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Authors

Ewing, Tyler
Barrios, Cristobal
Lau, Cecilia
et al.

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Predictors of Hazardous Drinking Behavior in 1,340 Adult Trauma Patients: A Computerized Alcohol Screening and Intervention Study

Tyler Ewing, BS, Cristobal Barrios, MD, Cecilia Lau, BS, Madhukar S Patel, ScM, Eric Cui, BS, Stephanie Diana Garcia, BA, Allen Kong, MD, Shahram Lotfipour, MD, MPH, FACEP, Michael Lekawa, MD, FACS, Darren Malinoski, MD, FACS

BACKGROUND: Alcohol screening and brief intervention (SBI) is used to decrease alcohol consumption, health care costs, and injury recidivism in trauma patients. Despite SBI being mandated for trauma centers, various concerns have led many centers to conduct SBI only on patients with a detectable blood alcohol concentration (BAC). We sought to determine the predictive nature of BAC on hazardous drinking behavior.

STUDY DESIGN: Adult trauma patients were included if they received an SBI before discharge. SBI was administered using a computerized alcohol screening and intervention (CASI) system with the Alcohol Use Disorder Identification Test (AUDIT). Data regarding demographics, injuries, and BAC were prospectively collected. Multivariate analyses were performed to identify independent predictors of hazardous drinking behavior.

RESULTS: Data were complete for 1,340 patients, with a mean age of 43 years (SD 20 years). Sixty-eight percent were male, 33% had detectable BAC, and 19% had hazardous drinking behavior. Multivariate analysis identified age (odds ratio [OR] 0.97 per year), male sex (OR 3.1), BAC (OR 1.009 per mg/dL), detectable BAC (OR 3.9), and legal intoxication (OR 7.8) as independent predictors of hazardous drinking behavior. Asian/Pacific Islander ethnicity was a significant negative predictor (OR 0.53) compared with white. Thirty-eight percent of patients with hazardous drinking behavior had no detectable BAC.

CONCLUSIONS: Younger age, male sex, and higher BAC are early predictors of hazardous drinking behavior in adult trauma patients. Asian/Pacific Islander patients are half as likely to report hazardous drinking behavior compared with white patients. More than one-third of patients with hazardous drinking behavior do not have detectable BAC on admission and are not receiving interventions in centers that screen solely based on BAC. (*J Am Coll Surg* 2012;215:489–495. © 2012 by the American College of Surgeons)

Trauma patients who present with alcohol intoxication on first admission are about 2.5 times more likely to return for a new injury compared with patients who were sober.^{1,2} Alcohol screening and brief intervention (SBI) was investigated as a possible solution to this issue in trauma patients

and has been found to significantly reduce the recurrence of injury by 47%, as well as reduce the occurrence of hazardous drinking, motor vehicle violations, and arrests.^{3,4} SBI has also been shown to be feasible and cost-effective. A half-time research assistant can screen most, eligible trauma patients, and it is estimated that every \$1 spent on SBI produces \$3.81 in savings.^{5,6}

Recently, a computerized alcohol screening and intervention (CASI) system has been shown to be user friendly, preferred by patients over a provider-administered SBI, and effective at reducing hazardous drinking behavior.^{7,8} CASI uses the 10-question Alcohol Use Identification Test (AUDIT) to determine drinking behavior, and its utility has been well investigated.⁹ In a case-control study, patients who received CASI were significantly less likely to report at-risk drinking behavior

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Received February 17, 2012; Revised May 7, 2012; Accepted May 9, 2012. From the Division of Trauma and Critical Care (Ewing, Barrios, Lau, Patel, Cui, Garcia, Kong, Lekawa) and the Department of Emergency Medicine (Lotfipour), University of California, Irvine; and the Department of Surgery, Cedars-Sinai Medical Center, Los Angeles (Malinoski), CA. Correspondence address: Darren Malinoski, MD, FACS, Cedars-Sinai Medical Center, 8635 West 3rd St, Suite 665w, Los Angeles, CA 90048. email: darren.malinoski@cshs.org

Abbreviation and Acronyms

AUDIT	= Alcohol Use Disorder Identification Test
BAC	= blood alcohol concentration
CASI	= computerized alcohol screening and intervention
ED	= emergency department
ISS	= Injury Severity Score
LOS	= length of stay
OR	= odds ratio
PID	= postinjury day
PPV/NPV	= positive/negative predictive value
SBI	= screening and brief intervention

compared with patients without an intervention ($p = 0.008$), and they significantly decreased their alcohol intake ($p = 0.006$) at 6-month follow-up.⁸ A study that surveyed CASI respondents in Spanish and English found that 98% of patients found the system easy to use and 75% preferred CASI over a provider-delivered SBI.⁷

