# The associations of factors with previous alcohol use in the Northern Territory compared to other states – an observational study

P. John Treacy,[1] Therese Rey-Conde,[2] Jennifer Allen,[2] Ryan T. Maloney,[3] John B. North[2]




## Abstract

**Background**: Data on previous alcohol use in surgical patients who died in the Northern Territory (NT) are lacking and have important public health implications.

**Methods**: The prevalence of previous alcohol (ab)use among surgical patients who died (n=560) was assessed in patients within the Northern Territory and the remainder of Australia (n=28,245) over nine years.

**Results**: The likelihood of previous alcohol use (21.4%; 120 of 560), was the outcome measured and was higher in the Northern Territory than outside it (5.9%; 1,660 of 28,245). Factors associated with the outcome of previous alcohol use were: male gender (aOR 1.6); Aboriginal and Torres Strait Islander status (aOR 2.0); liver disease (aOR 7.8); comorbidities (aOR 2.5); and trauma (aOR 1.1), in both the Northern Territory (aOR 11.5) and all Australia (aOR 7.8). In the Northern Territory, alcohol use was high in both Aboriginal and Torres Strait Islander people (31%) and non-Aboriginal and Torres Strait Islander (16%) people (p=0.316).

**Conclusion**: Of surgical patients who died, the likelihood of being a previous alcohol user was double in the Northern Territory as opposed to other states. Alcohol misuse is widespread across all groups in the Northern Territory.

**Implications for public health**: Previous alcohol (ab)use is a negative factor for survival in any racial group.


**Key words**: alcohol, surgical deaths, Indigenous population, liver disease

Previous alcohol use is among the top five risk factors contributing to the burden of disease in Australia,[1] responsible for 4.6% of the total burden of disease and injury in 2011, according to the Australian Institute of Health and Welfare.[2,3] It contributes to several diseases and injuries, especially liver disease, along with stroke, heart disease, neurological diseases and some cancers.[4] Alcohol also figures frequently in social traumas such as suicide, assault and motor vehicle crashes.[5,6]

Per capita consumption of alcohol in the Northern Territory (NT) – 15.1 litres of pure alcohol per person per year – is reportedly the second highest consumption rate in the world and about 50% higher than that for all of Australia.[7-10] Risky drinking behaviour, defined as drinking on average more than two standard drinks per day, was recorded in 28% of Northern Territory adults in 2016 – well above the national average of 17%.[3]

Significant increases in the rates of alcohol-attributed hospitalisations in the Northern Territory have been reported,[11] and alcohol-attributed deaths are 3.5 times more likely to occur in the Northern Territory than in all Australia.[10] In Australia, excessive alcohol use among Aboriginal and Torres Strait Islander people has been extensively reported.[7] High-risk excessive alcohol abuse within Aboriginal and Torres Strait Islander communities reportedly often leads to physical and social consequences,[7] with Indigenous persons more likely to be hospitalised for alcohol-attributable conditions than non-Indigenous persons.[11] Rates of hospitalisations are five times higher in Indigenous males and 10 times higher in Indigenous females, compared to non-Indigenous males and females.[11] Vos et al.[12] estimated that alcohol-related harm accounted for 6.2% of the burden of disease in Indigenous persons, compared with 4.6% of all Australians. Alcohol-attributable deaths (not only surgical) in Aboriginal and Torres Strait Islander people are 9–10 times higher in the Northern Territory compared to Australia as a whole.[10] Given that the population of the Northern Territory consists of a larger proportion of Indigenous people (30%) than any other Australian state or territory, it is possible that this is a contributing factor to the higher rates observed.[13]

The first aim of the study was to examine the associations between location (Northern Territory versus other Australian states and territories) and previous alcohol involvement specifically in surgical patients who had died in hospitals. A second aim was to identify physical factors associated with previous alcohol use among surgical patients who had died in hospital in the Northern Territory.

