Patterns of Alcohol Use after Traumatic Brain Injury

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Abstract

Alcohol misuse and traumatic brain injury (TBI) frequently co-occur. The negative consequences of this interaction are well documented, but the patterns of long-term post-injury alcohol consumption are less clear. This study examined patterns of alcohol use among 170 adults with a history of complicated mild to severe TBI. Participants were recruited from a Level 1 Trauma Center at the time of their injury and completed evaluations at 1 month, 6 months, 12 months, and 3–5 years post-injury. Pre-injury alcohol use was also assessed at the time of the 1-month assessment. A modified Quantity-Frequency Index of alcohol consumption was then calculated for each time point. The results revealed high levels of pre-injury alcohol consumption, followed by a reduction in consumption at 1-month post-injury. A significant increase in consumption was noted by 6 months post-injury, followed by more gradual increases in alcohol consumption at 1 year. Post-injury alcohol consumption was comparable to the general public at 6 months, 12 months, and 3–5 years post-injury. These results suggest that the first 6 months post-injury may be the critical window of opportunity for alcohol intervention.

Key words: alcohol; traumatic brain injury

Introduction

ALCOHOL MISUSE is a common and well-documented problem among persons who have sustained a traumatic brain injury (TBI). Retrospective analyses have demonstrated that before injury, persons who sustain a TBI have higher rates of alcohol abuse than their peers.¹ This may be especially true for young adults, because one study found that 46.4% of 20–29 year olds reported pre-injury alcohol misuse.² Further, substance abuse has been identified as the most common pre-injury psychiatric disorder in this population.³ High levels of alcohol use are also associated with the injury itself, with as many as one-third to one-half of persons intoxicated at the time of injury.^{4–6}

Following the injury, problematic drinking continues for a subset of individuals.^{7,8} In fact, it has been estimated that approximately one-third of individuals with TBI drink in the moderate to heavy range after their injury,⁹ and alcohol abuse/dependence is second only to major depressive disorder as the most common Axis I psychiatric disorder after TBI.^{3,10}

There are numerous reasons to be concerned about post-injury alcohol consumption. On its own, prolonged heavy alcohol use has been associated with cognitive impairments, especially in the domains of memory and learning, executive functioning, visuospatial skills, processing speed, and gait and balance.^{11–13} Similarly, TBI is often associated with persisting cognitive difficulties, especially as injury severity increases.¹⁴ It is widely thought that alcohol

consumption and TBI may have an additive effect, negatively impacting cognitive recovery and exacerbating other injury-related sequelae.¹⁵ Further, post-injury alcohol consumption may increase the risk for additional injury, reduce a person's ability to benefit from rehabilitation, increase risk for seizures, and increase the difficulty of returning to work.^{16,17} There is also evidence that persons with substance abuse problems, such as excessive alcohol use, also have higher levels of depression and report lower life satisfaction after TBI than injured persons without substance abuse difficulties.^{18–20} Finally, worsening emotional and behavioral functioning after TBI has been associated with post-injury drinking.²¹ Given these potentially serious health complications that may arise from the combined effects of alcohol use and TBI, it is critical that we better understand the temporal course of returning to drinking to identify high-risk periods for prevention and intervention efforts.

In studies that have evaluated return to drinking after 1 or 2 years post-injury, a general pattern has emerged that is characterized by reduced alcohol consumption immediately after TBI, followed by increased consumption over time.^{22,23} Bombardier and associates⁹ suggested, based on comparison of fairly similar reported levels of heavy drinking at several time points post-injury,^{9,16,23,24} that most persons who relapse into heavy drinking do so during the first year after injury. Risk factors for heavy drinking at that time point include pre-injury alcohol misuse, being a young male, and post-injury depression.²⁵ The temporal course of return to drinking is not

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yet fully understood, however, because some studies have suggested that rates of problematic drinking continue to increase after 1 year post-injury.^{23,26,27} This return to drinking may be age-related, because Corrigan and colleagues²⁸ found that the highest consumption of alcohol at 5 years post-injury was among those who were age 29 and younger. Longitudinal studies that encompass both the first year after injury, which has been identified by some as the “critical window” in terms of relapse,⁹ as well as longer post-injury time frames are needed to further our understanding of the timing of return to problematic alcohol consumption.

