Biases in the collection of blood alcohol data for adult major trauma patients in Victoria, Australia

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ABSTRACT

Background In-hospital alcohol testing provides an opportunity to implement prevention strategies for patients with high risk of experiencing repeated alcohol-related injuries. However, barriers to alcohol testing in emergency settings can prevent patients from being tested. In this study, we aimed to understand potential biases in current data on the completion of blood alcohol tests for major trauma patients at hospitals in Victoria, Australia.

Methods Victorian State Trauma Registry data on all adult major trauma patients from 1 January 2018 to 31 December 2021 were used. Characteristics associated with having a blood alcohol test recorded in the registry were assessed using logistic regression models.

Results This study included 14 221 major trauma patients, of which 4563 (32.1%) had a blood alcohol test recorded. Having a blood alcohol test completed was significantly associated with age, socioeconomic disadvantage level, preferred language, having pre-existing mental health or substance use conditions, smoking status, presenting during times associated with heavy community alcohol consumption, injury cause and intent, and Glasgow Coma Scale scores ($p<0.05$). Restricting analyses to patients from a trauma centre where blood alcohol testing was part of routine clinical care mitigated most biases. However, relative to patients injured while driving a motor vehicle/motorcycle, lower odds of testing were still observed for patients with injuries from flames/scalds/contact burns (adjusted OR (aOR)=0.33, 95% CI 0.18 to 0.61) and low falls (aOR=0.17, 95% CI 0.12 to 0.25). Higher odds of testing were associated with pre-existing mental health (aOR=1.39, 95% CI 1.02 to 1.89) or substance use conditions (aOR=2.33, 95% CI to 1.47–3.70), and living in a more disadvantaged area (most disadvantaged quintile relative to least disadvantaged quintile: aOR=2.30, 95% CI 1.52 to 3.48).

Conclusion Biases in the collection of blood alcohol data likely impact the surveillance of alcohol-related injuries. Routine alcohol testing after major trauma is needed to accurately inform epidemiology and the subsequent implementation of strategies for reducing alcohol-related injuries.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Alcohol screening for major trauma patients is important for the management of patient care and the surveillance of alcohol-related injuries.

WHAT THIS STUDY ADDS

⇒ This study identified several biases in data on the completion of blood alcohol tests after major trauma with regards to age, preferred language, socioeconomic status, injury cause and injury intent.

⇒ Many of the biases identified were not significant when alcohol testing was completed on a routine basis for major trauma patients.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ Biases in the data available from blood alcohol tests may impact on surveillance of alcohol-related injuries and the development of subsequent strategies to reduce alcohol-related injury events.

⇒ Consistent and routine alcohol screening practices across hospitals are essential for accurate surveillance and planning of effective interventions.

INTRODUCTION

Acute preinjury alcohol use is a preventable risk factor for both intentional and unintentional injuries, as well as injury recidivism.[1 2] A third of injured patients presenting to trauma centres are estimated to test positive for alcohol.[3] Consequently, injury-related hospital admissions provide an opportunity to screen for alcohol and identify patients who may benefit from interventions to reduce alcohol-related harms.[4] In-hospital alcohol screening also facilitates robust surveillance of alcohol-related injury events that can inform evidence-based injury prevention and harm reduction strategies. While routine in-hospital alcohol screening after injury is widely supported, there are several barriers to screening, including limited time and resources, and fear of negatively impacting patient rapport due to the stigma associated with alcohol consumption.[5 6] Furthermore, alcohol testing must be completed in a timely manner for results to be applicable to the injury event, which is not always feasible for delayed presentations after injury.[7] These barriers mean that not every injured patient will undergo in-hospital alcohol testing, potentially causing biases in the available data.

Single-centre studies from Canada have demonstrated biases in the completion of alcohol testing for patients admitted to hospital after injury.[8 9] One survey found that emergency and trauma clinicians were more likely to test patients who were younger in age, male, unemployed or from lower socioeconomic backgrounds.[8] These biases occurred despite alcohol testing being widely supported by staff and considered part of routine clinical care.[8] In another study, patients who were younger in age and male had higher odds of being tested for alcohol.[9] Importantly, these findings may not generalise to other countries since drinking cultures and associated practices can vary with different legal, cultural and religious views on alcohol consumption.[10] In this study, we aimed to identify potential biases in data from blood alcohol testing for adult major trauma patients presenting to hospital in Victoria, Australia.

METHODS

Setting and data source

The Victorian State Trauma System (VSTS) provides coordinated care across all 138 trauma-receiving hospitals in Victoria, Australia.[11] Each of the 138 sites is classified by service level using a tiered structure, enabling patients to be triaged to services with appropriate facilities in a timely manner. This system is centred around two adult major trauma centres (MTCs) (MTC1 and MTC2) and one paediatric MTC which provide definitive care for most (72%) major trauma patients in Victoria.[12] Data for this study were provided by the Victorian State Trauma Registry (VSTR), a population-based registry that uses an opt-out process to collect data from all 138 trauma-receiving hospitals in Victoria.[12] The VSTR defines major trauma using the following criteria: (1) Death after injury; (2) Admission to an intensive care unit (ICU) or high-dependency area for >24 hours and mechanically ventilated during the ICU stay; (3) Injury Severity Score (ISS) >12; or (4) Urgent surgery for intracranial, intrathoracic or intra-abdominal injury, or fixation of pelvic or spinal fractures.[12] This study included all adult (aged ≥18 years) major trauma patients in Victoria who were injured between 1 January 2018 and 31 December 2021. Although the VSTR collects all available blood alcohol test data, alcohol testing is inconsistent across sites. While MTC1 routinely requests blood alcohol tests for suspected major trauma patients, MTC2 completes tests based on clinician discretion.