*1. Northern Territory Medical School, Flinders University, Northern Territory*
*2. Northern Territory Audit of Surgical Mortality (NTASM), Queensland*
*3. Australian and New Zealand Audit of Surgical Mortality (ANZASM), The Royal Australasian College of Surgeons, Victoria*
**Correspondence to**: Associate Professor Peter John Treacy, PO Box 43022, Casuarina, NT 0811; e-mail: pj.treacy@bigpond.com
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## Methods

### Audit process and data collection

Data for this observational study were extracted from the database of the Royal Australasian College of Surgeons' (RACS) Australian and New Zealand Audit of Surgical Mortality (ASM).[14] Between 1 July 2010 and January 2019, a total of 28,805 cases of surgical death were identified from Australian in-hospital data. Due to differences in data collection methodologies, New South Wales (NSW) data are not included and all references to 'all of Australia' in this study exclude NSW. The methodology of the ASM has been reported previously.[15,16]

Briefly, all in-hospital deaths where a surgeon was involved in the care of the patient are included in the audit, whether the patient had undergone an operation or not. This included patients under the care of a physician (medical admission) who had undergone an operation with a surgeon. Once the ASM was notified of a death for inclusion in the audit, the consultant surgeon associated with the case was sent a structured questionnaire (surgical case form [SCF]) to complete. This standard form is used in all surgical mortality audits in Australia. Data recorded include demographic details, type of admission (emergency or elective), main surgical diagnosis, significant co-existing factors and details of operations performed. Each de-identified SCF is then forwarded to a peer consultant surgeon for an independent, external and anonymous review.

The definition of 'previous alcohol use' as reported in the SCF forms had been determined by surgeons, using their professional opinions. The level of previous alcohol use was not quantified. A search was conducted of the SCF data for any mention of terms related to previous alcohol use, such as "alcohol", "ethanol", "intoxication", "drinker", and derivatives of these terms. No distinction was made between acute alcohol intoxication and chronic alcohol abuse. Each SCF was counted only once, even if a search term appeared more than once on the form. SCFs with missing data were excluded from the total count of cases.

Eligible participants were surgical patients who had died in hospital and data from them were extracted from SCFs for demographic and clinical factors: age (per decade), sex, Aboriginal and Torres Strait Islander status, region, comorbidities, trauma, liver disease, renal disease, diabetes mellitus and inter-hospital transfers. All were included in the analysis as possible confounders for alcohol use. The surgeon's assessed risk of death at operation for each surgical patient who died in hospital was also included in the analysis. The outcome variable of interest for this study was previous alcohol use, as reported by surgeons, defined as a binary variable indicating the presence or absence of evidence of previous alcohol use. As all eligible patients were included there was no selection bias in the data. However, reporting bias may be present, as the use of alcohol was a subjective estimation by the surgeon.

### Statistical analysis

Data extraction was performed using custom-written code using data science libraries for the Python and R scripting languages. Summary statistics were reported as frequencies (percentages) for categorical data. The associations were investigated by using binary logistic regression models in a backwards stepwise approach with Stata Statistical Software (StataCorp. 2017. Release 15. College Station, TX: StataCorp LLC), where the presence or absence of evidence of alcohol use was the outcome variable. Data were first modelled for the full Australian sample – including the patient's region as a predictor (NT, or the remainder outside NT) – and then repeated after stratifying for the Northern Territory patient sample only. Univariable models were constructed, followed by multivariable models that included age at death, other comorbidities, and risk of death as potentially confounding or correlated factors. Effect estimates are presented as odds ratios (OR) with 95% confidence intervals (95%CI) and *p*-values (*p*-values less than 0.05 were considered statistically significant). Both unadjusted odds ratios and adjusted odds ratios (aOR) are presented.

### Qualified privilege

The Australian and New Zealand Audit of Surgical Mortality (ASM) has protection under the Commonwealth Qualified Privilege Scheme under Part VC of the Health Insurance Act 1973. ASM is an Australian Government quality assurance activity (gazetted 25 July 2016). This classification covers the external two-level peer-review process of the Audit. Hospital ethical approval was not required.

## Results

The data are described in two tables: Table 1 models demographic and clinical factors in alcohol use including region (NT or not NT) in our full sample of surgical patients who had died in hospital. Table 2 describes data of surgical patients who had died in hospital but is limited to those from the Northern Territory only, assessing the same factors for their association with alcohol use, except for region. Missing observations for any variable were omitted from regression models. The number of such missing cases are provided below Tables 1 and 2 for each variable.

Surgical patients from outside the Northern Territory (n=28,245) had a mean age of 72.9 years (SD ±18.4), the majority – 16,157 – were male (56%) and 652 (2.9%) identified as Aboriginal or Torres Strait Islander persons. The Northern Territory subset of data contained 560 surgical patients who died in hospital (Table 2). This table shows that Northern Territory patients were, compared with the remainder of our patient sample, younger (mean age 62.0 years, SD ±19.2), with a higher proportion of males (63%; 352 of 560) and a higher proportion of Aboriginal or Torres Strait Islander persons (37%; 206 of 560).

