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# Alcohol-related injury hospitalisations in relation to alcohol policy changes, Northern Territory, Australia, 2007–2022: A joinpoint regression analysis

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## Abstract

**Introduction:** The Northern Territory (NT) of Australia has the highest rates of alcohol consumption and injury in the country. We aimed to: (i) describe the epidemiology of alcohol-related injury (ARI) hospitalisations in the NT; (ii) estimate the proportion of alcohol involvement in injury hospitalisations; and (iii) consider the influence of alcohol policies on ARI hospitalisation trends.

**Methods:** We conducted a retrospective time-series study using coded hospitalisation data from NT public hospitals between 2007 and 2022. ARI hospitalisation was defined combining indicators for injury and acute alcohol use. We undertook descriptive analyses and calculated alcohol involvement against all injury hospitalisations. Annual percent changes (APC) were computed using joinpoint regression to examine the influence of alcohol policies on ARI hospitalisation trends by NT geographical regions (Central Australia and Top End).

**Results:** Alcohol use was associated with 22.6% of all injury hospitalisations. The most common cause of ARI hospitalisations was assault (46%). In Central Australia, a significant trend decline (APC −12.2; $p = 0.011$) was observed after 2017 following alcohol policies implemented between 2017 and 2018 (Banned Drinkers Register v2; Minimum Unit Price; and Police Auxiliary Liquor Inspectors). Consecutive years with the greatest decrease in Central Australia were 2013–2014 (APC −25.8) and 2018–2019 (APC −35.1); likely influenced by alcohol policies in effect at the time. In the Top End, a non-significant trend decline (APC −26.1; $p = 0.186$) was observed after 2020.

**Discussion and Conclusions:** Alcohol policies implemented between 2017 and 2018 were associated with reduced ARI hospitalisations in Central Australia. Alcohol policies that demonstrated reduced harm should be sustained.

**KEYWORDS**
alcohol, alcohol-related injury, hospitalisation, Northern Territory, policy

**Key Points**

- The incidence of alcohol-related injury is high in the Northern Territory compared to nationally, particularly in the region of Central Australia.
- More than one in five injury hospitalisations in the Northern Territory were related to alcohol use.
- Alcohol policies including the Banned Drinkers Register v2, Minimum Unit Price and Police Auxiliary Liquor Inspectors implemented between 2017 and 2018 were associated with reduced alcohol-related injury hospitalisations in Central Australia, but a similar reduction was not observed in the Top End.

# 1 | INTRODUCTION

## 1.1 | Alcohol

Harmful alcohol use was a leading risk factor for the global burden of disease and injury, accounting for 5.1% of all disability-adjusted life years (DALY) in 2016 [1]. In Australia, alcohol use contributed 4.5% to DALYs and was the fifth-ranked preventable risk factor in 2018 [2]. Alcohol use is closely associated with injury [3]. In 2019/2020, 5.7% of all injury hospitalisations and 14% of all injury deaths in Australia were related to alcohol use [4].

The Northern Territory (NT) of Australia has the highest rate of alcohol consumption in the country [5, 6] and high rates of alcohol-related harm [7]. Between 2014 and 2018, alcohol attributed to 15.6% of DALYs among the NT population [8]. In 2015/2016, the total social and economic cost of alcohol to the NT was estimated at 1.39 billion Australian dollars (AUD) [6]. Aboriginal and Torres Strait Islander peoples (respectfully referred to as Aboriginal peoples hereafter; the majority of Aboriginal and Torres Strait Islander peoples in the NT are of Aboriginal descent) represent approximately 31% of NT's population of 250,000 people [9]. While Aboriginal peoples are 1.3 times more likely to abstain from drinking alcohol compared to their non-Aboriginal counterparts, those who do consume alcohol tend to drink at risky levels, resulting in higher proportions of injuries and chronic health conditions [10]. The legacy of colonisation and intergenerational trauma are complex social issues which contribute to risky drinking behaviours among Aboriginal Australians, and holistic approaches are needed to address risky drinking [10, 11]. While acute intoxication was the most common cause of alcohol-related hospitalisations for Aboriginal peoples (60%) nationally between 2017 and 2019, dependence syndrome was the most common cause for non-Aboriginal people (52%) [12].