Measures

Using similar existing international studies as a guide, a range of variables related to patient demographics, preinjury health, and injury and hospital characteristics were extracted from the VSTR for exploration in this study.[8 9]

Patient demographics and preinjury health

Patient characteristics included age, sex, socioeconomic status and preferred language (English or language other than English). Age was divided into three categories (18–34 years, 35–64 years and ≥65 years) due to the non-linear relationship between age and the outcome. The VSTR has three sex categories: male, female and intersex. Intersex patients were excluded as small patient numbers would compromise patient confidentiality. Socioeconomic status was measured by mapping patient postcode of residence to the Index of Relative Socioeconomic Advantage and Disadvantage, which divides Australian postcodes into deciles using national census data.[13] Deciles were collapsed into quintiles ranging from 1 (most disadvantaged) to 5 (least disadvantaged). International Statistical Classification of Diseases and Related Health Problems, Tenth Revision, Australian Modification codes[14] were used to measure smoking status and preinjury mental health and substance use conditions using published methods.[15 16]

Hospital and injury characteristics

Patients can be transferred between service levels within the VSTS. As alcohol testing is time sensitive, this study focused on the first hospital the patient presented to postinjury. Hospitals were categorised based on service level as either a major trauma, metropolitan trauma, regional trauma or other service (including urgent and primary care centres, and sites outside of the VSTS). Given high patient numbers and differences in alcohol testing protocols, the two adult major trauma services (MTC1 and MTC2) were modelled as independent sites. Based on existing research, injuries were coded as occurring during high alcohol hours (windows of time when community alcohol consumption is highest) if they occurred between 20:00 on Friday and 6:00 on Saturday, and 20:00 on Saturday and 6:00 on Sunday.[17]

Injury causes were categorised as: motor vehicle/motorcycle collisions, other transport-related causes (including pedal cyclist and pedestrian injuries), low falls (<1 m or standing height), high falls (≥1 m), flames/scalds/contact burns, animal-related causes, being struck by/colliding with an object/person, cut/piercing injuries, and other/unspecified causes (including drowning, threat to breathing, firearms, machinery). People injured in motor vehicle/motorcycle collisions were separated into drivers and passengers as alcohol testing requirements differ for people injured while operating a vehicle in Victoria.[18] Injury intent was categorised as: unintentional, intentional self-harm, interpersonal violence, could not be determined, and other/unspecified (including police/legal interventions, adverse effects from medical care). Abbreviated Injury Scale Scores were used to generate an ISS for each patient and categorised into three groups: ISS<16, ISS 16–24 and ISS >24.[19 20] In line with clinical classifications, patient Glasgow Coma Scale (GCS) scores were divided into three categories indicating severe (GCS 3–8), moderate (GCS 9–12) and mild (GCS 13–15) impairments in consciousness.[21]

Alcohol testing

The VSTR collects information on both the type of alcohol test performed and the results of alcohol tests (blood alcohol concentration (BAC) in g/100 mL). Alcohol test type is reported in the VSTR using six categories: blood, breath, police test, unknown test type, alcohol detected but no value reported, and no test. In this study, patients were considered as ‘tested’ if they had a blood alcohol test completed for clinical purposes at the first hospital they presented to postinjury, regardless of whether corresponding test results were available in the registry. All other test types (ie, breath, police, alcohol detected but no value, and unknown) were coded as ‘no blood alcohol test’ along with ‘no test’. The ‘police test’ category included cases where testing was completed for legal requirements, usually for patients injured while operating a motor vehicle. As police tests are not completed for clinical purposes, and are therefore not expected to affect patient care or to have results recorded in the registry, police tests were coded as ‘no blood alcohol test’. ‘Unknown test type’ indicates cases where alcohol testing was completed, but the test type was not recorded. Since different test samples can produce inconsistent results depending on when the sample is taken, patients with breath or unknown test types were coded as ‘no blood alcohol test’. The ‘alcohol detected but no value reported’ category indicates cases where clinical staff suspected alcohol use (eg, staff reported the patient smelled of alcohol), but no test was completed.

Table 1 Patient and injury characteristics for all major trauma patients in Victoria, N (%).

