

Running title: Evolution of Irritability, Anger, Aggression

Evolution of Irritability, Anger, and Aggression after Traumatic Brain Injury: Identifying and Predicting Subgroups

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Abstract

The current prospective, multi-center, longitudinal cohort study examined how Veterans/Service Members (V/SM) changed in their irritability, anger, and aggression (IAA) scores from admission to discharge in post-acute rehabilitation settings. The goals were to identify trajectory subgroups, and explore if there were different predictors of the subgroups. V/SM (N=346) from 5 Veterans Affairs TBI Model Systems Polytrauma Rehabilitation Centers participated. The sample was mostly men (92%) and identified as White (69%) Black (13%), and other races (18%). Median age was 28 years, and 78% sustained a severe TBI. Staff rated IAA at admission and discharge using the Mayo-Portland Adaptability Inventory-4 item#15. Four IAA trajectory subgroups were identified: 1.) No IAA at admission or discharge (n=89, 25.72%), 2.) Resolved IAA (n=61, 17.63%), 3.) Delayed Onset IAA (n=31, 8.96%), 4.) Persistent IAA (n=165; 47.69%). Greater posttraumatic stress disorder (PTSD) symptoms were the only consistent predictor of belonging to all the subgroups who had IAA compared to the No IAA subgroup. We conclude, IAA had different trajectories after a TBI. The majority of V/SM had persistent impairment from IAA, a quarter of the sample had no impairment from IAA, followed by IAA resolving, or getting worse. Findings emphasize the importance of educating providers and family of the different ways and times IAA can manifest after TBI. Timely diagnosis and treatment of PTSD symptoms during and after rehabilitation are critical treatment targets.

Keywords: Anger; Aggression; Traumatic Brain Injury; Irritable Mood; Rehabilitation; Posttraumatic stress disorder

Introduction

Traumatic brain injury (TBI) is a major public health concern with an estimated 1.5 million Americans experiencing one annually.¹ Family members of those with TBI report that irritability, anger, and aggression (IAA) are some of the most distressing symptoms after the injury.² Irritability is a mood in which a person is quick to anger. Anger is an emotion. Aggression is a behavior. While distinct constructs, they are highly inter-related and often conflated in the literature. Consequently, we will refer to IAA as a single construct.

In civilians with mild to severe TBIs, 74%, 39%, and 45% reported irritability, anger, and aggression, respectively,^{3,4} which are higher than levels reported by healthy controls.⁵ Problems with IAA can be observed in the chronic phases of TBI recovery,^{2,3} lead to interpersonal problems within families^{3,6,7} and interfere with rehabilitation. For example, rehabilitation services may exclude patients with IAA due to safety concern for other patients.⁴

The extant literature has identified five categories of predictors of IAA after TBI, including demographics, injury characteristics, rehabilitation factors, neuropsychological difficulties, and mental health symptoms. Demographic factors that are related to more IAA include male sex,⁸ lower socioeconomic status,⁹ less education,^{9,10} and younger age.^{11,12} Demographic factors are relatively stable and not typically viable intervention targets.

TBI characteristics and rehabilitation factors are generally not modifiable but are important considerations when predicting IAA. TBI characteristics include location of lesion, with frontal^{13,14} and temporal^{15,16} lobe lesions being related to increases in IAA and agitation. Greater length of stay on a rehabilitation unit¹⁰ was positively associated with IAA. Neuropsychological abilities, such as deficits in executive functioning,⁹ communication ability,⁶ verbal memory, and visual perceptual skills,⁹ which may be modified with treatment, were predictive of greater IAA.⁹

Many types of mental health symptoms before and after TBI are related to IAA. IAA were associated with current posttraumatic stress disorder (PTSD) symptoms,¹⁷ current anxiety, past alcohol abuse, and past and current major depression and drug abuse.¹⁴

Individual psychological differences, such as hostile attribution bias¹⁸ and alexithymia¹⁹ were related to greater IAA in the chronic stages of TBI. Mental health symptoms are optimal for modification as there are widely disseminated treatments available.