## 1.2 | NT alcohol policies

Reducing alcohol-related harm in the NT continues to be a key priority for government [13]. Alcohol policies can play a crucial role in preventing problematic alcohol consumption and related health consequences [14]. Various alcohol policies have been implemented in the NT (Table 1) [15, 16] since the introduction of the NT Emergency Response ('The Intervention') in 2007, which banned alcohol possession and consumption on Aboriginal land as defined by the *Aboriginal Land Rights (Northern Territory) Act 1976* (Cth) [7]. Policies such as the Banned Drinker Register (BDR) v1 (2011–2012) and Substance Misuse and Referral for Treatment courts (2011–2013) were repealed within 2 years before their impact could be formally evaluated [15]. The newly elected NT government in 2012 subsequently introduced the Alcohol Mandatory Treatment (AMT) (2013–2017) and Alcohol Protection Orders (APO) (2013–2017) [15]. A second version of the BDR was reintroduced in 2017 and has since remained in place [17]. Between 2012 and 2018, police officers were stationed at takeaway liquor outlets across the towns of Alice Springs, Katherine and Tennant Creek to prevent alcohol from entering restricted areas in what was known as Temporary Beat Locations (TBL), later renamed to Point of Sale Interventions [15]. Enforcement of the program could not be sustained over time, so in 2018, Police Auxiliary Liquor Inspectors (PALI) were legislated to replace police officers [15]. Around the same time, a minimum unit price (MUP) of 1.30 AUD per standard alcoholic drink was implemented across the NT [18].

## 1.3 | Injury

In addition to alcohol, injury is also a leading contributor to the burden of disease in the NT [19]. Compared to other Australian jurisdictions, the NT had the highest age-standardised rate of injury hospitalisations (4602 per

**TABLE 1** Key alcohol policies and programs implemented in the Northern Territory, 2007–2022.[a]

| Policy/program name | Years in effect | Location | Brief description on alcohol-related measures |
|---|---|---|---|
| *Northern Territory National Emergency Response Act 2007* (Cth) ('The Intervention')/ *Stronger Futures in the Northern Territory Act 2012* (Cth) ('Stronger Futures') | 2007–2022 | Aboriginal land; NT-wide | Banned the possession and consumption of alcohol on Aboriginal land as defined by the *Aboriginal Land Rights (Northern Territory) Act 1976* (Cth); clubs that existed before 2007 were retained with additional restrictions. |
| Banned Drinker Register (BDR) v1 | 2011–2012 (officially repealed in 2013) | NT-wide | Prohibited individuals on the BDR from purchasing, possessing or consuming alcohol; enforced through scanning of ID at liquor outlets. |
| Substance Misuse and Referral for Treatment (SMART) courts | 2011–2013 | NT-wide | Court system that referred offenders with a history of substance misuse to rehabilitation. |
| Alcohol Mandatory Treatment (AMT) | 2013–2017 | NT-wide | Mandated chronic drinkers who were publicly intoxicated to receive community treatment. |
| Alcohol Protection Orders (APO) | 2013–2017 | NT-wide | APOs issued at police officers' discretion to prevent the possession and consumption of alcohol and entry into licensed premises; responsibility was on the drinker to adhere to the APO. |
| Temporary Beat Locations (TBL)/Point of Sale Interventions (POSI) | 2012–2018 (full coverage in Alice Springs 2013–2014) | Alice Springs, Tennant Creek, Katherine | Police officers stationed at takeaway liquor outlets during business hours to prevent alcohol from entering restricted areas.[b] Individuals purchasing alcohol needed to nominate a valid address where they intend to consume the alcohol, otherwise their purchase will be denied. |
| Banned Drinker Register (BDR) v2 | 2017–present | NT-wide | Similar to BDR v1 but with additional referral pathways. |
| Police Auxiliary Liquor Inspectors (PALI) | 2018–present (full coverage from October 2018 in Alice Springs; full coverage from January 2019 in Katherine and Tennant Creek) | Alice Springs, Tennant Creek, Katherine | Trained liquor inspectors (auxiliary police officers) stationed at takeaway liquor outlets during business hours to prevent alcohol consumption in restricted areas.[b] Individuals purchasing alcohol needed to nominate a valid address where they intend to consume the alcohol, otherwise their purchase will be denied. |
| Minimum Unit Price (MUP) | 2018–present | NT-wide | Alcohol sold in the NT priced at a minimum of 1.30 AUD per standard alcoholic drink. |

[a]*Source*: Clifford et al. and Miller et al. [15, 16]
[b]General and public restricted areas declared under the *Liquor Act 1978* (NT); currently *Liquor Act 2019* (NT).