		Total (n=14 221)	No blood alcohol test (n=9658)	Blood alcohol test (n=4563)	P value*
Age (years)	18 to 34	2934 (20.6)	1572 (16.3)	1362 (29.8)	**<0.001**
	35 to 64	5187 (36.5)	3101 (32.1)	2086 (45.7)	
	≥65	6100 (42.9)	4985 (51.6)	1115 (24.4)	
Sex†	Male	9774 (68.7)	6312 (65.4)	3462 (75.9)	**<0.001**
	Female	4446 (31.3)	3346 (34.6)	1100 (24.1)	
IRSAD quintile‡	5, least disadvantaged	3442 (24.8)	2102 (22.2)	1340 (30.3)	**<0.001**
	4	2465 (17.8)	1665 (17.6)	800 (18.1)	
	3	2704 (19.5)	1902 (20.1)	802 (18.2)	
	2	2413 (17.4)	1737 (18.3)	676 (15.3)	
	1, most disadvantaged	2859 (20.6)	2061 (21.8)	798 (18.1)	
Preferred language	English	13 098 (92.1)	8734 (90.4)	4364 (95.6)	**<0.001**
	Language other than English	1123 (7.9)	924 (9.6)	199 (4.4)	
Pre-existing mental health condition	No	12 000 (84.4)	8275 (85.7)	3725 (81.6)	**<0.001**
	Yes	2221 (15.6)	1383 (14.3)	838 (18.4)	
Pre-existing substance use condition	No	12 989 (91.3)	9133 (94.6)	3856 (84.5)	**<0.001**
	Yes	1232 (8.7)	525 (5.4)	707 (15.5)	
Smoking status	Non-smoker	9853 (69.3)	6976 (72.2)	2877 (63.1)	**<0.001**
	Current smoker	3269 (23.0)	2168 (22.4)	1101 (24.1)	
	Past smoker	1099 (7.7)	514 (5.3)	585 (12.8)	
Site of first admission	MTC1	3429 (24.1)	507 (5.2)	2922 (64.0)	**<0.001**
	MTC2	3422 (24.1)	2352 (24.4)	1070 (23.4)	
	Metropolitan trauma services	2886 (20.3)	2680 (27.7)	206 (4.5)	
	Regional trauma services	2416 (17.0)	2229 (23.1)	187 (4.1)	
	Other	2068 (14.5)	1890 (19.6)	178 (3.9)	
High-alcohol hours	No	13 046 (91.7)	9039 (93.6)	4007 (87.8)	**<0.001**
	Yes	1175 (8.3)	619 (6.4)	556 (12.2)	
Cause of injury	Motor vehicle/motorcycle collision (drivers)	2849 (20.0)	1495 (15.5)	1354 (29.7)	**<0.001**
	Motor vehicle/motorcycle collision (passengers)	612 (4.3)	331 (3.4)	281 (6.2)	
	Other transport-related causes	1592 (11.2)	987 (10.2)	605 (13.3)	
	Low falls	5974 (35.0)	4233 (43.8)	741 (16.2)	
	High falls	1714 (12.1)	1059 (11.0)	655 (14.4)	
	Flames/scalds/contact burns	195 (1.4)	81 (0.8)	114 (2.5)	
	Animal-related	406 (2.9)	333 (3.4)	73 (1.6)	
	Struck by or collided with an object or person	914 (6.4)	602 (6.2)	312 (6.8)	
	Cutting/piercing object	530 (3.7)	291 (3.0)	239 (5.2)	
	Other/unspecified	435 (3.1)	246 (2.5)	189 (4.1)	
Injury intent	Unintentional	12 475 (87.7)	8784 (91.0)	3691 (80.9)	**<0.001**
	Intentional self-harm	570 (4.0)	249 (2.6)	321 (7.0)	
	Interpersonal violence	900 (6.3)	485 (5.0)	415 (9.1)	
	Could not be determined	248 (1.7)	125 (1.3)	123 (2.7)	
	Other/unspecified	28 (0.2)	15 (0.2)	13 (0.3)	
Injury severity	Minor/moderate (ISS<16)	5872 (41.3)	4259 (44.1)	1613 (35.3)	**<0.001**
	Severe (ISS 16–24)	4753 (33.4)	3199 (33.1)	1554 (34.1)	
	Very severe (ISS>24)	3596 (25.3)	2200 (22.8)	1396 (30.6)	
GCS§	13–15	11 903 (86.0)	8392 (89.9)	3511 (78.0)	**<0.001**
	9–12	754 (5.4)	393 (4.2)	361 (8.0)	
	3–8	1182 (8.5)	552 (5.9)	630 (14.0)	

Values in bold font indicate statistically significant results.
*P values were derived from χ^2 analyses
†n=1 missing
‡n=338 missing
§n=382 missing
GCS, Glasgow Coma Scale; IRSAD, Index of Relative Socioeconomic Advantage and Disadvantage; ISS, Injury Severity Score; MTC, major trauma centre.

DATA ANALYSIS

The study sample was described using frequencies and percentages for categorical variables, and means and SD or medians and IQRs for continuous variables. χ^2 tests were used to compare patients with and without blood alcohol tests. Bivariate and multivariable logistic regression models were used to identify

Table 2 Patient and injury characteristics for all major trauma patients who received definitive care at MTC1, n (%)

		Total (n=3429)	No blood alcohol test (n=507)	Blood alcohol test (n=2922)	P value*
Age (years)	18 to 34	903 (26.3)	89 (17.6)	814 (27.9)	**<0.001**
	35 to 64	1456 (42.5)	135 (26.6)	1321 (45.2)	
	≥65	1070 (31.2)	283 (55.8)	787 (26.9)	
Sex	Male	2491 (72.7)	313 (61.7)	2178 (74.6)	**<0.001**
	Female	937 (27.3)	194 (38.3)	743 (25.4)	
IRSAD quintile†	5, least disadvantaged	1342 (40.5)	311 (63.3)	1031 (36.6)	**<0.001**
	4	565 (17.1)	70 (14.3)	495 (17.6)	
	3	486 (14.7)	36 (7.3)	450 (16.0)	
	2	444 (13.4)	41 (8.4)	403 (14.3)	
	1, most disadvantaged	473 (14.3)	33 (6.7)	440 (15.6)	
Preferred language	English	3256 (95.0)	452 (89.2)	2804 (96.0)	**<0.001**
	Language other than English	173 (5.0)	55 (10.8)	118 (4.0)	
Pre-existing mental health condition	No	2823 (82.3)	429 (84.6)	2394 (81.9)	0.14
	Yes	606 (17.7)	78 (15.4)	528 (18.1)	
Pre-existing substance use condition	No	3058 (89.2)	482 (95.1)	2576 (88.2)	**<0.001**
	Yes	371 (10.8)	25 (4.9)	346 (11.8)	
Smoking status	Non-smoker	2282 (66.6)	373 (73.6)	1909 (65.3)	**<0.001**
	Current smoker	361 (10.5)	63 (12.4)	298 (10.2)	
	Past smoker	786 (22.9)	71 (14.0)	715 (24.5)	
High-alcohol hours	No	3087 (90.0)	461 (90.9)	2626 (89.9)	0.46
	Yes	342 (10.0)	46 (9.1)	296 (10.1)	
Cause of injury	Motor vehicle/motorcycle collision (drivers)	898 (26.2)	56 (11.0)	842 (28.8)	**<0.001**
	Motor vehicle/motorcycle collision (passengers)	209 (6.1)	14 (2.8)	195 (6.7)	
	Other transport-related causes	496 (14.5)	60 (11.8)	436 (14.9)	
	Low falls	660 (19.2)	259 (51.1)	401 (13.7)	
	High falls	507 (14.8)	34 (6.7)	473 (16.2)	
	Flames/scalds/contact burns	122 (3.6)	18 (3.6)	104 (3.6)	
	Animal-related	69 (2.0)	6 (1.2)	63 (2.2)	
	Struck by or collided with an object or person	189 (5.5)	28 (5.5)	161 (5.5)	
	Cutting/piercing object	163 (4.8)	16 (3.2)	147 (5.0)	
	Other/unspecified	116 (3.4)	16 (3.2)	100 (3.4)	
Injury intent	Unintentional	2881 (84.0)	451 (89.0)	2430 (83.2)	**0.015**
	Intentional self-harm	200 (5.8)	17 (3.4)	183 (6.3)	
	Interpersonal violence	244 (7.1)	29 (5.7)	215 (7.4)	
	Could not be determined	97 (2.8)	10 (2.0)	87 (3.0)	
	Other/unspecified	7 (0.0)	0 (0.0)	7 (0.2)	
Injury severity	Minor/moderate (ISS<16)	1211 (35.3)	212 (41.8)	999 (34.2)	**<0.001**
	Severe (ISS 16–24)	1176 (34.3)	171 (33.7)	1005 (34.4)	
	Very severe (ISS>24)	1042 (30.4)	124 (24.5)	918 (31.4)	
GCS‡	13–15	2723 (80.6)	401 (82.5)	2322 (80.2)	0.14
	9–12	231 (6.8)	23 (4.7)	208 (7.2)	
	3–8	426 (12.6)	62 (12.8)	364 (12.6)	