This study aims to fill this gap in the literature by examining post-injury alcohol use at four time points post-injury (1 month, 6 months, 12 months, and 3–5 years) in a sample of persons with complicated mild to severe TBI. The present study also compares rates of pre- and post-TBI alcohol consumption to alcohol consumption rates in the general population.

Methods

Participants

Participants are a subset of individuals who were consecutively admitted to a Level I Trauma Center after sustaining a TBI and who were then enrolled in a seizure prophylaxis clinical trial within 24 h of admission.²⁹ Inclusion criteria for the original study were age 14 and older at time of injury and the presence of at least one of the following: depressed skull fracture, penetrating head injury, computed tomography (CT) evidence of cerebral contusion, or intracerebral, subdural, or epidural hematoma, or a seizure within 24 h of the injury.

Participants in this study were randomized to one of the following treatments: 1 month of valproate, 6 months of valproate, or 1 week of phenytoin. All participants took study medications for 6 months (active or placebo).²⁹ Results from the clinical trial found that valproate did not prevent post-traumatic seizures and did not have any effect, positive or negative, on neuropsychological functioning or health-related quality of life.³⁰ The severity of injuries in these participants ranged from complicated mild (i.e., Glasgow Coma Scale [GCS] score of 13–15 with CT abnormality) to severe (GCS score 3–8). The original clinical trial was approved by the Institutional Review Board (IRB) at the University of Washington. This project was approved by that IRB as well as the VA Puget Sound IRB.

The present study includes 170 persons who sustained a TBI, were at least 18 at the time of injury, and provided information on their pre-injury alcohol consumption, as well as the quantity and frequency of alcohol consumption at each of four time points post-injury (1 month, 6 months, 12 months, and 3–5 years). This represents a subset of the 316 eligible consenting survivors who were over the age of 18 when enrolled in the study. Ninety-four participants were lost to follow-up at some point during the study. An additional 52 participants were not followed at 1 year or 3–5 years post-injury because of budgetary constraints. Thirty-three persons died before the 1-month assessment and are not included in the total number of eligible consenting survivors.

The persons who were lost to follow-up, those not followed because of budgetary reasons, and the participants included in the current analyses did not significantly differ in terms of age, injury severity (GCS), or blood alcohol level (BAL) on admission. Group differences were present for race and sex. In particular, those included in the current study were more likely to be Caucasian ($p=0.006$) than those not included, and those lost to follow-up were more likely to be male than those included or not followed because of budgetary reasons ($p=0.048$).

Alcohol consumption data collected as part of the Centers for Disease Control and Prevention’s 1997 National Health Interview Survey (NHIS)³¹ were used to estimate rates of alcohol consumption in the general public. This survey assesses a wide range of health information from a representative sample of households in

the United States each year. The sample size for the data used in this article was 35,223. A subset of individuals ($n=837$) was excluded from the analysis because of incomplete information about alcohol use. The NHIS is completed every year, but data from the 1997 survey were used for this study because of its proximity to the time that the data from the TBI participants was collected.

Measures

Brain injury severity indices. Brain injury severity was evaluated with the GCS³² in the emergency department (first post-resuscitation assessment) and with Time to Follow Commands (TFC), operationally defined as time from injury to consistently following simple commands (i.e., GCS motor scale score of 6). GCS scores are missing from 17 participants, generally because of the presence of pre-hospital paralytics.

Demographic information and pre-morbid characteristics. A structured interview at 1-month post-injury gathered demographic data and information about pre-injury characteristics. For the majority of participants, this information was provided by either the participant alone (9%) or by the participant with confirmation by their significant other (SO, 68%). In 15% of cases, the information was provided by the SO only because of the severity of the injury of the subject, and in 7%, the SO provided information that was confirmed by the participant.

Assessment of alcohol use among persons with TBI and in the general population. In the TBI group, pre- and post-injury alcohol use was measured in terms of the quantity and frequency of alcohol consumed. At an interview that took place at 1 month post-injury, participants were asked about both pre-injury alcohol use and current alcohol use. Three additional follow-up interviews took place at 6 months, 12 months, and 3–5 years post-injury. At 1, 6, and 12 months, participants were asked to report on their alcohol use since the injury. At the 3–5 year follow-up, they were asked to report on their alcohol consumption over the past year. Average number of drinks per week at each time point was calculated by multiplying together the responses from the following two questions: (1) How often a week do you drink any kind of alcoholic beverage, and (2) how many drinks do you have per sitting on average? BAL was collected in the emergency department after their injury.