100,000) and deaths (76 per 100,000) in 2017/2018 [20]. The issue of alcohol has been identified as a cross-cutting factor in the prevention of injury in Australia [21]. Acute hospital presentations related to alcohol, such as injury and trauma, are preventable and can be influenced by alcohol policies in supply, demand and harm reduction [14]. Evidence from Alice Springs Hospital showed that in the year following alcohol policy implementation, decreases in intensive care unit (ICU) admissions associated with acute alcohol-related presentations (such as injury) were more marked than decreases in ICU admissions associated with chronic alcohol misuse [22]. This suggested injury due to alcohol intoxication may be a more sensitive indicator for determining policy effectiveness compared to all alcohol-related hospital attendances (both acute and chronic alcohol-related conditions).

## 1.4 | This study

Previous studies examined all alcohol-related emergency department (ED) presentations [23] and ICU admissions in the NT [22, 24]. The current study aimed to: (i) describe the epidemiology of alcohol-related injury (ARI) due to acute

alcohol use, manifested as admissions to NT public hospitals between 2007 and 2022; (ii) estimate the proportion of alcohol involvement in injury hospitalisations; and (iii) consider the potential influence of government alcohol policies on ARI hospitalisation trends.

## 2 | METHODS

### 2.1 | Data source and setting

We conducted a retrospective time-series study of ARI using de-identified hospitalisation data from NT public hospitals between 1 January 2007 and 31 December 2022. The six public hospitals were Royal Darwin Hospital, Palmerston Regional Hospital, Alice Springs Hospital, Katherine Hospital, Gove District Hospital and Tennant Creek Hospital, which together, provide acute care to most of NT's population including patients transferred from remote regions and communities. Admissions to the only private hospital in the NT and primary care visits were not included.

### 2.2 | Case definition

Hospitalisation data were coded using International Statistical Classification of Diseases and Related Health Problems, Tenth Revision, Australian Modification (ICD-10-AM) [25]. We defined an ARI hospitalisation as any hospital separation containing a diagnosis of injury (S00-T75; T79) and an additional diagnosis related to acute alcohol use (F10.0, F10.1, F10.2, R78.0, T51.0, T51.9, X45, X65, Y15, Y90, Z72.1) in any position of the diagnosis array (see Appendix 1, Data S1, Supporting Information, for ICD-10-AM code descriptions). The diagnosis codes for acute alcohol use included those that strongly indicated alcohol consumption as a contributing factor to injury [4]. Injury hospitalisations caused by someone else's use of alcohol but did not have a diagnosis related to alcohol use were not included. The same patient can have multiple hospitalisations counted if they were admitted on separate occasions. Chronic alcohol-related health conditions [4] were not included in the case definition, and dialysis patients and boarders were excluded (see Appendix 2, Data S1, for exclusion criteria). Patients deemed as non-NT residents were excluded ($n = 2499$) to enable the calculation of incidence rates.

### 2.3 | Alcohol policies

Key alcohol policies and interventions in the NT between 2007 and 2022 were defined as those identified by two papers (Table 1) [15, 16], and included the cessation of the *Stronger Futures in the Northern Territory Act 2012* (Cth) ('Stronger Futures') in July 2022.

### 2.4 | Statistical analysis

#### 2.4.1 | Descriptive analysis

We undertook descriptive analyses of ARI hospitalisations and all injury hospitalisations (containing only diagnosis of injury [S00-T75; T79]) by length of stay, age group, sex, Aboriginal status and external cause. External cause referred to the circumstance under which an injury event occurred, and can be categorised as intentional (X60-Y09, Y35-Y36), unintentional (V00-X59) or undetermined intent (Y10-Y34) (see Appendix 3, Data S1, for ICD-10-AM code descriptions) [4]. For hospital separations with multiple external causes, we analysed the first reported external cause in the diagnosis array. We divided ARI hospitalisations by all injury hospitalisations to calculate the proportion of alcohol involvement with injury. The estimated NT resident population stratified by year, age group, sex, Aboriginal status and epidemiological district was used as the denominator to calculate incidence rates. Age-standardised incidence rates were calculated by direct standardisation to the Australian Bureau of Statistics Australian Standard Population 2001. Rate ratios (RR) and 95% confidence intervals (CI) were calculated and considered significant at $p \leq 0.05$. All analyses were conducted using Stata v17 (Statacorp, College Station, Texas, USA) and Microsoft Excel 2016.