Values in bold font indicate statistically significant results.
*P values were derived from χ^2 analyses
†n=119 missing
‡n=49 missing
GCS, Glasgow Coma Scale; IRSAD, Index of Relative Socioeconomic Advantage and Disadvantage; ISS, Injury Severity Score; MTC, major trauma centre.

variables associated with having a blood alcohol test completed in: (1) All major trauma patients; and (2) Patients from MTC1, the only site to routinely request blood alcohol testing for suspected major trauma patients. As the models in this study were explanatory rather than predictive, all variables were included in multivariable models. Results are presented as ORs for bivariate analyses and adjusted ORs (aOR) for multivariable analyses, both with corresponding 95% CIs. Likelihood-ratio tests were used to generate global values of p indicating whether each variable significantly contributed to the model. Values of $p<0.05$ were considered statistically significant. Variance inflation factors were used to assess collinearity between variables.

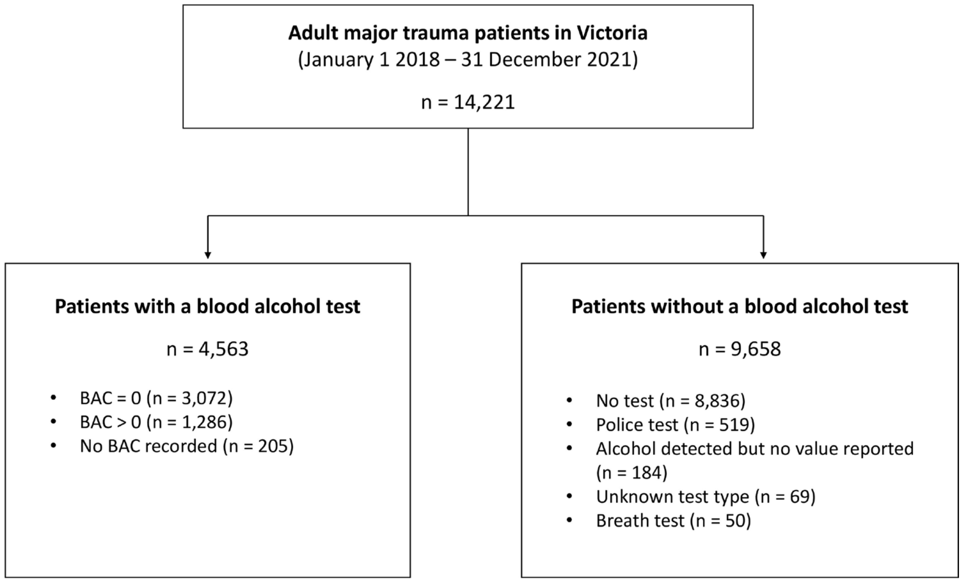

Figure 1 Flowchart showing alcohol testing for included patients. BAC, blood alcohol concentration

Goodness of fit was assessed using Hosmer-Lemeshow tests. Analyses were conducted using Stata V.17 (Statacorp, College Station, Texas, USA).

Patient and public involvement

Patients or members of the public were not involved in this study.

RESULTS

There were 14 221 patients recorded in the VSTR who met inclusion criteria. Participants were predominantly male (n=9774, 68.7%) with a mean age of 57.9 years (SD=22.4, range=18–103). Injuries were mostly unintentional (n=12 475, 87.7%). Low falls were the most common injury cause (n=5974, 35.0%). Almost half the included patients initially presented to a MTC (n=6851, 48.2%). Median ISS was 17 (IQR=13–24). Further sample characteristics are presented in tables 1 and 2 for the overall sample and patients from MTC1, respectively. MTC1 had a higher percentage of patients aged 35–64 years, living in less disadvantaged areas, and with higher injury severity compared with the overall sample. MTC1 also had a lower percentage of people injured from low falls.