The American College of Surgeons Committee on Trauma mandated in 2006 that all level 1 and level 2 trauma centers develop a protocol for administering SBI. The mandate, however, did not specify which patients to screen, and concerns regarding cost, logistics, and privacy have led many centers to screen only patients believed to be at high-risk for alcohol use disorders.^{5,10-12} A recent survey found that although 65% of emergency department directors at level 1 and level 2 trauma centers support alcohol screening, only 15% had formal SBI policies and only 12% of patients identified with an alcohol use disorder received a brief intervention. Among the perceived barriers to implementation were provider time (83%) and financial resources (55%).¹⁰ Another study cited confidentiality (14%) and threats to reimbursement (27%) as problems with SBI implementation.⁵ A survey of 204 level 1 trauma centers found that 71% use serum blood alcohol concentration (BAC) to screen for alcohol use.¹² There is little evidence to support BAC being a useful marker for hazardous drinking behavior in trauma patients.

The goal of this study was to find independent predictors of at-risk or dependent drinking behavior, which will be referred to as hazardous drinking behavior, in adult trauma patients and to specifically determine the predictive nature of BAC. Isolating a patient population that is significantly more likely to report hazardous drinking behavior could help direct screening efforts when resources and manpower are lacking.

METHODS

The University of California Irvine Medical Center has used the computerized alcohol screening and intervention (CASI) system to administer SBIs to trauma patients since

September 2009. The CASI device is a touch-screen tablet computer that delivers the Alcohol Use Disorder Identification Test (AUDIT) in both English and Spanish. AUDIT is a 10-item questionnaire that identifies drinking behavior as nondrinking (AUDIT = 0), not at-risk (AUDIT 1–7), at-risk (AUDIT 8–19), or dependent (AUDIT 20–40). Patients who report at-risk or dependent drinking behavior receive a brief, computerized intervention. Patients with dependent drinking behavior are additionally referred to a social worker.

Screening was attempted on all adult trauma patients by undergraduate research assistants from 8:00 AM to midnight in the emergency department (ED) and 8:00 AM to noon in the inpatient units. The research assistants were trained on how to deliver the CASI system and would approach as many patients as possible without interfering. The research assistants would identify themselves as members of the trauma team and would explain that alcohol use screening was a part of standard care for all trauma patients. Patients seen and discharged from the ED between midnight and 8:00 AM were often missed by the screening system due to the interval nature of the research assistants' shifts. Patients were not approached for screening if they met any of the following criteria: pre-existing psychiatric problem, altered mental status, refusal of SBI, language barrier, critically ill, acutely intoxicated, incarcerated, non-cooperative, or combative. Screening was attempted daily on patients who were missed in the inpatient units.

All trauma patients had a BAC measured as early as possible on arrival. A BAC < 5 mg/dL was not measurable by the test and was recorded as an undetectable BAC. All adult trauma patients treated in the ED or admitted to the hospital were prospectively enrolled from September 2009 to February 2011. Patients who received an SBI with CASI were included in the study. Data regarding age, sex, postinjury day (PID) of CASI, ethnicity, admission status, injury mechanism, injury severity, blood alcohol concentration, hospital length of stay, ICU length of stay, and ventilator days were recorded. Admission status included hospital admission, ICU admission, and ED disposition (operating room, ICU, or wards). Injury severity included Injury Severity Score (ISS) ≥ 15 , Abbreviated Injury Score (AIS) ≥ 3 for all body regions, and Glasgow Coma Scale (GCS). Blood alcohol concentration was analyzed as a continuous variable as well as 3 categorical variables: BAC > 0 mg/dL, BAC ≥ 80 mg/dL, and BAC ≥ 100 mg/dL. The BAC ≥ 80 mg/dL variable was chosen because it is the legal limit to operate a motor vehicle. The BAC ≥ 100 mg/dL variable was chosen to compare across studies. Ventilator days were analyzed as a continuous variable as well as a patient being

ventilator dependent at any time during hospitalization (ventilator days ≥ 1).