#### 2.4.2 | Joinpoint regression analysis

To examine the trends of ARI hospitalisations over time against alcohol policies, annual percent changes (APC) in age-standardised rates were computed by joinpoint regression across the study period and between individual years, using the Joinpoint Trend Analysis Software v5.0.2 developed by the United States National Cancer Institute [26]. The joinpoint regression accounted for variability in annual rates over time by detecting unspecified 'change-points' (not limited to policy implementation years) and fitting multi-segmented lines; considered significant at $p \leq 0.05$ [27]. Trend changes following an alcohol policy implementation or event (e.g., onset of the Coronavirus disease 2019 [COVID-19] pandemic) were examined. The software based on available data points supplied determined a maximum of two joinpoints [26]. We stratified the analysis by the two broad geographical regions of the NT—Central Australia and Top End (see

Appendix 4, Data S1, for a map of the NT). This regional analysis was appropriate due to variations in alcohol consumption patterns and the implementation of alcohol policies (e.g., TBLs and PALIs were primarily deployed in Central Australia) and their timelines [15]. We used the weighted Bayesian Information Criterion method to select the most optimal model [26]. The trend analysis was conducted in calendar years.

### 2.5 | Ethics

Ethics approval was granted by the Human Research Ethics Committee of the NT Department of Health and Menzies School of Health Research (2023-4658), and the Human Research Ethics Committee of the Australian National University (H/2023/1359).

## 3 | RESULTS

### 3.1 | Characteristics of patients hospitalised with an ARI

There were 36,469 ARI hospitalisations among NT residents during the study period, representing 22.6% of all injury hospitalisations (Table 2). Patients admitted with an ARI were predominantly male (51%), aged 35 ≤ 45 years (29%), and the majority were Aboriginal peoples (82%). In terms of the distribution among age groups, ARI hospitalisations were more concentrated among those aged 25 ≤ 55 years (75%) compared to all injury hospitalisations (53%). Hospital length of stay was shorter for ARI hospitalisations (0.5 days; IQR [0.3, 2.5]) compared to all injury hospitalisations (1.0 days; IQR [0.3, 3.2]). The annual age-standardised ARI hospitalisation rate was 927 per 100,000 (Table 3). The annual age-standardised ARI hospitalisation rate among the Aboriginal population was 2868 per 100,000, compared to 250 per 100,000 among the non-Aboriginal population (RR 11.46; 95% CI 11.16, 11.77; $p < 0.001$).

The most common cause of ARI hospitalisations was assault (46%), followed by falls (20%) and intentional self-harm (9%) (Figure 1). The causes of ARI hospitalisations were more likely to be of an intentional nature (56%) compared to those of all injury hospitalisations (30%) (Table 2). Assault was associated with 44% of ARI hospitalisations among Aboriginal males and 61% of ARI hospitalisations among Aboriginal females. For non-Aboriginal males, falls was the most common cause (32%), and for non-Aboriginal females, intentional self-harm was the most common cause (36%).

### 3.2 | Trends in ARI hospitalisations

The annual age-standardised ARI hospitalisation rate in Central Australia (2291 per 100,000) was 3.79 times (95% CI 3.71, 3.87; $p < 0.001$) higher than the Top End (604 per 100,000). In Central Australia, a significant decrease in the hospitalisation rate of 12.2% per annum ($p = 0.011$) was detected between 2017 and 2022, following a period of increase by 5.2% per annum ($p = 0.006$) between 2007 and 2017 (Figure 2). Consecutive years with the greatest decrease in Central Australia were 2013–2014 (APC −25.8) and 2018–2019 (APC −35.1). In the Top End, the ARI hospitalisation rate increased by 10.1% per annum ($p < 0.001$) between 2007 and 2020, and decreased by 26.1% per annum ($p = 0.186$) between 2020 and 2022 (period with COVID-19 pandemic restrictions).

## 4 | DISCUSSION

The higher ARI hospitalisation rate between 2007 and 2022 in Central Australia compared to the Top End reflected the greater burden of alcohol-related harm in Central Australia, predominantly driven by assault in people aged between 25 and 55. The annual age-standardised ARI hospitalisation rate was substantially higher in the NT (927 per 100,000) compared to the available national estimate (118 per 100,000) in 2019/2020 [4]. More than one in five injury hospitalisations in the NT (22.6%) were related to alcohol use. These findings were positively correlated with high levels of alcohol-related harm [7], alcohol consumption [5] and injury [19, 20] reported in other publications.