Blood alcohol tests were completed for 4563 (32.1%) patients. Most blood alcohol testing occurred at MTC1 (64.0%), followed by MTC2 (23.4%) and non-major trauma sites (12.5%). MTC1, which was the only site with routine blood alcohol testing protocols, tested 85.2% (n=2922) of their patients. At MTC2, 31.3% (n=1070) of patients were tested for alcohol. Non-major trauma sites tested 7.8% (n=571) of their patients. For patients who had a blood alcohol test recorded, 3072 (67.3%) had a BAC of 0, 1286 (28.2%) had a BAC>0 and 205 (4.5%) had no test results available (figure 1). Alcohol was detected in 19.0% (n=555) of tested patients at MTC1, 37.0% (n=381) at MTC2 and 86.2% (n=350) at non-major trauma sites. The median BAC of patients with a BAC >0 was 0.16 g/100 mL (IQR=0.07–0.23) overall, 0.17 g/100 mL (IQR=0.09–0.25) at MTC1, 0.16 g/100 mL (IQR=0.09–0.23) at MTC2 and 0.12 g/100 mL (IQR=0.01–0.21) at non-major trauma sites. Of the 9658 (67.9%) patients with no blood alcohol test recorded, 519 (5.4%) had police tests, 184 (1.9%) were suspected to have used alcohol but were not tested, 69 (0.7%) had unknown test types and 50 (0.5%) had breath tests.

Patient demographics and preinjury health

Unadjusted analyses

All demographic and preinjury health variables included in the study were significantly associated with blood alcohol testing in unadjusted analyses (table 3). Older age, female sex and preferring a language other than English were significantly associated with lower unadjusted odds of testing in the overall sample (table 3). Comparatively, smoking and pre-existing mental health and substance use conditions were associated with higher odds of testing (table 3). Results were consistent between the overall and sensitivity (MTC1) analyses with the exceptions of socioeconomic disadvantage and pre-existing mental health conditions. While higher levels of socioeconomic disadvantage were consistently associated with lower unadjusted odds of testing relative to the least disadvantaged group in the overall sample (table 3), the reverse was observed in sensitivity analyses (ie, higher levels of disadvantage were associated with greater odds of testing at MTC1). Pre-existing mental health conditions were not associated with testing in sensitivity analyses (p=0.14).

Adjusted analyses

Apart from sex, all patient demographic and preinjury health variables were significant in the adjusted analysis for the overall sample (p<0.05; table 3). Patients aged ≥65 years had significantly lower odds of blood alcohol testing (aOR=0.57; 95% CI 0.48 to 0.68) relative to patients aged 18–34 years. Preferring a language other than English was associated with lower odds of testing relative to patients who preferred English (aOR=0.62; 95% CI 0.52 to 0.81). Higher odds of testing were also observed for people with pre-existing mental health conditions (aOR=1.18; 95% CI 1.02 to 1.37), pre-existing substance use conditions (aOR=4.10; 95% CI 3.44 to 4.89), and who were current smokers (aOR=1.33; 95% CI 1.16 to 1.52). Higher levels of socioeconomic disadvantage were consistently associated with greater odds of testing in adjusted analyses for both the overall sample and for MTC1 (tables 3 and 4). Age, socioeconomic disadvantage, and pre-existing mental health and substance use conditions continued to be significantly associated with testing when analyses were restricted to MTC1 (p<0.05); however, biases related to sex, preferred language and smoking status were not significant (table 4).

Table 3 Predictors of having a blood alcohol test following admission to any hospital for a major trauma injury event