There was a greater likelihood of previous alcohol use where patient region was the Northern Territory as opposed to the remainder of our patient sample (21.4%; 120/560 versus 5.9%; 1,660/28,245 OR 4.4; 95%CI 3.5-5.4, $p<0.001$). This was most pronounced in the age groups spanning 30 to 60 years (see Figure 1). The likelihood for the association of Northern Territory region and previous alcohol use remained significant (aOR 2.2; 95%CI 1.6-2.9, $p<0.001$) after adjusting for potentially confounding factors in the multivariable regression model.

The multivariable regression for all of Australia (Table 1) revealed several factors significantly associated with increased likelihood of previous alcohol use, including: male gender (aOR 1.6; 95%CI 1.4-1.9, $p<0.001$); Aboriginal and Torres Strait Islander status (aOR 2.0, 95%CI 1.5-2.7, $p<0.001$); presence of liver disease (aOR 7.8; 95%CI 6.7-9.1, $p<0.001$); and presence of other comorbidities (aOR 2.5; 95%CI 2.2-2.8, $p<0.001$). Factors that were not significantly associated with previous alcohol use included having diabetes mellitus, risk of death at operation as assessed by the surgeon, and inter-hospital transfer of a patient (Table 1).

In sum, Table 1 shows that surgical patients who died in Australia with evidence of "alcohol" use were twice as likely to be from the Northern Territory, 60% more likely to be male, twice as likely to be Aboriginal and Torres Strait Islander, eight times more likely to have liver disease, approximately half as likely to have renal disease, less likely to be elderly, more than twice as likely to have other comorbidities, and more likely to have suffered trauma.

For the Northern Territory subset alone, the multivariable model showed that factors significantly associated with previous alcohol use included liver disease (aOR 11.5; 95%CI 6.1-21.7, $p<0.001$); the presence of other comorbidities (aOR 4.3; 95%CI 2.4–7.7, $p<0.001$); and younger patient age (aOR 1.25; 95%CI 1.1-1.4, $p=0.002$) – *increased* patient age was associated with a *reduced* likelihood for alcohol use, as expressed in the model (Table 2).

Factors not significantly associated with previous alcohol use included the presence of diabetes mellitus, risk of death at operation as assessed by the surgeon, and the inter-hospital transfer of patients.

The association between alcohol and trauma for our full ASM sample (NT included) was statistically significant (aOR 1.3; 95%CI 1.1-1.5, $p=0.001$; Table 1), whereas the association between alcohol and trauma was not the case in the Northern Territory alone (aOR 1.2; 95%CI 0.6-2.4, $p=0.630$; Table 2). To summarise Table 2: surgical patients who died in the Northern Territory with the presence of "alcohol" use identified were many times more likely to have liver disease, many times more likely to have other comorbidities and less likely to be elderly. Other results were not statistically significant, once adjusted.

## Discussion

This study shows that the likelihood of previous alcohol use among Northern Territory region hospital surgical patients who died is significantly greater than for the remainder of the Australian patient sample (outside the Northern Territory). Using adjusted multivariable regression models, previous alcohol use was also strongly shown to be associated with liver disease. These findings were strongly both statistically and clinically significant. Alcohol misuse is widespread across all groups in the Northern Territory.

**Table 1: Associations with previous alcohol involvement in surgical deaths in all patients (including NT) with Region included as risk factor n=28,805.**