Research has focused on identifying factors related to IAA. Less work has examined how IAA evolve after TBI and which factors influence change. On average, IAA decrease from admission to discharge in a post-acute rehabilitation setting.¹⁷ Measures of central tendencies, such as mean score changes, describe the entire group and can mask subgroups that may not adhere to the typical change pattern. For example, in the Miles study¹⁷ not all patients had reductions in IAA. Some patients' IAA remained stable, and others' got worse. Another study¹¹ found 25% of patients were classified as aggressive at 6 to 60 months post-TBI. While the percentage who were rated aggressive remained consistent at 25%, patients moved between being classified as aggressive and non-aggressive. These studies suggest there may be subgroups of patients who have different trajectories of IAA after a brain injury. Understanding how IAA can change overtime, and the factors related to change, can assist with personalized treatment approaches, timing of interventions, and discharge planning. The goal of this manuscript was to identify subgroups of Veterans/Service Members' (V/SM) and how they change in their IAA from admission to discharge in post-acute rehabilitation for TBI (e.g. resolved, delayed onset IAA). Subsequently, we explored if there were different predictors of IAA subgroups.

Materials and Methods

Participants and Setting

Participants enrolled prospectively in the Veterans Affairs (VA) TBI Model Systems (TBIMS) National Database: a multicenter, longitudinal study of TBI outcomes. Participants were age 18 or older and admitted to one of five rehabilitation programs at VA Polytrauma Rehabilitation Centers (PRC: Richmond, VA; Tampa, FL; Minneapolis, MN; Palo Alto, CA; and San Antonio, TX). See Lamberty et al. (2014) for VA TBIMS inclusion and exclusion criteria. Analyses were conducted with a subset of TBIMS participants who were: 1) Enrolled between 2010 and 2020, 2) Admitted to one of the VA Polytrauma Transitional Rehabilitation Programs (PTRP) for post-acute rehabilitation, and 3) Not missing data on

variables of interest. PTRP are for V/SM with TBI that focus on community reintegration to home, work, school, or military service.²⁰

Procedures

This study was a sub-study of the parent VA TBIMS study which was approved by local Institutional Review Boards at the PRC. The study conforms to all state and federal research regulations. Participants or their proxies provided informed consent prior to data collection. Demographics were obtained at study enrollment from interviews with the participants or their proxies including family members and staff familiar with participants after admission.²¹ Participants completed self-report measures. Study staff extracted medical records for injury characteristics, including computerized tomography (CT) and magnetic resonance imaging (MRI) results. Clinical staff rated the Functional Independence Measure (FIM)²² at discharge from acute inpatient rehabilitation and the Mayo-Portland Adaptability Inventory-4 (which contained the IAA item) at admission to and discharge from PTRP (post-acute rehabilitation).

Measures

Demographic and injury characteristics. Demographics are found in Table 1. TBI severity was classified as mild, moderate, or severe based on the most severe metric available (i.e. Glasgow Coma Scale score, time to follow commands, or duration of altered consciousness/posttraumatic amnesia).^{23,24} TBI characteristics included mechanism of injury and CT/MRI findings. CT/MRI findings included the first set of scans within 7 days of the TBI or first available CT/MRI regardless of time since injury. CT/MRI findings were categorized as either “Yes” or “No” for the following non-mutually exclusive categories: intracranial compression greater than 5mm, punctate/petechial hemorrhages, frontal contusions, and temporal contusions.

Mental health. Mental health variables were collected at enrollment, coded as “Yes” or “No”, and included if the V/SM had: ever received mental health treatment, ever attempted suicide, and used illicit /non-prescription drugs in the past year. Alcohol use was also assessed by the number of drinks per week in the month prior to injury via the Behavioral Risk Factor Surveillance System.²⁵ Scoring included abstaining (0 drinks), light

(1-3 drinks), moderate (3-14 for men; 3-7 for women) and heavy use (>14 for men; >7 for women). PTSD symptoms were measured with the PTSD Checklist—Civilian version (PCL-C)²⁶ which is a 17-item self-report measure of how much individuals were bothered by PTSD symptoms in the past month. Responses range from 1 (not at all) to 5 (extremely).