		OR (95% CI)	P value*	aOR (95% CI)	P value*
Age (years)	18 to 34	1.00	**<0.001**	1.00	**<0.001**
	35 to 64	**0.78 (0.71 to 0.85)**		0.98 (0.85 to 1.12)	
	≥65	**0.26 (0.23 to 0.28)**		**0.57 (0.48 to 0.68)**	
Sex	Male	1.00	**<0.001**	1.00	0.101
	Female	**0.60 (0.55 to 0.65)**		0.90 (0.79 to 1.02)	
IRSAD quintile	5, least disadvantaged	1.00	**<0.001**	1.00	**0.003**
	4	**0.75 (0.68 to 0.84)**		**1.34 (1.13 to 1.58)**	
	3	**0.66 (0.59 to 0.74)**		**1.30 (1.10 to 1.53)**	
	2	**0.61 (0.55 to 0.68)**		1.13 (0.95 to 1.34)	
	1, most disadvantaged	**0.61 (0.55 to 0.68)**		**1.25 (1.06 to 1.47)**	
Preferred language	English	1.00	**<0.001**	1.00	**<0.001**
	Language other than English	**0.43 (0.37 to 0.50)**		**0.65 (0.52 to 0.81)**	
Pre-existing mental health condition	No	1.00	**<0.001**	1.00	**0.028**
	Yes	**1.35 (1.23 to 1.48)**		**1.18 (1.02 to 1.37)**	
Pre-existing substance use condition	No	1.00	**<0.001**	1.00	**<0.001**
	Yes	**3.19 (2.83 to 3.59)**		**4.10 (3.44 to 4.89)**	
Smoking status	Non-smoker	1.00	**<0.001**	1.00	**<0.001**
	Past smoker	0.97 (0.87 to 1.09)		**1.20 (1.01 to 1.43)**	
	Current smoker	**2.21 (2.03 to 2.41)**		**1.33 (1.16 to 1.52)**	
Site of first admission*	Major trauma centre 1	1.00	**<0.001**	1.00	**<0.001**
	Major trauma centre 2	**0.08 (0.07 to 0.09)**		**0.05 (0.04 to 0.06)**	
	Metropolitan trauma services	**0.01 (0.01 to 0.02)**		**0.01 (0.01 to 0.02)**	
	Regional trauma services	**0.01 (0.01 to 0.02)**		**0.01 (0.01 to 0.01)**	
	Other	**0.02 (0.01 to 0.02)**		**0.02 (0.01 to 0.02)**	
High alcohol hours	No	1.00	**<0.001**	1.00	**<0.001**
	Yes	**2.03 (1.80 to 2.29)**		**1.90 (1.59 to 2.27)**	
Cause of injury	Motor vehicle/motorcycle collision (drivers)	1.00	**<0.001**	1.00	**<0.001**
	Motor vehicle/motorcycle collision (passengers)	0.94 (0.79 to 1.12)		0.90 (0.70 to 1.16)	
	Other transport-related causes	**0.68 (0.60 to 0.77)**		**0.60 (0.50 to 0.72)**	
	Low falls	**0.19 (0.17 to 0.22)**		**0.37 (0.31 to 0.44)**	
	High falls	**0.68 (0.60 to 0.77)**		**0.65 (0.55 to 0.78)**	
	Flames/scalds/contact burns	**1.55 (1.16 to 2.09)**		**0.36 (0.23 to 0.57)**	
	Animal-related	**0.24 (0.19 to 0.32)**		**0.31 (0.21 to 0.45)**	
	Struck by or collided with an object or person	**0.57 (0.49 to 0.67)**		**0.41 (0.30 to 0.55)**	
	Cutting/piercing object	0.91 (0.75 to 1.09)		**0.31 (0.22 to 0.43)**	
	Other/unspecified	0.85 (0.69 to 1.04)		**0.52 (0.38 to 0.72)**	
Injury intent	Unintentional	1.00	**<0.001**	1.00	**<0.001**
	Intentional self-harm	**3.07 (2.59 to 3.64)**		**1.93 (1.45 to 2.57)**	
	Interpersonal violence	**2.04 (1.78 to 2.33)**		**2.29 (1.70 to 3.09)**	
	Could not be determined	**2.34 (1.82 to 3.01)**		1.23 (0.81 to 1.87)	
	Other/unspecified	2.06 (0.98 to 4.34)		2.00 (0.74 to 5.43)	
Injury severity (ISS)	Minor/moderate (ISS<16)	1.00	**<0.001**	1.00	0.105
	Severe (ISS 16–24)	**1.28 (1.18 to 1.39)**		**1.14 (1.01 to 1.29)**	
	Very severe (ISS>24)	**1.68 (1.53 to 1.83)**		1.08 (0.94 to 1.24)	
GCS	13–15	1.00	**<0.001**	1.00	**<0.001**
	9–12	**2.20 (1.89 to 2.55)**		**1.93 (1.55 to 2.40)**	
	3–8	**2.73 (2.42 to 3.08)**		**1.70 (1.41 to 2.06)**	

Values in bold font indicate statistically significant results.
*P values were derived using likelihood ratio tests.
aOR, adjusted OR; GCS, Glasgow Coma Scale; IRSAD, Index of Relative Socioeconomic Advantage and Disadvantage; ISS, Injury Severity Score.

Hospital and injury characteristics

Unadjusted analyses

All hospital and injury characteristics were significantly associated with blood alcohol testing in the unadjusted analyses for the overall sample ($p<0.05$; table 3). Presenting to hospital during high alcohol hours, with a flame/scald/contact burn injury, an intentional injury, higher ISS or lower GCS were all associated with significantly greater odds of testing (table 3). Meanwhile, compared with patients injured while driving a motor vehicle, patients injured in other transport-related injury events, falls and animal-related injuries had lower unadjusted odds of testing (table 3). Results were largely consistent between analyses for the overall sample and sensitivity analyses. One key exception was patient

Table 4 Predictors of having a blood alcohol test following admission to MTC1 for a major trauma injury event