For the general population, the average number of drinks per week was calculated based on responses to the following questions on the NHIS: (1) “In the past year, how often did you drink any type of alcoholic beverage” (this information is provided in the NHIS database in terms of number of days per week), and (2) “In the past year, on those days that you drank alcoholic beverages, on the average, how many drinks did you have?”

Quantity frequency index. Alcohol consumption among the participants with TBI was divided into four discrete categories (abstinent, light drinking, moderate drinking, and heavy drinking) for descriptive purposes. The categorization was based on the classification parameters reported by Bombardier and coworkers,⁹ which were developed to be consistent with the classic quantity frequency index created by Calahan and colleagues.³³

One modification to these criteria was made for the purposes of this study. In particular, the definition of abstainer was broadened to include participants who endorsed drinking 0 days per week and/or an average of 0 drinks per sitting. This modification was made for two reasons; we thought that it better captured the reported level of alcohol consumption and it permitted more consistency in categorization between the TBI and general populations groups given differences in the questionnaires completed by these two groups. Light drinking was defined as 1–2 drinks up to twice a week while moderate drinking was defined as 1–2 drinks between three and six

times per week or 3–4 drinks on 1–4 occasions per week. Consuming alcohol seven or more times a week was considered heavy alcohol consumption, regardless of amount. In addition, consuming five or more drinks on a single occasion at least once a week was considered heavy drinking.³⁴

Of note, the NHIS includes questions about alcohol consumption during the past year, as well as lifetime. All participants who indicated that they had consumed 12 or more alcohol drinks in their life were asked the questions about quantity and frequency of alcohol consumption. Participants who reported that they had consumed less than 12 alcohol drinks in their life and persons who reported no alcohol consumption in the past year were categorized as abstainers. For the remaining persons in the NHIS database, the criteria described above were used to categorize persons as abstainers, light drinkers, moderate drinkers, or heavy drinkers for the purposes of this study.

National Institute on Alcohol Abuse and Alcoholism (NIAAA) recommended daily drinking limits. To consider gender effects on alcohol consumption, alcohol use in the mTBI group was also categorized according to the percent of persons who exceeded the recommended daily drinking limits that have been established by the NIAAA.³⁴ This was defined as men who reported drinking ≥ 5 drinks per sitting and women who consumed ≥ 4 drinks per sitting.

Statistical analyses

Paired sample *t* tests were used to compare post-injury alcohol consumption with pre-injury alcohol consumption. A series of paired sample *t* tests was used to evaluate the number of drinks per week post-injury (1 month vs. 6 months, 6 months vs. 12 months, 12 months vs. 3–5 years). Chi-square tests were used to evaluate the relationship between injury severity and post-injury alcohol consumption. A McNemar-like test³⁵ comparing heavier to lighter drinking was used to evaluate change in consumption categories over time in the group with TBI. Comparisons between the mean number of drinks reported by the TBI sample and the general population (NHIS data) were performed using blocked Wilcoxon tests,³⁶ stratified by both age and sex to adjust for the demographic differences in the composition of the two samples.

Results

Demographic information and injury characteristics for the group with TBI are presented in Table 1. Consistent with the epidemiology of TBI in the region where these data were collected, this sample was largely male and Caucasian. Age at time of injury

ranged from 18–89, with a mean of 36.6 years. Years of education at the time of injury ranged from 7–20 years, and 75% had completed high school or a higher level of education. Emergency department BAL was available on 165 participants; of those, 36% ($n = 59$) had a BAL greater than or equal to 0.08, the legal limit. An additional nine persons (5% of sample) had some alcohol on board at the time of injury, but their BAL was <0.08 . Severity of injury ranged from complicated mild to severe, with the majority of participants falling into the milder end of the range.