Rehabilitation and TBI variables. Length of stay in PTRP was counted in days. The FIM²² is an 18-item clinician-rated measure of independence in activities of daily living. Items are rated on an ordinal 1 (total dependence) to 7 (complete independence) scale. Two items were rated by clinicians at discharged from inpatient rehabilitation and used for the study: Expression (ability to use clear vocal and non-vocal expression of language) and Problem Solving (the ability to make reasonable and safe decisions regarding financial, social, and personal affairs, and self-correction of tasks). Expression was chosen because impaired communication is associated with greater IAA.⁶ Problem solving was chosen as a proxy for executive functioning ability which is related to greater IAA.⁹

Outcome variable: IAA at admission to and discharge from PTRP. The 29-item Mayo-Portland Adaptability Inventory-4 (MPAI-4)²⁷ is completed by clinical staff and measures problems in abilities, adjustment, and relationships. All patient behavior displayed in front of staff was used to determine the scores for PTRP admission and discharge using clinical team consensus. Ratings were based on observations within a 3-week window at both time points. To evaluate IAA, Item #15 asked program staff to rate the level at which the patient experiences: "Irritability, anger, aggression: Verbal or physical expressions of anger." Answer choices include: 0 (None); 1 (Mild problems but does not interfere with activities; may use assistive device or medication); 2 (Mild problems, interferes with activities 5-24% of the time); 3 (Moderate problems; interferes with activities 25-75% of the time); 4 (Severe problems; interferes with activities more than 75% of the time). Scores ≥ 1 indicate impairment by IAA. Scores ≥ 2 indicate disability from IAA. Both impairment and disability can be treatment goals.

Data analysis

Data were analyzed using statistical software Rv3.6.1 (R Foundation for Statistical Computing, Vienna, Austria) for descriptive statistics and modeling, and SAS 9.4 (SAS

Institute Inc, Cary, NC) macro www.andrew.cmu.edu/user/bjones/index.htm for group-based multi-trajectory models.²⁸⁻³⁰

We performed group-based multi-trajectory modeling to identify latent groups of participants who followed the same trajectories in IAA status from PTRP admission to discharge. Models for up to 4 groups were explored. The four-group model was chosen as the best model with the lowest Bayesian Information Criterion (BIC) and further verified by a clinical perspective. The four group model had participants with No IAA, Delayed Onset IAA, Resolved IAA, and Persistent IAA.

A multinomial logistic regression model was then fit to the identified 4 subgroups to examine the associations between different variables and each subgroup. Estimated relative risk ratios for each independent variable examined how the risk of falling in the comparison group compared to the risk of falling in the reference group (No IAA). Independent variables were chosen based on the literature: PTRP length of stay (days), years of education (\leq high school vs. $>$ high school), employment status (student/employed vs. not), sex (men vs. women), ever received mental health treatment (yes vs. no), past year use of illicit drugs (yes vs. no), drinking category (abstaining /light vs. moderate/heavy), PCL-C total, ever attempted suicide (yes vs. no), FIM Discharge: Expression (continuous like score), FIM Discharge: Problem Solving (continuous like score), extent of intracranial compression >5 mm (yes vs. no), punctate/ petechial hemorrhages (yes vs. no), frontal contusions (yes vs. no), and temporal contusions (yes vs. no). The analysis was conducted on all participants who had variables of interest, reducing the multivariate sample to $n=172$ (Table 2). We also examined the model with other covariates that may have been related to IAA, including if the participant had ever been involved in special education due to learning difficulties (yes vs. no) and if the participant had current feelings of sadness and depression, measured by an item from the Neurobehavioral Symptom Inventory (0 vs. >0).³¹

Results

Four hundred and four participants were admitted and discharged from the PTRP and eligible for the study. Of these, $n=372$ and $n=346$ had an MPAI-4 at admission and

discharge, respectively. These 346 V/SM made up the study sample. V/SM were mostly men (92%), were a median age of 28 years at injury, and had earned more than a high school diploma (61%). Most identified as white (69%), followed by other races (18%; Asian, American Indian, Native Hawaiian), and black (13%). The majority had sustained a severe TBI (78%; Table 1).