Alcohol-related injury hospitalisation rates for both the Aboriginal (2868 per 100,000) and non-Aboriginal (250 per 100,000) populations in the NT were higher than national estimates [4]. These results demonstrated that risky drinking is a population-wide issue, and affected both population groups in the NT. The three main causes of ARI hospitalisations (assault, falls and intentional self-harm) reinforced the importance of minimising community violence and strengthening access to support services.

### 4.1 | Interpretation of trends in relation to NT alcohol policies

#### 4.1.1 | Central Australia

The trend decline in Central Australia after 2017 may have been caused by the combined effect of alcohol

**TABLE 2** Alcohol-related injury and all injury hospitalisations by demographic groups and external cause, Northern Territory public hospitals, 2007–2022.

| | ARI hospitalisations, *n* (%) | All injury hospitalisations, *n* (%) | Proportion of alcohol involvement with injury (%) |
|---|---|---|---|
| Total | 36,469 | 161,145 | 22.6% |
| Median length of hospital stay, days [IQR] | 0.5 [0.3, 2.5] | 1.0 [0.3, 3.2] | – |
| Age-group, years | | | |
| <15 | 71 (<1%) | 20,321 (13%) | 0.3% |
| 15 ≤ 25 | 4737 (13%) | 26,216 (16%) | 18.1% |
| 25 ≤ 35 | 9587 (26%) | 33,105 (21%) | 29.0% |
| 35 ≤ 45 | 10,560 (29%) | 29,148 (18%) | 36.2% |
| 45 ≤ 55 | 7348 (20%) | 22,068 (14%) | 33.3% |
| 55 ≤ 65 | 2796 (8%) | 13,131 (8%) | 21.3% |
| ≥65 | 1370 (4%) | 17,156 (11%) | 8.0% |
| Sex | | | |
| Male | 18,678 (51%) | 89,989 (56%) | 20.8% |
| Female | 17,780 (49%) | 71,116 (44%) | 25.0% |
| Unknown/not stated | 11 (<1%) | 40 (<1%) | – |
| Aboriginal status | | | |
| Aboriginal and Torres Strait Islander | 29,817 (82%) | 91,516 (57%) | 32.6% |
| Neither Aboriginal nor Torres Strait Islander | 6622 (18%) | 69,509 (43%) | 9.5% |
| Unknown/not stated | 30 (<1%) | 120 (<1%) | – |
| External cause | | | |
| Intentional | 20,247 (56%) | 47,377 (30%) | 42.7% |
| Intentional self-harm | 3411 (9%) | 8715 (5%) | 39.1% |
| Assault | 16,836 (46%) | 38,662 (24%) | 43.5% |
| Unintentional | 15,674 (43%) | 109,918 (68%) | 14.3% |
| Accidental poisoning | 298 (1%) | 2505 (2%) | 11.9% |
| Falls | 7437 (20%) | 39,633 (25%) | 18.8% |
| Transport | 2520 (7%) | 16,258 (10%) | 15.5% |
| Contact with objects | 2115 (6%) | 23,115 (14%) | 9.1% |
| Drowning and submersion | 20 (<1%) | 184 (<1%) | 10.9% |
| Thermal causes | 403 (1%) | 4463 (3%) | 9.0% |
| Choking and suffocation | 43 (<1%) | 387 (<1%) | 11.1% |
| Electricity and air pressure | 6 (<1%) | 192 (<1%) | 3.1% |
| Forces of nature | 74 (<1%) | 385 (<1%) | 19.2% |
| Contact with living things | 882 (2%) | 11,952 (7%) | 7.4% |
| Overexertion | 165 (<1%) | 2283 (1%) | 7.2% |
| Other unintentional causes | 1711 (5%) | 8561 (5%) | 20.0% |
| Undetermined intent | 548 (1%) | 3850 (2%) | 14.2% |

Abbreviations: ARI, alcohol-related injury; IQR, interquartile range.

reforms implemented between 2017 and 2018 (BDR v2 [2017–present]; MUP [2018–present]; PALIs [2018–present]) that primarily targeted takeaway alcohol. In conjunction, COVID-19 pandemic restrictions likely confounded the decline, including restrictions on the movements in and out of designated areas under the

**TABLE 3** Number and annual incidence rates of alcohol-related injury hospitalisations by Aboriginal status, Northern Territory public hospitals, 2007–2022.

| | Aboriginal and Torres Strait Islander | Non-Aboriginal | Rate ratio (95% CI; *p*-value) | Total[a] |
|---|---|---|---|---|
| Number of ARI hospitalisations | 29,817 | 6622 | - | 36,469 |
| Crude rate per 100,000 population | 2619 | 246 | 10.62 (10.34, 10.91; $p < 0.001$) | 953 |
| Age-standardised rate per 100,000 population | 2868 | 250 | 11.46 (11.16, 11.77; $p < 0.001$) | 927 |

Abbreviations: ARI, alcohol-related injury; CI, confidence interval.
[a]Including 30 admissions with unknown Aboriginal status.