		OR (95% CI)	P value*	aOR (95% CI)	P value*
Age (years)	18 to 34	1.00	**<0.001**	1.00	**0.012**
	35 to 64	1.07 (0.81 to 1.42)		1.24 (0.90 to 1.69)	
	≥65	**0.30 (0.24 to 0.39)**		0.83 (0.58 to 1.19)	
Sex	Male	1.00	**<0.001**	1.00	0.525
	Female	**0.55 (0.45 to 0.67)**		0.95 (0.74 to 1.22)	
IRSAD quintile	5, least disadvantaged	1.00	**<0.001**	1.00	**<0.001**
	4	**2.13 (1.61 to 2.82)**		**1.43 (1.05 to 1.95)**	
	3	**3.77 (2.62 to 5.42)**		**2.04 (1.38 to 3.01)**	
	2	**2.96 (2.10 to 4.19)**		**1.50 (1.03 to 2.20)**	
	1, most disadvantaged	**4.02 (2.76 to 5.86)**		**2.30 (1.52 to 3.48)**	
Preferred language	English	1.00	**<0.001**	1.00	0.102
	Language other than English	**0.35 (0.25 to 0.48)**		0.69 (0.45 to 1.05)	
Pre-existing mental health condition	No	1.00	0.138	1.00	**0.019**
	Yes	1.21 (0.94 to 1.57)		**1.39 (1.02 to 1.89)**	
Pre-existing substance use condition	No	1.00	**<0.001**	1.00	**<0.001**
	Yes	**2.59 (1.71 to 3.93)**		**2.33 (1.47 to 3.70)**	
Smoking status	Non-smoker	1.00	**<0.001**	1.00	0.852
	Past smoker	0.92 (0.69 to 1.24)		0.98 (0.70 to 1.37)	
	Current smoker	**1.97 (1.51 to 2.57)**		1.09 (0.80 to 1.49)	
High alcohol hours	No	1.00	0.458	1.00	0.738
	Yes	1.13 (0.82 to 1.57)		0.96 (0.66 to 1.41)	
Cause of injury	Motor vehicle/motorcycle collision (drivers)	1.00	**<0.001**	1.00	**<0.001**
	Motor vehicle/motorcycle collision (passengers)	1.04 (0.53 to 2.03)		1.29 (0.67 to 2.50)	
	Other transport-related causes	**0.47 (0.32 to 0.71)**		**0.62 (0.42 to 0.94)**	
	Low falls	**0.11 (0.08 to 0.15)**		**0.17 (0.12 to 0.25)**	
	High falls	0.86 (0.54 to 1.36)		1.07 (0.68 to 1.70)	
	Flames/scalds/contact burns	**0.41 (0.22 to 0.76)**		**0.33 (0.18 to 0.61)**	
	Animal-related	0.74 (0.28 to 1.92)		0.67 (0.27 to 1.66)	
	Struck by or collided with an object or person	**0.40 (0.24 to 0.66)**		**0.33 (0.18 to 0.60)**	
	Cutting/piercing object	0.61 (0.33 to 1.14)		0.47 (0.22 to 1.01)	
	Other/unspecified	**0.42 (0.22 to 0.79)**		**0.38 (0.20 to 0.73)**	
Injury intent	Unintentional	1.00	**0.009**	1.00	0.781
	Intentional self-harm	**2.12 (1.22 to 3.69)**		1.20 (0.65 to 2.21)	
	Interpersonal violence	1.23 (0.82 to 1.85)		1.32 (0.70 to 2.47)	
	Could not be determined	1.78 (0.86 to 3.69)		0.89 (0.43 to 1.85)	
	Other/unspecified	–		–	
Injury Severity (ISS)	Minor/moderate (ISS<16)	1.00	**<0.001**	1.00	0.212
	Severe (ISS 16–24)	1.25 (1.00 to 1.55)		1.18 (0.91 to 1.53)	
	Very severe (ISS>24)	**1.57 (1.24 to 2.00)**		1.25 (0.92 to 1.71)	
GCS	13–15	1.00	0.115	1.00	0.062
	9–12	**1.56 (1.00 to 2.43)**		1.57 (0.95 to 2.58)	
	3–8	1.01 (0.76 to 1.35)		0.72 (0.50 to 1.03)	

Values in bold font indicate statistically significant results.
*P values were derived using likelihood ratio tests.
aOR, adjusted OR; GCS, Glasgow Coma Scale; IRSAD, Index of Relative Socioeconomic Advantage and Disadvantage; ISS, Injury Severity Score.

GCS, which was significantly associated with testing in the overall analysis ($p<0.001$) but not in the sensitivity analysis ($p=0.12$). Relative to patients who presented to MTC1, patients who presented to other sites had significantly lower odds of testing (table 3).

Adjusted analyses

In the overall sample, all hospital and injury characteristics included were significantly associated with the odds of testing except for injury severity ($p=0.11$). There were lower odds of testing (relative to people injured while driving a motor vehicle) for patients with other transport-related injuries (aOR=0.60, 95% CI 0.50 to 0.72), low falls (aOR=0.37, 95% CI 0.31 to 0.44), high falls (aOR=0.65, 95% CI 0.55 to 0.78) and animal-related injuries (aOR=0.31, 95% CI 0.22 to 0.43). Higher odds of testing were observed for intentional injuries (self-harm: aOR=1.93, 95% CI 1.45 to 2.57; interpersonal violence: aOR=2.29, 95% CI 1.70 to 3.09), patients injured during high alcohol hours (aOR=1.90, 95% CI 1.59 to 2.27), and patients with a lower GCS (relative to GCS 13–15; GCS 9–12: aOR=1.93, 95% CI 1.55 to 2.40; GCS 3–8: aOR=1.70, 95% CI 1.41 to 2.06). When analyses were restricted to MTC1, most biases that were detected in the overall sample were not significant, including being injured during high alcohol hours, injury intent and severity, and GCS (table 4). The only injury or hospital characteristic significantly associated with testing at MTC1 was injury cause (table 4).

Postestimation data

The variance inflation factors for variables included in multivariable models ranged from 1.03 to 1.33, indicating low levels of collinearity between variables. For the model restricted to MTC1, the Hosmer-Lemeshow test indicated adequate fit across deciles (χ^2 (8, n=3255)=11.77, p=0.16). For the model examining all sites, the Hosmer-Lemeshow test was significant across deciles (χ^2 (8, n=13 505)=47.40, $p<0.05$) but demonstrated adequate goodness of fit across octiles (χ^2 (6, n=13 505)=9.50, p=0.15), likely due to the small number of observations with a blood alcohol test in some deciles.

DISCUSSION

Alcohol testing practices are currently inconsistent across Victorian hospitals. Most major trauma patients who presented to sites with non-routine testing approaches were not tested for alcohol and several biases were detected in data from these sites. These biases highlight potential gaps in the epidemiological surveillance of alcohol-related injury events and our understanding of who might benefit from targeted prevention strategies. Fewer biases were detected at MTC1, where testing was routinely completed and most patients had alcohol data available, demonstrating the value of routine alcohol testing for accurate estimation of prevalence of alcohol exposure and identification of potential patients for intervention.