Alcohol use over time in the group with TBI

The first aim of this study was to examine pre- and post-injury alcohol use in the TBI group. Figure 1 illustrates the overall alcohol use patterns for this sample. Before the injury, more than half of the participants (52%) drank in the moderate to heavy range (31% of the sample reported alcohol consumption in the heavy range), while 38% of the sample reported that they abstained from alcohol. Men reported that they consumed an average of approximately 14 drinks per week pre-injury, while women averaged approximately 6 drinks per week (Table 2).

A significant drop in alcohol consumption was noted just after the injury, with the large majority (88%) of participants reporting abstinence from alcohol at the 1-month assessment. As illustrated in Figure 1, abstinence rates decreased over time, with the largest percentage of return to drinking occurring between 1 and 6 months post-injury (67% of sample reported abstinence at 6 months post-injury, 65% at 12 months post-injury, and 61% at 3–5 years post-injury). Even by 3–5 years post injury, however, the percent of persons reporting abstinence from alcohol was significantly higher than pre-injury (38%).

On the other end of the spectrum, rates of heavy alcohol use were significantly lower at each time point post-injury relative to pre-injury levels. The percentage of the sample reporting heavy alcohol consumption never exceeded 13% at the post-injury follow-ups for the full sample, including just 9% who reported heavy drinking at 3–5 years post-injury (relative to 31% pre-injury). In contrast, rates of light and moderate alcohol consumption at 3–5 years post-injury were very comparable to pre-injury rates (i.e., light drinking was reported by 10% of the sample pre-injury and 9% at 3–5 years post injury; moderate alcohol consumption was reported by 21% of the sample at both pre-injury and 3–5 years post-injury). Further, although a significant increase in alcohol consumption was reported between 1 and 6 months post-injury ($p < 0.001$), changes between time periods after that were not significant (each $p > 0.2$).

TABLE 1. DEMOGRAPHICS AND INJURY SEVERITY CHARACTERISTICS

N	170
Mean age (SD)	36.6 years (14.4)
Mean education (SD)	12.9 years (2.4)
% Male	79%
% Caucasian	88%
GCS	N (%)
Complicated mild	96 (63%)
Moderate	32 (21%)
Severe	25 (16%)
Missing	17
Time to follow commands	
≤ 24 hours	100 (59%)
25 h– 6 days	32 (19%)
7–13 days	15 (9%)
>13 days	23 (14%)

SD, standard deviation; GCS, Glasgow Coma Scale.

FIG. 1. Alcohol consumption over time.

TABLE 2. ALCOHOL CONSUMPTION AMONG PARTICIPANTS WITH TRAUMATIC BRAIN INJURY AND THE GENERAL POPULATION

	Overall	Females	Males	Significance (vs. CDC)		
				Overall	Females	Males
<i>Drinks per week</i>						
CDC NHIS*	3.6	1.2	4.2	—	—	—
TBI						
Pre-injury	12.2	6.1	13.8	.000	.000	.000
1 month post-injury	0.9	0.1	1.1	.000	.007	.000
6 months post-injury	3.4	1.3	4.0	.168	.906	.124
12 months post-injury	4.0	1.5	4.7	.501	.168	.197
3–5 years post-injury	4.3	1.1	5.2	.739	.752	.818

*These statistics are sex- and age-weighted to better match the composition of the traumatic brain injury (TBI) sample, thus making for a more appropriate comparison. The original unweighted statistics reported by the Centers for Disease Control and Prevention (CDC) for drinks per week was 2.4.

Finally, the results of a series of paired sample *t* tests on the full sample revealed a significant increase in number of drinks consumed per week between 1 and 6 months post-injury ($t[170] = -5.33, p < 0.001$). There was not a significant increase between 6 and 12 months, or 12 months and 3–5 years post-injury. Paired sample *t* tests also revealed that alcohol consumption (drinks per week) at 1 month ($t[170] = 7.90, p < 0.001$), 6 months ($t[169] = 6.19, p < 0.001$), 12 months ($t[169] = 5.14, p < 0.001$), and 3–5 years ($t[169] = 4.82, p < 0.001$) post-injury was lower than pre-injury rates (see Table 2 for mean drinks per week for full sample and men and women separately). Taken together, these numbers suggest that approximately one-third of persons do return to regular drinking post-injury, but overall the quantity and frequency of alcohol consumption is decreased post-injury relative to pre-injury levels.