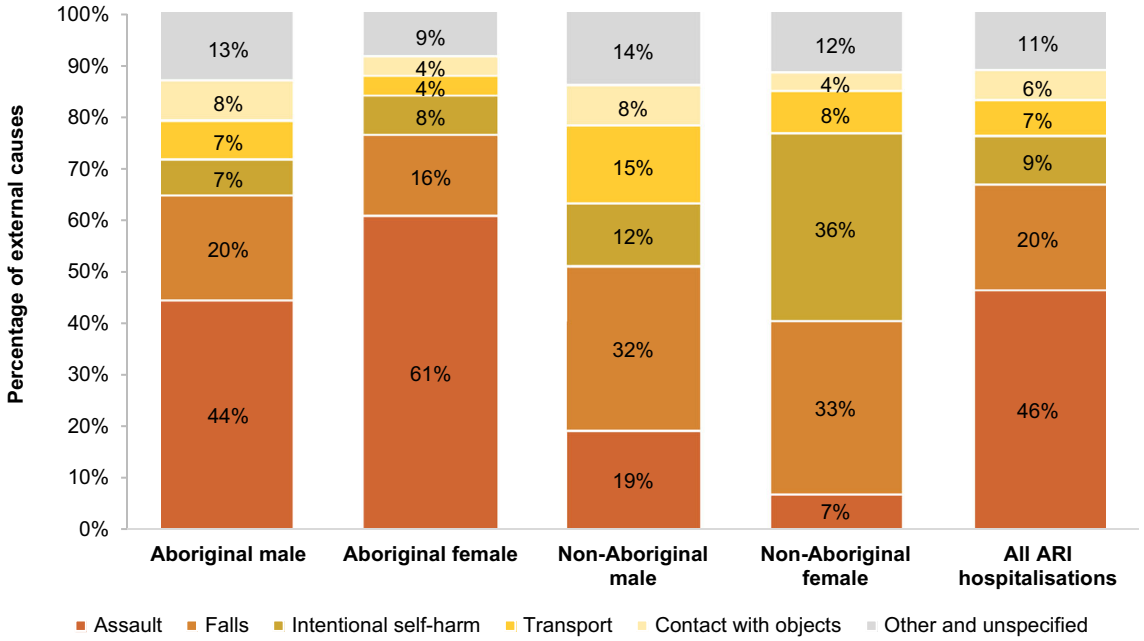


**FIGURE 1** Percentage of external cause of alcohol-related injury (ARI) hospitalisations by Aboriginal status and sex, Northern Territory public hospitals, 2007–2022.

*Biosecurity Act 2015* (Cth), and hospitals admitting fewer non-severe patients in 2021/2022 (5.6% decrease in hospital separations compared to 2020/2021) to mitigate pressures on bed capacity [28, 29]. The decreased ARI incidence in Central Australia during 2018–2019 was consistent with post-policy implementation statistics that recorded marked decreases in alcohol sales, alcohol-related assaults and domestic violence [30, 31]. A 24-month evaluation of the reinstated BDR showed declining trends of alcohol-related ED presentations and assault offences from early 2018 [17]. Evaluation of the MUP also found significant declines in alcohol-related ED presentations and admissions to Alice Springs Hospital from mid-2018 [18]. In Alice Springs and Tennant Creek, alcohol-related assaults decreased by 40% and 32% respectively between 2018 and 2019, which were attributed to the full coverage of PALIs at all takeaway liquor outlets [32].