The group-based modeling of longitudinal data was conducted to identify subgroups in how IAA evolved from PTRP admission to discharge. We examined 2, 3, and 4 subgroup options. All subgroup options included n=89 V/SM who had no IAA at admission and discharge (MPAI-4#15 scores=0 at both time points). The 2 Group option included the No IAA subgroup (n=89) and another subgroup that contained the rest of the sample who either increased or decreased their IAA from admission to discharge (n=257). The 3 Group option included the No IAA subgroup (n=89) and two other subgroups that had both increases and decreases in IAA (n=222 and n=35). A 4 Group option was generated, had the lowest BIC, and produced the following groups that made clinical sense:

- **No IAA** (n=89, 25.72%): MPAI-4#15 =0 at admission and discharge.
- **Resolved IAA** (n=61, 17.63%): MPAI-4#15 >0 at admission and MPAI-4#15 =0 at discharge.
- **Delayed Onset IAA** (n=31, 8.96%): MPAI-4#15 =0 at admission and >0 at discharge.
- **Persistent IAA** (n=165; 47.69%): MPAI-4#15 >0 at admission and discharge (Table 2).

Next, we used a multinomial logistic regression to determine which predictors distinguished between the 4 subgroups (Table 3). Relative risk ratios were estimated with the No IAA subgroup as the reference. McFadden's Pseudo R^2 of the fitted model =58.86%, indicating a good fit. PTSD symptoms were the only consistent predictor that distinguished between the reference subgroup and all other subgroups. A one-point increase on the PCL-C was associated with an increase in the relative probability of being in each comparison group (i.e. the Resolved IAA, Delayed Onset IAA, and Persistent IAA) over being in the reference group (i.e. No IAA group) by 17-19%.

For the Delayed Onset IAA group, only PTSD symptoms (RRR=1.192; CI: 1.094, 1.299) and temporal contusions (RRR=8.623; CI: 1.382, 53.781) carried elevated relative

risks of being in this subgroup compared to the No IAA subgroup. For the Resolved IAA subgroup, greater PTSD symptoms (RRR=1.194; CI: 1.104, 1.291), longer PTRP stay (RRR=1.011; CI: 1.001, 1.02), and being employed before TBI (RRR=16.709, CI: 2.157, 129.438) were associated with an elevated relative risk of being in the Resolved IAA subgroup compared to the No IAA subgroup. Finally, for those in the Persistent IAA subgroup, greater PTSD symptoms (RRR=1.173; CI: 1.088, 1.264) and being employed prior to the TBI (RRR=4.519; CI: 1.067, 19.143) increased the risk of being in the Persistent IAA subgroup by 3.519 compared to the risk of being in the No IAA subgroup. The significant findings remain unchanged when history of special education and feeling depressed were added to the model as additional predictors (results not displayed).

Discussion

The study examined how IAA changed from admission to discharge in post-acute TBI rehabilitation. We identified 4 subgroups. The largest subgroup consisted of V/SM who had Persistent IAA (47.69%), meaning that clinical levels of IAA endured throughout rehabilitation. IAA may have become more or less extreme from admission to discharge; however, some level of impairment was present at both time points (MPAI-4 item#15 scores 1-4). The No IAA subgroup was the second largest (25.7%) and contained V/SM who did not have IAA at admission or discharge. The third subgroup (Resolved IAA; 17.6%) had impairment from IAA at admission which resolved by discharge. Delayed Onset IAA was the final and smallest subgroup (8.9%) with IAA at admission but not at discharge.

The subgroups speak to the different ways IAA can evolve after TBI. While previous work found the average IAA scores statistically decreased from admission to discharge,¹⁷ the subgroups in this study showed that there is variation in how IAA change. Over half of the current sample had some level of impairment from IAA at discharge. As IAA can contribute to family discord and suboptimal rehabilitation, providers should consider it a critical and early treatment target.

We used a multinomial regression model to determine if established risk factors of IAA could distinguish between trajectory subgroups. PTSD symptoms were the only consistent risk factor for all IAA subgroups when compared to the No IAA subgroup.