Alcohol consumption according to sex

Examination of heavy alcohol consumption rates for men and women separately revealed that heavy drinking was reported by 14% of males at 6 months post-injury, 13% at 1 year post-injury, and 11% at 3–5 years post-injury. For the women, 6% reported heavy drinking at 6 months post-injury, but this decreased to 3% at 1 year post-injury and 0% at 3–5 years post-injury.

Similarly, the percentage of persons whose reported drinks per sitting exceeded NIAAA daily recommended drinking limits was highest at pre-injury. A significant dropoff was seen at 1-month post-injury, with the biggest post-injury increase occurring between 1 and 6 months post injury. After that time, gender differences were evident, with the percent of men reporting excessive alcohol consumption peaking at 1 year post-injury and then remaining the same at 3–5 years post-injury. In contrast, the percent of women reporting excessive alcohol consumption peaked at 6 months post-injury and then declined over time. Table 3 presents these data for males and females at each time point.

TABLE 3. PERCENT OF SAMPLE WHO EXCEEDED NATIONAL INSTITUTE ON ALCOHOL ABUSE AND ALCOHOLISM MAXIMUM DAILY DRINKING LIMITS

	Pre-injury	1 month post-injury	6 months post-injury	12 months post-injury	3–5 years post-injury
Males	31.3%	1.5%	10.4%	14.9%	14.3%
Females	19.4%	0.0%	11.1%	8.3%	2.8%

Alcohol consumption in the general population compared with those with TBI

The second aim of this study was to examine the rates of alcohol consumption among persons with TBI compared with the general population. Table 2 compares alcohol consumption among persons in this sample and the general population (NHIS data). The results indicate that pre-injury alcohol consumption in the TBI group, in terms of average number of drinks per week, was higher than the general population for males and females ($p < 0.001$). In contrast, alcohol consumption for the full sample (mean number of drinks per week) at 1 month post-injury was significantly lower than the general population ($p < 0.001$ overall and for males; $p = 0.007$ for females). From 6 months onward, alcohol consumption in the TBI sample did not differ from that in the general population.

Relationship between injury severity and post-injury alcohol consumption

Figure 2 illustrates the relationship between abstinence over time and injury severity (GCS score). Abstinence rates are lowest at the pre-injury time point compared with post-injury time points, regardless of injury severity. There was no difference in pre-injury rates of abstinence according to injury severity ($p > 0.05$). As expected, the highest rates of abstinence for every level of injury severity were reported at 1 month post-injury. Rates of abstinence

FIG. 2. Percent of traumatic brain injury sample abstaining from alcohol over time according to injury severity (Glasgow Coma Scale score).

FIG. 3. Percent of traumatic brain injury sample with moderate to heavy alcohol consumption over time according to injury severity (Glasgow Coma Scale score).

at this time point did not significantly vary according to injury severity, although those with severe injuries reported the highest rates of abstinence and those with mild injuries reported the lowest rates of abstinence.

A significant difference emerged at 6 months post-injury ($\chi^2 [2, N=153]=10.81, p=0.004$), with highest rates of abstinence among those who were severely injured and the lowest rates of abstinence in the mild TBI group. No group differences were present at 1 year or 3–5 years post-injury.

Rates of moderate to heavy alcohol consumption over time according to injury severity were also evaluated. Chi-square tests comparing rates of moderate to heavy alcohol consumption according to injury severity were not significant at any of the post-injury time points. However, Figure 3 suggests, however, that while moderate to heavy drinking is low in all severity groups at 1 month, most of those who sustained mild or moderate TBIs and returned to moderate to heavy drinking do so by 6 months; moderate to heavy drinking continues to rise until 1 year among those with severe injuries.

Discussion

The primary aim of this study was to improve our current understanding of alcohol consumption after TBI by evaluating alcohol use at multiple times post-injury, ranging from 1 month to 3–5 years. In this sample of persons with complicated mild to severe TBI, several significant findings emerged. First, consistent with previous research,^{7,9,16,37,38} pre-injury alcohol consumption, as indicated by both self-report data and intoxication at the time of injury, was high. Second, this study is unique in its examination of patterns of alcohol consumption at four time points post-injury, spanning both post-acute and long-term recovery.