The decreased ARI incidence in Central Australia during 2013–2014 may have been influenced by alcohol policies in effect at the time (TBLs in Alice Springs, Katherine and Tennant Creek [2012–2018]; AMT [2013–2017]; APOs [2013–2017]). However, attributing this decreased incidence to any specific policy should be interpreted with caution, as our model did not detect a trend decline after 2013. Conversely, the trend significantly increased between 2007 and 2017 following the implementation of 'The Intervention' and a suite of policies with overlapping timelines. The AMT program was the only policy evaluated among other policies

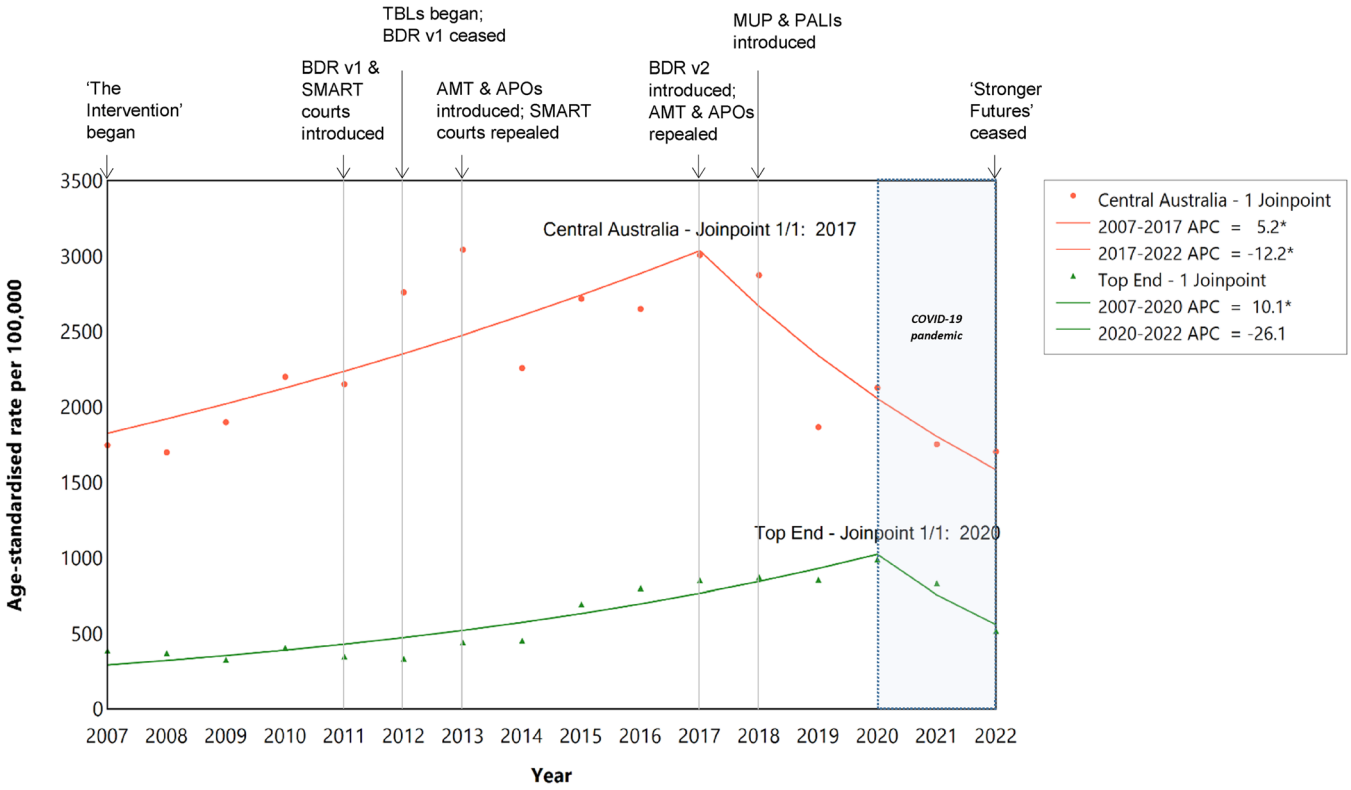


**FIGURE 2** Joinpoint regression analysis of alcohol-related injury hospitalisations by geographical regions of the Northern Territory, against alcohol policies and the COVID-19 pandemic, 2007–2022. *Indicates statistical significance ($p \leq 0.05$). Abbreviations: AMT, alcohol mandatory treatment; APC, annual percent change; APOs, alcohol protection orders; BDR, banned drinker register; MUP, minimum unit price; PALIs, police auxiliary liquor inspectors; SMART courts, Substance Misuse and Referral for Treatment courts; Stronger Futures, *Stronger Futures in the Northern Territory Act 2012* (Cth); TBLs, Temporary Beat Locations; The Intervention, *Northern Territory National Emergency Response Act 2007* (Cth).

introduced during this period (2011–2016), to which the authors did not find any statistically significant difference in hospitalisation between people who underwent mandatory treatment and those who did not [33]. It was unlikely that AMT had an immediate impact on ARI incidence in 2014, given treatment interventions take time to improve problematic drinking behaviours, and the policy only came into effect from July 2013 [15]. The impact of APOs was unclear due to a lack of evidence related to its effectiveness.

