perhaps those individuals had greater functional independence, and thus greater access to alcohol, while those with poorer physical functioning might have been more dependent on caregivers and more closely supervised. It is also possible that individuals with residual motor problems were more aware of the impact of their injury, and reduced their drinking as a result of increased negative expectancies for alcohol consumption.

The lack of relationship between drinking and overall life satisfaction was somewhat unexpected. The questions used to assess life satisfaction might not have been adequate to reveal such a relationship, if it truly existed. Alternatively, individuals with sustained abstinence, and those with moderate or heavy use who were not trying to reduce consumption, might have reported greater life satisfaction, while those drinking but wanting to abstain or reduce their consumption might have reported lower satisfaction.

Clinical Implications

The present findings have direct implications for the assessment and treatment of persons with TBI. Persons with TBI who also have a history of substance abuse might require additional interventions, including substance abuse treatment and longer-term follow-up, as they are at high risk for substance abuse following TBI. Even for patients without such a history, advice to limit or abstain from alcohol consumption appears warranted. While our present data do not include information about whether participants were given such advice, a simple, low-cost intervention of this type could potentially provide significant long-term benefit. In fact, brief interventions of this type have been associated with reduced alcohol consumption, and lower incidence of hospital and emergency-department admissions (Gentilello et al., 1999).

Similarly, the present results suggest the importance of assessing depressive symptoms in TBI patients, as depression is common in this population and may also be associated with substance abuse or other difficulties. Ideally, such assessment and initial treatment would occur as soon as is feasible after such patients come to the attention of health care providers.

Methodological Considerations

Despite the large sample size and rigorous sampling techniques, several methodological issues deserve consideration. First, comparison of participants with non-participants indicated that non-participants tended to be minorities, uninsured, and older than age 65. This would pose non-response bias if the non-participants' pattern of alcohol use differed significantly from that of participants. However, the number of drinks per month among participants did not differ much by insurance and age group when stratified by minority status, suggesting that the missing information is at random and that the bias would not be sufficiently strong to change significantly the observed results.

Second, the use of telephone interview data could raise questions about their validity, particularly in a sample that includes cognitively impaired persons. However, previous studies have shown that valid data can be obtained by telephone from individuals with TBI (MacKenzie et al., 2002; McCaffrey et al., 1987), including the SF-36 (Findler et al., 2001). It is also possible that some participants in the present

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Table 3. Crude and adjusted odds ratios of alcohol use after TBI by various risk characteristics

	Crude odds ratio (95% confidence interval)		Adjusted odds ratio (95% confidence interval)	
Characteristics	Heavy drinking	Moderate drinking	Heavy drinking	Moderate drinking
Age group (*vs.* 65 and older)				
18–24	17.2 (7.4, 40.3)*	7.4 (4.0, 13.6)*	7.7 (2.4, 25.2)*	2.4 (0.9, 6.5)
25–44	15.8 (6.9, 36.6)*	6.1 (3.3, 11.1)*	7.7 (2.5, 23.9)*	2.2 (0.9, 5.5)
45–64	7.1 (3.0, 16.7)*	3.3 (1.8, 6.3)*	3.9 (1.3, 11.7)*	1.6 (0.6, 3.9)
Gender (*vs.* female)				
Male	6.0 (4.1, 8.9)*	2.0 (1.5, 2.7)*	5.7 (3.7, 8.7)*	1.7 (1.2, 2.4)*
Level of education (*vs.* college graduate)				
No high school diploma	1.5 (0.9, 2.5)	0.9 (0.5, 1.4)	0.9 (0.5, 1.7)	0.6 (0.3, 1.1)
High school diploma	1.6 (1.0, 2.6)	1.1 (0.7, 1.8)	1.1 (0.6, 1.8)	0.8 (0.5, 1.4)
Some college	1.6 (1.0, 2.7)	1.4 (0.9, 2.2)	1.1 (0.6, 1.9)	1.0 (0.6, 1.7)
Marital status (*vs.* married)				
Not married/single	3.3 (2.3, 4.6)*	2.3 (1.6, 3.1)*	1.5 (1.0, 2.4)	1.3 (0.8, 1.9)
Separated/divorced	2.3 (1.6, 3.5)*	1.5 (1.0., 2.2)	1.6 (1.0, 2.5)	1.2 (0.8, 1.9)
Widowed	0.4 (0.2, 0.9)*	0.4 (0.2, 0.9)*	1.8 (0.6, 5.3)	1.1 (0.4, 2.9)
Insurance status (*vs.* Medicare)				
Uninsured/Medicaid/indigent care	6.1 (3.5, 10.8)*	7.0 (3.7, 13.1)*	1.1 (0.5, 2.5)	3.1 (1.2, 7.7)*
Commercial private insurance	4.4 (2.5, 7.6)*	5.3 (2.9, 9.7)*	0.9 (0.4, 2.1)	2.2 (0.9, 5.3)
Severity of TBI (*vs.* mild ICD/AIS = 2)				
Severe (ICD/AIS 3–6)	0.8 (0.6, 1.0)	0.8 (0.6, 1.1)	0.8 (0.6, 1.2)	0.8 (0.6, 1.2)
Pre-TBI psychiatric treatment (*vs. no*)				
Yes	1.7 (1.1, 2.4)*	1.0 (0.6, 1.5)	1.2 (0.8, 2.0)	1.1 (0.7, 1.8)
Pre-TBI alcohol/drug treatment (*vs. no*)				
Yes	3.1 (2.1, 4.6)*	1.4 (0.9, 2.3)	2.2 (1.4, 3.5)*	1.5 (0.9, 2.5)
Post-TBI depression (*vs. no*)				
Yes	1.4 (1.0, 1.9)	0.6 (0.4, 1.0)*	1.6 (1.1, 2.5)*	0.7 (0.5, 1.2)
Satisfaction with life (*vs. satisfied)*				
No	1.3 (1.0, 1.7)	0.7 (0.5, 1.0)*	1.1 (0.7, 1.6)	0.7 (0.4, 1.0)
Physical functioning (*vs. excellent)*				
Poor	0.3 (0.2, 0.4)*	0.4 (0.3, 0.5)*	0.3 (0.2, 0.4)*	0.5 (0.3, 0.7)*
Fair/moderate	0.5 (0.4, 0.8)*	0.8 (0.5, 1.1)	0.5 (0.3, 0.8)*	0.9 (0.6, 1.4)
Mental health (*vs. excellent)*				
Poor	1.2 (0.9, 1.7)	0.9 (0.6, 1.3)	1.3 (0.8, 2.1)	1.5 (0.9, 2.4)
Fair/moderate	1.6 (1.1, 2.2)*	1.2 (0.9, 1.7)	1.6 (1.1, 2.4)*	1.5 (1.0, 2.2)*