| Factor | Denominator | Previous Alcohol Use Count (%) | Crude Odds Ratio (95% CI) | *p*-value | Adjusted (for age, other comorbidities) Odds Ratio (95% CI) | *p*-value |
|---|---|---|---|---|---|---|
| **Region** | | | | | | |
| NT | n=560 | 120 (21.4%) | 4.4 (3.5, 5.4) | p<0.001 | 2.2 (1.6; 2.9) | p<0.001 |
| Not NT | n=28,245 | 1,660 (5.9%) | Ref | | Ref | |
| **Gender** | | | | | | |
| Male | n=16,157 | 1,230 (7.6%) | 1.8 (1.6, 2.0) | p<0.001 | 1.6 (1.4, 1.9) | p<0.001 |
| Female | n=12,643 | 550 (4.4%) | Ref | | Ref | |
| **Aboriginal and Torres Strait Islander Status** | | | | | | |
| Aboriginal and Torres Strait Islander | n=652 | 149 (22.9%) | 4.6 (3.8, 5.6) | p<0.001 | 2.0 (1.5, 2.7) | p<0.001 |
| Non-Aboriginal and Torres Strait Islander | n=22,171 | 1,335 (6.0%) | Ref | | Ref | |
| **Liver Disease** | | | | | | |
| Yes | n=2,105 | 609 (28.9%) | 9.0 (8.0, 10.0) | p<0.001 | 7.8 (6.7, 9.1) | p<0.001 |
| No | n=23,346 | 1,014 (4.3%) | Ref | | Ref | |
| **Renal Disease** | | | | | | |
| Yes | n=7,323 | 393 (5.4%) | 0.8 (0.7, 0.9) | p<0.001 | 0.7 (0.6, 0.8) | p<0.001 |
| No | n=18,128 | 1,230 (6.8%) | Ref | | Ref | |
| **Diabetes mellitus** | | | | | | |
| Yes | n=5,210 | 329 (6.3%) | 1.0 (0.9, 1.1) | | 0.9 (0.8, 1.1) | p=0.330 |
| No | n=20,241 | 1,294 (6.4%) | Ref | p=0.837 | Ref | |
| **Inter-Hospital Transfer** | | | | | | |
| Yes | n=7,327 | 522 (7.1%) | 1.2 (1.1, 1.3) | p=0.001 | 1.0 (0.9, 1.0) | p=0.628 |
| No | n=20,578 | 1,233 (6.0%) | Ref | | Ref | |
| **Age** | | | | | | |
| Per decade | | n/a | 0.8 (0.8, 0.8) | p<0.001 | 0.9 (0.8, 0.9) | p<0.001 |
| **Other Comorbidities** | | | | | | |
| Yes | n=6,863 | 795 (11.6%) | 2.8 (2.5, 3.1) | p<0.001 | 2.5 (2.2, 2.8) | p<0.001 |
| No | n=18,588 | 828 (4.5%) | Ref | | Ref | |
| **Trauma** | | | | | | |
| Yes | n=5,198 | 367 (7.1%) | 1.1 (1.0, 1.2) | p=0.204 | 1.3 (1.1, 1.5) | p=0.001 |
| No | n=13,845 | 906 (6.5%) | Ref | | Ref | |

*Notes:*

*CI: confidence interval; NT: Northern Territory; n/a: not applicable; n/c: not computable.*

*Missing observations excluded: 5 observations "Gender"; 5,982 observations "Indigenous status"; 3,354 "Liver Disease"; 3,354 "Renal Disease"; 3,354 "Diabetes"; 900 "Inter-Hospital Transfer"; 3 "Age per Decade"; 3,354 "Other Comorbidities"; 9,762 "Trauma".*

There was no statistically significant difference in the association with previous alcohol use for males and females within the Northern Territory. Neither was there any difference between Aboriginal and Torres Strait Islander persons and non-Aboriginal and Torres Strait Islander persons in the Northern Territory, indicating that excessive alcohol use could be as prevalent in both men and women, and among Indigenous and non-Indigenous populations. These findings are unexpected and important, given the evidence for increased risk of problem drinking in Indigenous populations in the Northern Territory,[7-11] and data showing that men generally tend to drink in greater quantities and more often than do women in Australia.[17-19]These results may possibly be more significant in social terms, rather than medical or surgical terms.

Table 2: Associations of clinical and demographic factors with previous alcohol involvement in Northern Territory alone (n=560). This table does not include data from other Australian states.