Simply, greater PTSD symptoms predicted having IAA at some point after TBI. Providers should be aware that PTSD is often associated with anger and aggression in V/SM,³² particularly those who have difficulty managing emotions.³³ Unfortunately, TBI can make managing emotions difficult.⁵ Thus, V/SM with TBI and PTSD symptoms may be particularly vulnerable to IAA. This finding emphasizes the importance of diagnosing and treating PTSD as part of rehabilitation for V/SM with TBI. Evidence based psychotherapies for PTSD, such as Cognitive Processing Therapy and Prolonged Exposure Therapy, are the gold standard treatments for reducing symptoms and can be completed by those who have sustained TBIs of all severity levels.^{34,35}

While No IAA is ideal result after TBI, the next preferred outcome would be for IAA to resolve before discharge. Length of stay at PTRP was associated with Revolved IAA as compared to No IAA. V/SM may have learned methods to manage their IAA while in PTRP. Being employed or a student prior to TBI was associated with a relative risk of being in the Resolved IAA and the Persistent IAA subgroups (compared to the No IAA subgroup). People who were employed versus retired may have more financial stress to manage after TBI, and stress can trigger IAA.

Finally, experiencing a temporal contusion was associated with a higher relative risk of belonging to the Delayed Onset IAA subgroup compared to the No IAA subgroup. This finding should be tempered by the fact that the scans included CT and MRI readings that were conducted at the different time points after injury. However, the finding is consistent with previous literature that demonstrates damage to the temporal lobes or the underlying limbic system are related to aggressive behavior.^{15,16} While location of lesion is not malleable, clinicians can use this knowledge proactively for planning purposes and address IAA prior to discharge. Providing education to family members about delayed onset IAA may also assist with expectation management and seeking appropriate treatments.

Study Limitations and Strengths

Limitations of the study included using a single item to assess IAA, which is less reliable than a scale and does not allow for distinctions between irritability, anger, and

aggression. The sample for the multinomial logistic regression was a reduced model due to missingness of some variables. We were unable to control for medication effects, used a proxy variable for learning challenges (receiving special education), and only had a single item to measure depression.³¹ Also, granularity of neuropathological findings on imaging were unavailable. Diagnostic interviews for PTSD would strengthen this research. Finally, the V/SM sample from the VA TBIMS may not generalize to civilians with TBI. VA TBIMS participants are more likely to be young men who experience severe injuries, while the average civilian with TBI is likely to sustain a mild injury.³⁶ Fortunately, our age range and race/ethnicity proportions deviated only slightly from civilians with TBI who are admitted for rehabilitation³⁷ and are consistent with the overall veteran population.³⁸

Strengths of the study included an adequate sample size allowing examination of IAA subgroups and multiple types of predictors. We considered demographics, clinician ratings, self-report measures, and neuroimaging in order to distinguish between subgroups. Longitudinally examining the evolution of IAA subgroups is a strength over cross-sectional samples or mean score changes within the total sample. Program staff rated veterans' IAA, which is more objective than self-report of socially undesirable behaviors. Finally, our sample contained moderate and severe TBI, while most PTSD and TBI literature has focused on mild TBI.

Conclusion

Almost half the V/SM began and ended PTRP with at least mild impairment from IAA. Fewer V/SM left PTRP with resolved IAA, and an even smaller group had delayed onset IAA. Clinical implication include educating family member and patients about how IAA can change during rehabilitation. This information may alleviate distress that might arise if IAA is unexpected and may also provide hope because IAA may not be permanent. Second, identifying PTSD symptoms, employment status, and location of lesions can assist in predicting how IAA may change. Employment status was related to having persistent and resolved IAA (compared to no IAA), which may signal financial stress after the injury. Proactive intervention might include financial counseling.³⁸ Finally, PTSD symptoms distinguished between the No IAA subgroup and all other subgroups. Providers can screen for PTSD using self-report measures which are inexpensive and not time intensive to

administer. Providers can then make appropriate mental health referrals. Treating the PTSD in rehabilitation may be beneficial as the dropout rates from PTSD in outpatient settings can be as high as 72%.³⁹⁻⁴¹ V/SM with moderate and severe TBI can benefit from evidence-based treatments for PTSD.^{34,35}

Author Contribution: All authors contributed to the conception of the design, critically revised the content, have approved the final version, and have agreed to be accountable for the work in ensuring questions about the study are appropriately investigated and resolved.