Despite trends indicating reductions in alcohol consumption for younger populations and increases for older populations, older patients were less likely to be tested for alcohol.[22] This is consistent with existing research,[8 9] reiterating existing recommendations that policy and prevention efforts should include older adults in addition to younger demographics.[23] Patients who preferred a language other than English were also less likely to be tested. While this is consistent with reports that people from households that speak a language other than English are more likely to abstain from alcohol, this demographic is traditionally under-represented in surveys on alcohol use.[23] Consistent with existing research, higher levels of socioeconomic disadvantage were associated with greater adjusted odds of testing.[8] Notably, the direction of odds of testing were inconsistent between unadjusted and adjusted analyses for the overall sample. In this study, the majority of testing occurred at MTC1, likely due to their routine approach to testing. MTC1 also cared for a greater proportion of patients who lived in less disadvantaged areas, potentially explaining why patients who lived in more disadvantaged areas had lower unadjusted, but greater adjusted, odds of alcohol testing. The lack of biases related to age and preferred language in data from MTC1, which had a routine alcohol testing protocol, demonstrates how routine screening could help mitigate selection biases. Implementing consistent and routine alcohol testing policies across trauma centres would enable us to generate representative epidemiological data that can accurately inform targeted prevention strategies.

Clinician perceptions towards the utility and relevance of testing may contribute to the selection biases identified in this study. Consistent with a study which reported that clinical staff were more likely to screen individuals with serious head injuries,[8] patients presenting with lower GCS Scores had greater odds of being tested. Since impairments to consciousness can result from both head injuries and intoxication, higher testing in these groups may reflect clinical investigation required to manage patient care.[24] Higher odds of testing were also observed during high alcohol hours and for patients with pre-existing mental health or substance use conditions, potentially indicating situations where clinicians were expecting higher chances of alcohol involvement and/or they perceived the test to be more relevant to patient care.[8] Findings that smokers were more likely to be tested than non-smokers were also consistent with existing research[25] and with knowledge that comorbid alcohol and tobacco use is common.[26]

While biases in testing may indicate demographics that have previously been shown to have greater risk of experiencing alcohol-related harms, clinician judgement of intoxication has low agreement with objective alcohol tests.[27 28] Shifting alcohol use trends and a lack of set criteria to inform clinician judgement likely prevents consistent decision making regarding who should be tested, reiterating the potential benefits of routine testing protocols. Notably, the American Medical Association recommends that blood alcohol testing should be routinely completed for trauma patients to enable referral to appropriate healthcare services and interventions;[29] however, this has not translated to consistent or high levels of testing in American trauma centres.[30] This emphasises the need to couple policies with systems that can support routine testing protocols. For example, blood alcohol tests are automatically included in the panel of laboratory tests ordered for trauma patients at MTC1, eliminating the need for clinicians to explicitly order additional tests. Research from primary care settings has demonstrated age, sex and race-related disparities in the delivery of brief alcohol interventions, with authors noting that stigma and perceptions of lower treatment need in certain demographics (eg, women) has potentially contributed to these disparities.[31] Similar disparities may be observed in trauma settings that have adopted similar brief intervention pathways in line with recommendations from the American Medical Association. While the benefits of routine testing may have limited clinical impact in settings without these brief intervention pathways in place, there still remains to be clear benefits associated with routine testing from an epidemiological perspective.

Notably, some biases were still detected in settings where alcohol testing was conducted routinely (MTC1). This is consistent with existing research where clinicians and nurses reported being more likely to test certain patient groups for alcohol even in settings where testing was considered routine.[8] Further research is needed to understand what may be influencing these biases, whether these biases are consistent across different sites, and the clinical impacts of implementing routine testing protocols for reducing these biases.

Limitations

The majority of alcohol testing occurred at MTC1, which had some differences related to age, socioeconomic status and injury severity compared with the broader sample. Therefore, findings may not generalise to other hospitals. Given that fewer biases were observed in data from MTC1 compared with the overall major trauma population in Victoria, some of the biases identified in the overall sample may be more pronounced at sites other than MTC1. This study did not consider tests that occurred after a hospital transfer as time delays associated with the transfers could lead to false-negative test results; however, some of these tests may have been valid if the delay was not substantial. Since breath and blood alcohol test results can be inconsistent due to differing windows of detection for alcohol,[7] this study focused on blood alcohol tests. Although breath tests can be a convenient alternative to blood tests in emergency settings, the proportion of breath tests in this study was small. There were also 205 patients who were missing blood alcohol data in the registry despite being tested. While this does not impact on the current study, which examined the completion of blood alcohol testing in trauma patients, it is worth noting that biases in the completion of alcohol testing may not be the same as biases associated with having blood alcohol data available. Patients aged <18 years were excluded from this study. While the minimum legal age for drinking in Australia is 18 years, alcohol contributes to injury events in adolescents[32] and consideration of these patients as part of routine surveillance may be important.

CONCLUSIONS

This study identified several biases regarding which major trauma patients have in-hospital blood alcohol tests completed in Victoria, with implications for the surveillance of alcohol-related injuries, and for the development of targeted interventions. From an epidemiological perspective, biases in the data will affect estimates of prevalence and the quantification of risk for alcohol-related injuries. Clinically, biases in testing could impact on the management of patients with alcohol-related injuries and limits our understanding on who might benefit from targeted prevention strategies and interventions. Routine alcohol testing for major trauma patients has potential to mitigate these biases, enabling the collection of robust data on alcohol-related injuries and facilitating consistent testing practices for patient care.

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Contributors GL acts as guarantor for this study and was responsible for study design, data analysis and interpretation, and drafting the manuscript. BG, BM, PD, SR and BB contributed to study design, interpretation of data and critical revision of the manuscript. PC, DR and ES assisted with interpretation of data and critical revision of the manuscript.

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Data availability statement Data may be obtained from a third party and are not publicly available. All data in this study were obtained from the VSTR, which is governed by the VSTORM group. Access to the VSTR requires approval from the data custodians, VSTORM. Data requests must comply with relevant ethics requirements and can be made through the following link: https://www.monash.edu/medicine/sphpm/vstorm.

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