The primary outcome measure was at-risk or dependent drinking behavior (hazardous drinking behavior), as determined by the AUDIT score. At-risk and dependent behaviors were grouped as an outcome because these patients were candidates for an alcohol intervention. The screened group and not-screened group were also compared to determine the generalizability of the results. Reasons for not being screened were recorded. Sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) were determined for the categorical BAC variables.

Pearson chi-square or Fisher's exact test was used to analyze categorical values, and the independent *t*-test was used to analyze continuous variables. Clinically significant variables with $p < 0.1$ on univariate analyses were included in a binomial regression model to identify independent predictors of hazardous drinking behavior. Related variables were evaluated using separate models, and the concordance index (c-statistic) was used to determine the predictive capacity of each model. If a variable was included in more than 1 model, the odds ratio (OR) from the model with the highest c-statistic was used. The Hosmer-Lemeshow test was also calculated, with a $p > 0.05$ indicating acceptable model fit. A BAC of 0 mg/dL was used as the reference for the continuous BAC variable and categorical BAC > 0 mg/dL variable. A BAC < 80 mg/dL was used as a reference for the BAC ≥ 80 mg/dL variable, and BAC < 100 mg/dL was used as a reference for the BAC ≥ 100 mg/dL variable. Statistical Package for the Social Sciences software version 19.0 (SPSS Inc) was used for the analyses and the study was approved by the Institutional Review Board of the University of California, Irvine.

RESULTS

Over the 17-month study period, 2,855 adult trauma patients were prospectively enrolled, 1,340 (47%) of whom were screened with CASI. Common reasons for not receiving CASI (Table 1) included being discharged before approach in the ED (46%), being discharged before approach in the inpatient units (26%), and the patient having a psychiatric history or altered mental status (7.5%). Table 2 shows a comparison of patients who received CASI and patients who did not receive CASI. Screened patients were significantly older and were more likely to be admitted to the hospital, have a higher Glasgow Coma Scale, have a longer hospital stay, and have injuries with Abbreviated Injury Score ≥ 3 . Screened patients were significantly less likely to be intoxicated on admission and required fewer days of mechanical ventilation. Sixty-nine percent of the patients who received CASI were screened in the inpa-

Table 1. Reasons for Not Receiving Computerized Alcohol Screening and Intervention

Variable	n (total = 1,515)	%
Discharged before approach (ED)	698	46
Discharged before approach (inpatient)	400	26
Psychiatric/altered	113	7.5
Refused	104	6.9
Language barrier	60	4.0
Medically unstable	53	3.5
Died	41	2.7
Intoxicated	17	1.1
Device failure	15	1.0
Incarcerated	14	0.9

ED, emergency department.

tient units and 31% were screened in the ED. On average, patients received CASI on PID 1.5 ± 3.0 . The average screening PID for patients in the inpatient units was PID 2.0 ± 3.3 .

Of the 1,340 patients who received CASI, 19% were classified as having hazardous drinking behavior. Sixty-two (5%) were dependent, 15% were at-risk, 35% were not-at-risk, and 46% were nondrinking. Patients who reported hazardous drinking behavior (19% of patients screened with CASI or 11% of trauma patients eligible to be screened) received an intervention. All patients had a BAC measured on arrival. Thirty-three percent had a detectable BAC (BAC ≥ 0 mg/dL) and 16% were over the legal limit (80 mg/dL). Table 3 shows the univariate analysis of risk factors for hazardous drinking behavior. The following variables had $p < 0.1$ and were chosen for logistic regression: Age, male sex, penetrating injury, Glasgow Coma Scale, BAC as a continuous variable, detectable BAC, BAC ≥ 80 mg/dL, and BAC ≥ 100 mg/dL.

Table 3 also shows the relationship between ethnicity and the primary outcome variable. The table reports the ethnic breakdown of the patients in each outcome group. However, another way to interpret these data is to report the percentage of each ethnic group that exhibited hazardous drinking behavior; Hispanic patients were the most likely to report such behavior (28%), followed by blacks (19%), whites (18%), and Asian/Pacific Islanders (9%). Compared with white patients, Hispanic patients were significantly more likely ($p = 0.001$) and Asian/Pacific Islander patients were significantly less likely ($p = 0.005$) to report hazardous drinking behavior. Hispanic vs white ethnicity and Asian/Pacific Islander vs white ethnicity were also included in logistic regression.