| Factor | Denominator | Alcohol Use Count (%) | Crude Odds Ratio (95% CI) | *p*-value | Adjusted (for age, other comorbidities) Odds Ratio (95% CI) | *p*-value |
|---|---|---|---|---|---|---|
| **Gender** | | | | | | |
| Male | n=352 | 81 (23.0%) | 1.3 (0.8, 2.0) | p=0.236 | 1.2 (0.7, 2.2) | p=0.543 |
| Female | n=208 | 39 (18.8%) | Ref | | Ref | |
| **Aboriginal and Torres Strait Islander Status** | | | | | | |
| Aboriginal and Torres Strait Islander | n=206 | 64 (31.0%) | 2.4 (1.6, 3.6) | p<0.001 | 1.4 (0.7, 2.8) | p=0.316 |
| Non-Aboriginal and Torres Strait Islander | n=354 | 56 (15.8%) | Ref | | Ref | |
| **Liver Disease** | | | | | | |
| Yes | n=104 | 61 (58.7%) | 10.0 (6.0, 16.4) | p<0.001 | 11.5 (6.1, 21.7) | p<0.001 |
| No | n=361 | 45 (12.5%) | Ref | p<0.001 | Ref | |
| **Renal Disease** | | | | | | |
| Yes | n=159 | 32 (20.1%) | 0.8 (0.5, 1.3) | p=0.323 | 0.5 (0.3, 1.1) | p=0.073 |
| No | n=306 | 74 (24.2%) | Ref | | Ref | |
| **Diabetes mellitus** | | | | | | |
| Yes | n=153 | 30 (19.6%) | 0.8 (0.5, 1.2) | p=0.252 | 0.5 (0.3, 1.1) | p=0.718 |
| No | n=312 | 76 (24.4%) | Ref | | Ref | |
| **Inter-Hospital Transfer** | | | | | | |
| Yes | n=84 | 21 (25.0%) | 1.2 (0.7, 2.1) | p=0.424 | 1.0 (0.8, 1.2) | p=0.718 |
| No | n=460 | 97 (21.1%) | Ref | | Ref | |
| **Age** Per decade | | n/a | 0.8 (0.7, 0.9) | p<0.001 | 0.8 (0.6, 0.9) | p<0.002 |
| **Other Comorbidities** | | | | | | |
| Yes | n=160 | 68 (35.8%) | 3.5 (2.2, 5.5) | p<0.001 | 4.3 (2.4, 7.7) | p<0.001 |
| No | n=275 | 38 (13.8%) | Ref | | Ref | |
| **Trauma** | | | | | | |
| Yes | n=139 | 31 (22.3%) | 1.0 (0.6, 1.6) | p=0.925 | 1.2 (0.6, 2.4) | p=0.603 |
| No | n=356 | 78 (21.9%) | Ref | | Ref | |

*Notes:*

*CI: confidence interval; NT: Northern Territory; n/a: not applicable.*

*Missing observations excluded: 95 "Liver Disease"; 95 "Renal Disease"; 95 "Diabetes"; 16 "Inter-Hospital Transfer"; 95 "Other Comorbidities"; 125 "Risk of Death"; 3,354 "Other Comorbidities"; 65 "Trauma".*

Although the social abuse of alcohol has been widely reported, any contribution of alcohol to deaths specifically of in-hospital surgical patients in the Northern Territory has been poorly addressed elsewhere. In this study looking at wider Australia and Northern Territory separately, the likelihood of previous use of alcohol in surgical patients across Australia who died in hospital was significantly greater in Aboriginal and Torres Strait Islander patients than in non-Aboriginal and Torres Strait Islander patients (see Table 1). The effect was still statistically significant when corrected for age and other comorbidities, except for the effect of inter-hospital transfers. The prevalence of comorbidities in surgical patients who die in hospital has been reported as being higher in the Northern Territory than in the rest of Australia, which may have some correlation with previous alcohol abuse.[13] Whether this prevalence of comorbidities is causative of disease is unclear. Alcohol is known to contribute to a variety of diseases, especially liver disease, stroke, heart disease, neurological diseases and cancer.[4,19]

This paper therefore highlights the continued need for preventative public health measures to address excessive drinking behaviours in two arenas – in both the Northern Territory specifically and Australia more widely. It demonstrates the range of negative effects of those excesses on the health and welfare of alcohol drinkers.

For patients across Australia, there was a significant 30% increase in the likelihood of previous alcohol use in the involvement of trauma (aOR 1.3, 95%CI 1.1 -1.5, *p*=0.001). However, accurate estimates of the amount of alcohol consumed were not available for this study, which is a limitation. For patients in the Northern Territory, there was no significant association between trauma and the presence of previous alcohol use. This is perhaps surprising, as excessive alcohol use has been reported to contribute greatly in the Northern Territory to social traumas such as suicide, assaults and motor vehicle crashes,[4,5] but without the reporting of quantities of alcohol consumed in the surgical audit, firm conclusions cannot be drawn and there may be negative reporting bias present.

Reasons for the anomaly of lack of previous alcohol use reporting in the surgical audit,

despite a high incidence of trauma cases, could lie in the road conditions and travel distances of the Northern Territory – individuals involved in road crashes often die before reaching a hospital because of vast distances to some health facilities.[5,6] Transport-related deaths have been reported to be more than twice as likely to occur in remote and very remote settings in the Northern Territory than in accessible or moderately accessible regions,[6] and these deaths are not captured in surgical audits. The road death toll in the Northern Territory has for many years been at least three times the national average,[5,6] and some 48% of Northern Territory road fatalities involve an illegal blood alcohol concentration compared with less than 30% in other jurisdictions[5] – further evidence that accurate consumption measures are needed.