*$p < .05$. The significance level refers to the difference between the odds ratio and that of each variable's reference level, as noted in the Table.

study under-reported their alcohol use because of social desirability or similar factors, and that others incorrectly estimated their alcohol consumption because of cognitive deficits. Nevertheless, previous research on self-reported alcohol consumption, including in persons with TBI, suggests that such reports are generally valid (Bombardier et al., 2002; Corrigan et al., 1995). The questions used to assess drinking in our survey have been used in national surveys, and were constructed to be easily understood, even by persons who might be cognitively compromised.

Third, as our survey was not designed to provide DSM–IV diagnoses, alcohol consumption had to be classified based on available quantity and frequency data. The high intraclass correlation in our preliminary analyses between the modified QFVI and the scheme proposed by Corrigan et al. (2003) suggests that our results would not have differed substantially if Corrigan et al.'s scheme had been used. As the survey did not include all questions that would have been necessary to compute the QFVI, the verbal descriptions of each classification level were applied, possibly introducing some error. However, many of the variables that predicted heavy drinking also predicted "moderate" drinking, suggesting that minor differences in classifying individuals in these two categories would not have substantially altered the findings.

As the available data precluded definitive classification of which participants' drinking was "problematic," we opted for a somewhat conservative scheme in which "heavy drinking" reflected a level that most clinicians would consider cause for concern. Nevertheless, it should be noted that even "moderate" drinking on the QFVI exceeds recommended consumption for persons with no medical conditions, and is thus clearly contraindicated for persons with TBI. The category label "moderate" is therefore somewhat

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misleading, but was retained in the present study in order to maintain consistency with previous work.

Directions for Future Research

The above discussion suggests several directions for future investigations. The present study examined alcohol use one year after TBI; predictors of drinking patterns at other time points post-injury remain largely unknown. Previous research from clinical samples suggests that alcohol consumption increases with time since injury (Corrigan et al., 1995, 1998, 1999; Dikmen et al., 1995; Kreutzer et al., 1996a); a similar finding might be expected in non-clinical samples. In fact, we are continuing to collect such data for individuals 2 and 3 years following TBI.

Future investigations could also address some of the methodological limitations of the present study. In future, population-based studies, additional questions about the quantity and frequency of alcohol consumption would improve the precision of alcohol use data, and would facilitate classification into relevant groupings that could be directly comparable with those used in previous studies. Questions directly assessing the DSM-IV diagnostic criteria for alcohol abuse and dependence would further help in identifying those individuals whose alcohol use is of clinical concern. In addition, more specific questions regarding psychiatric diagnosis and treatment both before and after TBI would help to clarify which such factors are most strongly associated with problematic drinking following TBI.

Despite these potential sources of error, the present study has identified demographic and clinical variables associated with heavy alcohol consumption in a large, population-based, non-clinical sample of persons with TBI. The findings support the generalizability of some results from previous clinical studies, and extend what is known about predictors of problematic alcohol use in this population. The ability to identify, early in the course of recovery from TBI, those individuals at greatest risk for alcohol problems could ultimately lead to specialized interventions that would improve the quality of life for such individuals, while lessening the cost to society of these frequently co-occurring disorders.

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