Table 4 shows the multivariate analysis of risk factors for hazardous drinking behavior. Because the BAC variables were inherently related, they were evaluated using separate regression models. Because non-BAC variables were in-

Table 2. Comparison of Patients Who Received a Computerized Alcohol Screening Intervention vs Those Who Did Not (Total n = 2,855)

Variable	Not screened (n = 1,515)	Screened (n = 1,340)	p Value
Demographics			
Age, y*	41 ± 19	43 ± 20	0.001
Male sex, % [†]	70	68	0.392
Ethnicity, % [†]			0.071 [‡]
White	50	54	—
Hispanic	24	21	—
Black	2.1	2.1	—
Asian	14	12	—
Other	10	11	—
Admission status, %			
Hospital admit [†]	54	80	<0.001
ICU admit (any time) [†]	43	40	0.190
ED disposition [†]			0.057 [‡]
Operating room	12	10	—
ICU	35	32	—
Wards	53	59	—
Injury data, %			
Penetrating injury [†]	14	9.1	0.529
ISS ≥ 15 [†]	15	17	0.150
AIS head ≥ 3 [†]	14	15	0.348
AIS face ≥ 3 [§]	0.1	0.2	0.347
AIS chest ≥ 3 [†]	11	17	<0.001
AIS abdomen ≥ 3 [†]	3.6	6.6	<0.001
AIS extremity ≥ 3 [†]	5.0	12	<0.001
AIS external ≥ 3 [§]	0.1	0.1	1.00
GCS*	14 ± 3.0	15 ± 1.7	<0.001
BAC, %			
Undetectable [†]	52	67	<0.001
≥0 mg/dL [†]	48	33	<0.001
≥80 mg/dL [†]	31	16	<0.001
≥100 mg/dL [†]	29	15	<0.001
Continuous*	73 ± 116	41 ± 95	<0.001
Resource utilization			
Hospital LOS*	3.9 ± 9.3	5.5 ± 7.9	<0.001
ICU LOS*	1.5 ± 5.0	1.6 ± 4.0	0.265
Ventilator days*	1.0 ± 4.5	0.6 ± 2.6	0.002
Ventilator days ≥ 1 [†]	11	9.3	0.095

*t-test.

†Chi-square test.

‡p Values for ethnicity and ED disposition were calculated across all groups.

§Fisher's exact test.

AIS, Abbreviated Injury Score; BAC, blood alcohol concentration; ED, emergency department; GCS, Glasgow Coma Scale; ISS, Injury Severity Score; LOS, length of stay.

cluded in all models, their odds ratios in Table 4 represent the model containing the continuous BAC variable. This model had the highest c-statistic, 0.946, indicating excellent discrimination. The odds ratios for non-BAC variables did not change significantly between models. All models had a Hosmer-Lemeshow test with $p > 0.05$ and a c-statistic > 0.7 , indicating acceptable model fit and discrimination respectively. Independent positive predictors of hazardous drinking behavior with $p < 0.05$ after binary regression included male sex (OR 3.06, 95% CI 1.90 to 4.94), BAC continuous variable (OR 1.009 per mg/dL, 95% CI 1.007 to 1.010), detectable BAC (OR 3.9, 95% CI 2.8 to 5.5), BAC ≥ 80 mg/dL (OR 7.8, 95% CI 5.3 to 11.4), and BAC ≥ 100 mg/dL (OR 8.2, 95% CI 5.6 to 12.0). Negative predictors included age (OR 0.97 per year, 95% CI 0.96 to 0.99) and Asian/Pacific Islander ethnicity compared with white ethnicity (OR 0.53, 95% CI 0.28 to 1.00).

Table 5 shows the sensitivity, specificity, PPV, and NPV of the categorical BAC variables. Detectable BAC had the highest sensitivity (62%) and NPV (89%); BAC ≥ 100 mg/dL had the highest specificity (92%) and PPV (58%). Although detectable BAC was an independent predictor of the primary outcomes measure, 38% of adult trauma patients with an undetectable BAC reported hazardous drinking behavior.

DISCUSSION

This study was designed to identify independent predictors of at-risk or dependent drinking behavior (hazardous drinking behavior) in adult trauma patients, all of whom were eligible to receive an SBI. In addition, this study sought to specifically examine the predictive nature of BAC because about 70% of providers use BAC to screen for alcohol use.^{10,12} In the 1,340 adult trauma patients who received the BSI with CASI, 19% reported hazardous drinking behavior and were candidates for a brief intervention or referral to a social worker. Male sex, younger age, and BAC were strong independent predictors of hazardous drinking behavior. Patients with Asian/Pacific Islander ethnicity were half as likely to report hazardous drinking behavior as patients with white ethnicity.