That no significant association was demonstrated between trauma and the presence of previous alcohol use in the Northern Territory may also relate to chronic alcohol involvement, as suggested by the high baseline rate of chronic liver disease. Trauma is usually associated with more acute alcohol usage, rather than chronic alcohol involvement.

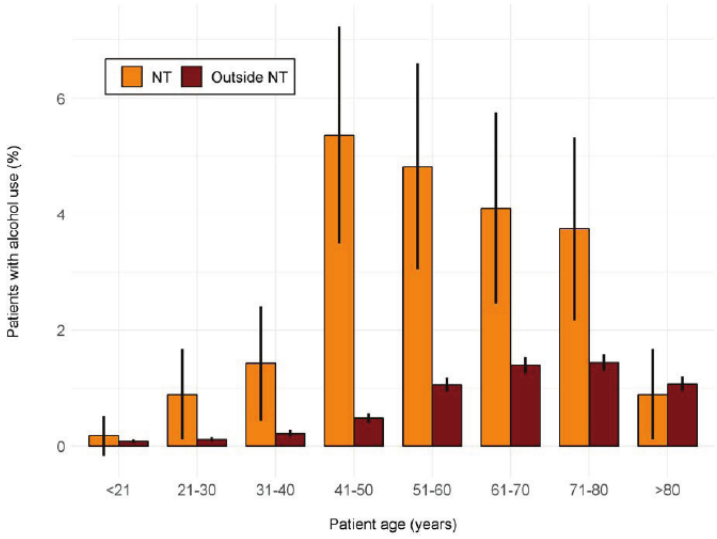
Out-of-hospital deaths were not assessed in the present study. The nature of the ASM and its focus is in-hospital surgical deaths. Capturing deaths associated with trauma arising from previous alcohol use and/or intoxication cannot be investigated using these data. More work and a different approach are needed in this regard. However, the relationship between excessive alcohol use and the negative physical effects of such use is not as widely published, nor are the social impacts of alcohol use. We see from this paper that previous alcohol use likely sets patients up for less-than-ideal physical sequelae following surgery. Considering the physical and social implications of this issue, it is hoped that more direct data will be available in the future.

A strength of the present report is that Indigenous status was recorded for 100% of Northern Territory patients in the present sample, compared to 79% of patients outside the Northern Territory – an indication of the rigour of the Northern Territory data. However, surgeons in the Northern Territory may be more conscious of the role of previous alcohol use than those in other jurisdictions, and thus may be reporting it more frequently, leading to possible positive reporting bias. Furthermore, given that 30% of the Northern Territory population are of Aboriginal and Torres Strait Islander origin, surgeons in the Northern Territory may be more sensitive to the importance of correctly recording a patient's Aboriginal and Torres Strait Islander status. Confounding factors may also be present; in such complicated care situations, it is difficult to lay all the blame of ill-health solely on the use or abuse of alcohol. However, the broader extent of "previous alcohol use", as defined in this report, is not quantified – a potential limitation. The findings nevertheless highlight the need for culturally appropriate interventions focusing on alcohol use and misuse in the Aboriginal and Torres Strait Islander populations of the Northern Territory, as well as in the broader Australian context. The Northern Territory Government has many years of experience in these endeavours and could guide this process Australia-wide.

The public health message of this study is important, providing reinforcement for what is known about alcohol use in Australia, especially how alcohol use in our society results in real physical costs to our surgical patients of any race. Any preventative health measures relating to alcohol misuse should not just focus on one subset of the population.

Given the significance of the likelihood of previous alcohol use (and probable abuse) identified in the present study, we recommend increasing the current health preventative measures directed at the prevention of alcohol misuse. We particularly recommend routine national recording in hospital emergency departments of previous alcohol use and misuse in all ethnic groups. Simple blood alcohol tests could be included with the routine full blood counts and biochemistry, avoiding the need for additional venepunctures. Similar measures should be taken on a national scale in the RACS' Audits of Surgical Mortality by routinely recording levels of alcohol use/abuse on the surgical case form.

Figure 1: Likelihood of alcohol use by age group.




*Notes:*

*Frequency of Alcohol use in the patient sample, broken down according to age groups. Bars show the percentage of patients where alcohol was identified as a factor. Percentages were computed separately for total patients from the NT (gold bars) and the remainder of the sample outside the NT (burgundy bars). Black error bars give the 95% confidence intervals for the observed percentages.*

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