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Table 1.**Demographic Characteristics of the Total Sample**

Variables	Observed N	Summary
Male	346	92% (318)
Race	331	
White		69% (230)
Black		13% (43)
Other		18% (58)
Marital status	346	
Married		31% (108)
Other		69% (238)
Education	346	
≤ High school diploma		39% (135)
> High school diploma		61% (211)
Annual earnings	247	
< \$50,000		72% (179)
≥ \$50,000		28% (68)
Employment	346	
Student/employed		85% (293)
Other		15% (53)
<u>TBI Characteristics</u>		
Age at index TBI	346	23;28;40

Injury severity category	316	
Mild		9% (29)
Moderate		13% (42)
Severe		78% (245)
Cause of injury	344	
Vehicular		57% (196)
Fall		17% (58)
Violence: penetrating		5% (18)
Violence: blast		4% (13)
Other		17% (59)
Days from TBI to PTRP admission	346	57; 84;149
CT status	290	
CT done		90% (262)
CT not done		10% (28)

Note: Categorical data expressed as % and (n). Continuous data

expressed as quantiles.

Table 2: A summary of predictors of Irritability, Anger, and Aggression (IAA) for total sample and subgroups

	All		No IAA		Delayed Onset IAA		Resolved IAA		Persistent IAA	
	N	Summary	N	Summary	N	Summary	N	Summary	N	Summary
IAA at admission (MPAI#15)	34		8		3		6		16	
	6		9		1		1		5	
None		35% (120)		100% (89)		100% (31)		0% (0)		0% (0)
Mild problem: without interference		24% (84)		0% (0)		0% (0)		56% (34)		30% (50)
Mild problem: with interference		28% (96)		0% (0)		0% (0)		31% (19)		47% (77)
Moderate problem		11% (38)		0% (0)		0% (0)		11% (7)		19% (31)
Severe problem		2% (8)		0% (0)		0% (0)		2% (1)		4% (7)
IAA at discharge (MPAI#15)	34		8		3		6		16	
	6		9		1		1		5	
None		43%		100%		0% (0)		100%		0% (0)

	(150)	(89)	(61)		
Mild problem: without interference	32% (109)	0% (0)	65% (20)	0% (0)	54% (89)
Mild problem: with interference	19% (66)	0% (0)	29% (9)	0% (0)	35% (57)
Moderate problem	5% (18)	0% (0)	3% (1)	0% (0)	10% (17)
Severe problem	1% (3)	0% (0)	3% (1)	0% (0)	1% (2)
PTRP length of stay, days	34 50; 6 83;120	8 45; 9 74;107	3 56; 1 92;120	6 61;102;1 1 37	16 46; 5 80;116
Years of education	34 6	8 9	3 1	6 1	
≤ High school diploma	39% (135)	38% (34)	29% (9)	48% (29)	38% (63)
> High school diploma	61% (211)	62% (55)	71% (22)	52% (32)	62% (102)
Employment	34 6	8 9	3 1	6 1	16 5
Student/emplo yed	85% (293)	83% (74)	90% (28)	87% (53)	84% (138)
Other	15% ()	17%	10% ()	13% (8)	16% ()

		53)		(15)		3)			27)	
Male	34	92%	8	92%	3	81%	6	93%	16	93%
	6	(318)	9	(82)	1	(25)	1	(57)	5	(154)
Ever received mental health treatment	34	35%	8	24%	3	29% (	6	38%	16	42%
	6	(122)	9	(21)	1	9)	1	(23)	5	(69)
Use of illicit drugs	34	12% (	8	12%	3	7% (2)	6	13% (8)	16	13% (
	3	42)	8	(11)	0		1		4	21)
Drinking category	32		8		2		5		15	
	7		6		8		6		7	
		49%		47%		57%		41%		52%
Abstaining/ligh t		(160)		(40)		(16)		(23)		(81)
		51%		53%		43%		59% (33)		48%
Moderate/hea vy		(167)		(46)		(12)				(76)
PCL-C total	28	20;27;3	7	19;21;2	2	20;27;3	5	24;34;43	13	22;31;4
	4	8	1	4	4	9	6		3	5
Past suicide attempt	34	11% (	8	8% (7)	3	3% (1)	6	10%(6)	16	14%
	5	37)	9		1		1		4	(23)
FIM Expression	28	6;6;7	8	6;6;7	2	6.0;6.5;	5	5;7;7	12	6;6;7
	8		1		6	7.0	3		8	
FIM Problem Solving	29	4;5;6	8	4;5;6	2	4;5;6	5	4;5;6	12	4;5;6
	0		2		6		3		9	
Extent of intracranial	26	13% (	7	14%	2	14% (	5	14% (7)	11	12%
	1	34)	1	(10)	1	3)	1		8	(14)

compression**>5 mm**

Punctate/pete	27	37%	(7	41%	2	36%	(5	39%	12	33%
chial	0	99)	1	(29)	2	8)	1	(20)	6	(42)

hemorrhages

Frontal	26	57%	7	56%	2	41%	(5	61%	12	58%
contusions	8	(152)	1	(40)	2	9)	1	(31)	4	(72)