Evaluation of alcohol consumption in this sample at 1 month, 6 months, and 12 months post-injury revealed that a significant increase in alcohol consumption occurs between 1 and 6 months post-injury. After 6 months, there was a slight increase in the percentage of participants reporting moderate to heavy alcohol consumption, but the change over time did not reach statistical significance and the rates never reached pre-injury levels. Further, by 6 months post-injury, weekly alcohol consumption was comparable to the general public and remained that way at subsequent follow-ups.

These results build on previous literature that had identified an increase in alcohol consumption by 1 year post-injury. Bombardier and associates⁹ called that first year the “critical window” for

targeted alcohol intervention. These results suggest that narrowing that window and offering targeted alcohol education and intervention within the first 6 months of injury might be more beneficial clinically.

The role of injury severity in post-injury alcohol consumption also deserves some attention. As might be expected, those with complicated mild injuries reported the lowest rates of abstinence at 1 month post-injury, compared with those with moderate and severe injuries. The pattern was similar at 6 months. By 12 months post-injury, however, rates of abstinence were comparable to those who had complicated mild and severe injuries. By 3–5 years post-injury, severity of injury did not impact the rates of abstinence, which ranged from 63–64% regardless of injury severity.

In terms of moderate to heavy alcohol consumption, there were no significant differences in alcohol consumption according to injury severity, but some suggestion that while the rate of heavy drinking stabilized by 6 months in those with complicated mild or moderate injury, it continued to rise until 1 year in those with severe injury. There was essentially no change in rates of problematic drinking between 12 months and 3–5 years.

There are several limitations to this study that should be mentioned related to the characteristics of the TBI sample and the measurement of alcohol use. First, the participants in this TBI group were mostly Caucasian males. Although this is representative of the epidemiology of TBI in Seattle, caution should be exercised when generalizing these findings to other racial or ethnic backgrounds. Similarly, the sample size for females with TBI was small. Next, the sample was limited to participants who completed the alcohol use questions at each time point assessed.

Our analyses revealed that those who were included in the study did not differ from those who were either lost to follow-up or not followed because of budgetary constraints in terms of age, pre-injury alcohol use, or blood alcohol level at the time of injury. Those who were not followed for these reasons, however, were more likely to be non-Caucasian and those who were lost to follow-up were more likely to be male. These factors should be taken into consideration when evaluating the representativeness of the sample.

In terms of the assessment of alcohol use, it is worth noting that all alcohol consumption data reported in this study were based on the self-report of participants as opposed to structured diagnostic assessments. Although previous research has suggested that self-report of alcohol use is reliable and valid,³⁹ future research should consider extending these findings to diagnostic criteria for an Alcohol Use Disorder as defined by the *Diagnostic and Statistical Manual of Mental Disorders-Fifth Edition (DSM-V)*.⁴⁰

Further, the assessment of alcohol consumption was not identical across groups in terms of the specific questions asked and the assessment time frame. In particular, the time frames at 1 month and 6 months post-injury were shorter (1 month and 6 months, respectively, as it was defined as time since injury). The other assessments (both for the TBI group at 1 year and 3–5 years post-injury as well as the normative NHIS data) were based on the past year. Within this limitation, however, we were able to define drinking categories that were consistent across groups to provide the information reported above.

Finally, the criteria used to categorize alcohol consumption as abstinent, mild, moderate, or heavy did not take into account the sex of the participant. To address this, at least in part, information about the number of male and females participants who report exceeding the daily drinking limits provided by NIAAA is included in the article. Future research may want to incorporate sex differences into the calculation of the quantity-frequency index.

Conclusion

This study evaluated the longitudinal pattern of alcohol consumption after complicated mild to severe TBI, and identified the first 6 months post-injury as the time when the majority of at-risk persons return to drinking. The potential negative impact of post-injury alcohol consumption on both mental and physical health, vocational and educational functioning, and overall quality of life is well established.^{4,15–17,19} The results of this study suggest that the first 6 months post-injury, particularly for those with milder injuries, should be considered for early targeted alcohol intervention, including education about the potential additional negative impact of alcohol consumption.⁴¹ Additional interventions are likely to also be useful over time, especially for those with more severe injuries. Future studies should evaluate the characteristics of individuals who do and do not have problematic alcohol consumption post-injury so as to improve our understanding of individuals who are most at risk.

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Author Disclosure Statement

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