Compared with not-at-risk drinkers, patients with a detectable BAC (BAC ≥ 0 mg/dL) were 3.9 times more likely to report hazardous drinking behavior, although 38% of patients with no detectable BAC reported this outcome. This accounts for the relatively low sensitivity (62%) and PPV (36%) of the detectable BAC test. This indicates that a detectable BAC is a weak screening test because false negatives are relatively common at 38%, and only 36% of patients with a detectable BAC actually

Table 3. Univariate Analysis of Risk Factors for Hazardous Drinking Behavior (n = 1,340)

Variable	Not at-risk (n = 1,083)	At-risk or dependent (n = 257)	p Value
Demographics			
Age, y*	45 ± 21	35 ± 14	<0.001
Male sex, % [†]	64	88	<0.001
Ethnicity, % [†]			<0.001
White (reference)	54	53	—
Hispanic [†]	19	31	0.001 [‡]
Asian/Pacific Islander [†]	13	5.5	0.005 [‡]
Black [§]	2.1	2.1	1.000 [‡]
Other [†]	12	8.4	0.276 [‡]
CASI PID*	1.5 ± 3.1	1.5 ± 2.5	0.647
Admission status, %			
Hospital admission [†]	80	82	0.479
ICU admission [†]	41	38	0.418
ED disposition [†]			0.407
Operating room	10	11	—
ICU	32	28	—
Wards	58	61	—
Injury data, %			
Penetrating injury [†]	8	14	0.008
ISS ≥ 15 [†]	18	16	0.567
AIS head ≥ 3 [†]	16	13	0.289
AIS face ≥ 3 [§]	0.3	0	1.00
AIS chest ≥ 3 [†]	18	16	0.429
AIS abdomen ≥ 3 [†]	6.7	6.2	0.766
AIS extremity ≥ 3 [†]	12	10	0.335
AIS external ≥ 3 [§]	0	0.4	0.192
GCS*	15 ± 1.6	14 ± 2.2	0.025
BAC, %			
Undetectable [†]	74	38	<0.001
>0 mg/dL [†]	26	62	<0.001
≥80 mg/dL [†]	8.6	48	<0.001
≥100 mg/dL [†]	7.9	46	<0.001
Continuous*	21 ± 66	126 ± 143	<0.001
Resource utilization			
Hospital LOS*	5.5 ± 7.3	5.4 ± 10	0.849
ICU LOS*	1.7 ± 4.2	1.5 ± 3.2	0.414
Ventilator days*	0.6 ± 2.7	0.5 ± 2.2	0.664
Ventilator days > 1, % [†]	9.0	10	0.595

*t-test.

†Chi-square test.

‡p < 0.05 across all ethnic groups, p values for individual ethnicities use white as a reference.

§Fisher's exact test.

||p Value calculated across all groups.

AIS, Abbreviated Injury Score; BAC, blood alcohol concentration; CASI, Computerized Alcohol Screening and Intervention; ED, emergency department; GCS, Glasgow Coma Scale; ISS, Injury Severity Score; PID, postinjury day.

report hazardous drinking behavior. Increasing the BAC cut-off to 80 mg/dL further decreases the sensitivity of the test to 48% and increases the PPV to 57%. Fifty-two percent of the results of this test are false negatives and only 57% of patients with BAC > 80 mg/dL report hazardous drinking behavior. The American College of Surgeons Committee on Trauma agrees that BAC should not be used as the sole criterion for determining who receives a BSI, as "many who are not intoxicated at admission will screen positive for problem drinking and therefore be at risk for future alcohol-related injury."¹³

Similar to this study, Savola and colleagues¹⁴ sought to determine the predictive nature of BAC on hazardous drinking behavior in a prospective study of 349 trauma patients ages 16 to 49.¹⁴ It was found that BAC was the best predictor of hazardous drinking behavior when compared with various venous blood tests. A BAC > 0 mg/dL had 68% sensitivity, 94% specificity, 96% PPV, and 57% NPV. Savola and colleagues' study, however, differed from ours in that BAC was determined heterogeneously from either breath air or serum rather than serum alone, alcohol use disorders were determined at 6-week follow-up instead of during the hospital visit, and hazardous drinking was defined by answers to author-created questions rather than a widely accepted questionnaire like AUDIT. Our study also differed in that it had a larger sample size and included all adult patients ages 18 and older rather than just young adults and working-age patients.