Temporal	26	39%	7	32%	2	55%	5	38%	12	40%
contusions	7	(103)	1	(23)	2	(12)	0	(19)	4	(49)

Note: Categorical data expressed as % and (n). Continuous data expressed as quantiles.

IAA = irritability, anger, and aggression measured by the MPAI-4 = Mayo Portland

Adaptability Inventory-4. PTRP = Polytrauma Transitional Rehabilitation Program. PCL-C =

Posttraumatic Stress Disorder Checklist – Civilian version. FIM = Functional Independence

Measure at rehabilitation discharge.

Table 3:

Results from multinomial logistic regression model (No IAA as reference)

		Delayed Onset IAA (relative to No IAA)	Resolved IAA (relative to No IAA)	Persistent IAA (relative to No IAA)
Predictor	Comparison	RRR (95% CI)	RRR (95% CI)	RRR (95% CI)
Days in PTRP	One day longer	1.002 (0.989, 1.015)	1.011 (1.001, 1.02)	1.001 (0.993, 1.01)
Years of education	> HS diploma vs. HS diploma or <	1.14 (0.254, 5.109)	0.76 (0.272, 2.125)	1.162 (0.5, 2.701)
Employment	Student/employed vs. Other	2.306 (0.303, 17.55)	16.709 (2.157, 129.438)	4.519 (1.067, 19.143)
Male	Male vs. Female	0.341 (0.039, 3.013)	0.683 (0.087, 5.343)	5.394 (0.444, 65.487)
Ever received mental health treatment	Yes vs. No	0.679 (0.122, 3.783)	1.345 (0.36, 5.023)	0.809 (0.259, 2.525)
Use of illicit drugs	Yes vs. No	0.678 (0.044, 10.463)	1.106 (0.17, 7.202)	1.056 (0.21, 5.323)
Drinking category	Moderate/heavy vs. Abstaining/light	1.639 (0.394, 6.812)	1.818 (0.618, 5.346)	0.958 (0.391, 2.346)
PCL-C total	One score higher	1.192 (1.094, 1.299)	1.194 (1.104, 1.291)	1.173 (1.088, 1.264)

Ever attempt suicide	Yes vs. No	0.617 (0.046, 8.344)	0.567 (0.072, 4.448)	0.714 (0.129, 3.949)
FIM Expression	One score higher	1.509 (0.587, 3.881)	1.469 (0.776, 2.779)	0.711 (0.429, 1.179)
FIM Problem Solving	One score higher	1.351 (0.622, 2.932)	1.127 (0.666, 1.909)	0.961 (0.621, 1.486)
Intracranial compression > 5mm.	Yes vs. No	1.436 (0.21, 9.832)	1.066 (0.246, 4.619)	0.942 (0.265, 3.342)
Punctate/petechial hemorrhages	Yes vs. No	0.373 (0.059, 2.372)	0.848 (0.267, 2.695)	0.595 (0.223, 1.584)
Frontal contusions	Yes vs. No	0.172 (0.029, 1.028)	0.931 (0.274, 3.161)	0.928 (0.342, 2.515)
Temporal contusions	Yes vs. No	8.623 (1.382, 53.781)	0.964 (0.305, 3.042)	1.062 (0.412, 2.735)

Note. RRR=relative risk ratio, CI=confidence interval. PTRP = Polytrauma Transitional Rehabilitation Programs. PCL-C = Posttraumatic Stress Disorder Checklist – Civilian Version. FIM = Functional Independence Measure at discharge from rehabilitation. Bolded values are those with a CI excluding 1 or statistically significant with $p \leq 0.05$. The model did not change when special education and depression were added into the model (results now shown).