Although the sensitivity of detectable BAC in our study (62%) is similar to that in Savola's study¹⁴ (68%), there was a large difference in PPV (36% vs 96%). Sensitivity is not influenced by disease prevalence, but PPV and prevalence are directly related. The difference between the studies can be explained by the increased prevalence of the primary outcome in Savola's study, which identified 69% of the study population as having hazardous drinking behavior compared with our study, which identified 19%. The outcome from the Savola study was defined as dependent or frequent binge drinking behavior and was not determined by a well-accepted questionnaire like AUDIT.

The strength of this study is rooted in its design. All adult trauma patients capable of receiving an SBI were enrolled in the study, as opposed to only patients with a detectable BAC. To our knowledge, there are currently no studies investigating risk factors for hazardous drinking behavior, as defined by a standardized questionnaire, in a study population that includes all adult trauma patients regardless of their alcohol intoxication status. Screening

was conducted with CASI, which has been cited as effective and user friendly.^{7,8}

This study is limited in that screening all adult trauma patients was attempted, but only 47% actually received an SBI. Although patient characteristics played a role, the most common reasons for not receiving CASI were patients being missed before discharge in the ED (46%) and being missed before discharge from the inpatient units (26%). Table 2 shows that screened and unscreened patients differed significantly. Screening only half of the eligible patients can be attributed to gaps in research assistant coverage, which occurred between midnight and 8:00 AM in the ED and noon to 8:00 AM in the inpatient units. It may also be attributed to unfamiliarity with the CASI protocol and understaffing of the research assistants in the early stages of CASI implementation. Current measures are underway to increase the number of patients screened with CASI at our institution. More research shifts have been added to the ED and patients slated to be discharged in the inpatient units are now prioritized for screening by our research staff.

CONCLUSIONS

This study shows that younger age, male sex, and BAC are strong, independent predictors of hazardous drinking behavior. Additionally, patients of Asian/Pacific Islander ethnicity are about half as likely as patients of white ethnicity to report hazardous drinking behavior. Patients with a positive BAC are about 4 times more likely to report hazardous behavior compared with patients with no detectable BAC. However, 38% of patients with hazardous drinking behavior have no detectable BAC and are not receiving interventions at trauma centers that administer SBIs solely based on BAC. As

Table 4. Multivariate Analysis of Independent Predictors for Hazardous Drinking Behavior (n = 1,340)

Variable	Odds ratio	95% CI	p Value
Male sex*	3.06	1.90–4.94	<0.001
Age*	0.97	0.96–0.99	<0.001
Hispanic vs white	1.14	0.77–1.69	0.510
Asian vs white*	0.53	0.28–1.00	0.050
Penetrating injury	0.85	0.49–1.45	0.548
GCS	0.94	0.86–1.04	0.226
BAC*†	1.009	1.007–1.010	<0.001
>0 mg/dL*†	3.91	2.79–5.48	<0.001
≥80 mg/dL*†	7.77	5.31–11.37	<0.001
≥100 mg/dL*†	8.17	5.55–12.02	<0.001

*Statistically significant (p < 0.05).

†Each BAC variable was evaluated separately in its own regression model. Non-BAC variables were included in each model and results shown are from the model with the highest c-statistic.

BAC, blood alcohol concentration; GCS, Glasgow Coma Scale.

Table 5. Sensitivities, Specificities, Positive Predictive Values, and Negative Predictive Values of Categorical Blood Alcohol Concentration Variables, %

BAC variable, mg/dL	Sensitivity	Specificity	PPV	NPV
>0	62	74	36	89
≥80	48	91	57	88
≥100	46	92	58	88

BAC, blood alcohol concentration; NPV, negative predictive value; PPV, positive predictive value.

such, centers should begin screening a larger patient population and future studies should investigate the ability of brief interventions to reduce injury recidivism and hazardous drinking in trauma patients who present without a detectable BAC.

Author Contributions

Study conception and design: Ewing, Malinoski

Acquisition of data: Lau, Cui, Garcia

Analysis and interpretation of data: Ewing, Patel, Malinoski

Drafting of manuscript: Ewing

Critical revision: Barrios, Lau, Patel, Kong, Lotfipour, Lekawa, Malinoski

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