Full coverage of TBLs in Alice Springs from February 2013 was initially praised for effectively reducing alcohol consumption and related harm [34]. However, sporadic police presence at takeaway liquor outlets from late 2014 onwards led to a rise in public drinking and fighting, which was reflected in our model in 2015. Given the increase in trend between 2007 and 2017, the initial phases of 'The Intervention' and policies introduced between 2011 and 2013 did not sustain lower ARI incidence in Central Australia during this period. This may be due to the re-direction of alcohol policies which followed a change of government in 2012 [35], and the intermittent nature concerning the TBLs program. On balance, it was possible that the commencement of full coverage of TBLs between 2013 and 2014, especially following the completion of 'Operation Leyland' in early 2014, contributed to the observed ARI decrease in the same period [7, 36].

### 4.1.2 | Top End

Decreased ARI incidence corresponding to policy implementations was less noticeable in the Top End which had a lower baseline incidence rate compared to Central Australia. This regional variation could have been partially due to stricter alcohol control measures in Central Australia such as the deployment of TBLs and PALIs [15, 24], as well as generally greater high-risk alcohol use and per capital alcohol consumption in regional and remote NT [37, 38]. A previous study showed a greater reduction in ICU admissions at Alice Springs Hospital following the implementation of the MUP compared to admissions at Royal Darwin Hospital [24]. When

additional data sources such as police and ambulance were examined in the evaluation of the MUP, decreases for various indicators were similarly less pronounced in the Top End compared to Central Australia [18]. The significant and steady rise in ARI hospitalisations in the Top End between 2007 and 2020 suggests that regionally specific alcohol policies may have had a greater impact on harm reduction than NT-wide policies. Given the distinct contexts of alcohol sale and consumption between Central Australia and the Top End (especially the Greater Darwin area), developing strategies specific to the Top End warrants policy attention [7].

## 4.2 | Implications for Aboriginal and Torres Strait Islander peoples

The overrepresentation of Aboriginal peoples in this study must be understood within the historical context of colonisation, dispossession and intergenerational trauma [10]. Having limited the study definition to ARI as a representation of acute alcohol-related presentations, the study emphasised the involvement of Aboriginal peoples due to acute intoxication to a greater degree compared to non-Aboriginal people who are more likely to have alcohol dependency [12]. Interventions targeting alcohol-related harms among Aboriginal peoples need to address the underlying inequities across social, political and economic determinants of risky drinking [11], be delivered in a culturally safe and sensitive manner without negative discrimination [10], and have engagement from Aboriginal leaders and communities [39]. Importantly, Aboriginal peoples' right to self-determination regarding alcohol policies affecting their communities, that is, 'the right to determine their own pathway', should be respected [40]. Recent examples of community-led restrictions have been demonstrated in Fitzroy Crossing and Norseman in Western Australia, with positive outcomes of reduced alcohol consumption, assaults, domestic violence, alcohol-related hospital admissions and a range of other social benefits [39].

## 4.3 | Sustain alcohol policies

Effective reduction of risky drinking behaviours demands sustainable, consistent, and long-term alcohol strategies. It is also crucial to allow sufficient time for alcohol policies to be fully implemented and properly evaluated before making significant changes. Adequate funding to maintain existing programs like the BDR and PALIs was said to cost the NT government more than 9 million AUD per annum combined in operational costs and wages [41, 42]. However, this pales when compared to the tangible and intangible costs of alcohol to the NT estimated at 1.39 billion AUD per annum [6]. Alcohol policies implemented in the NT, namely those targeting pricing (MUP) and alcohol availability (BDR v2 and PALIs), had a positive impact on reducing ARI hospitalisations in Central Australia. However, the successes of these policies (and future policies) across the NT are contingent on ensuring implementation is coordinated and culturally appropriate, adequately funded and sustained over time. Collection of multidisciplinary alcohol-related harm indicators, beyond hospitalisation data, would support more comprehensive analysis to inform policy decisions.

## 4.4 | Limitations

The methods used were unable to determine whether alcohol use preceded injury occurrence or directly led to injury occurrence [4]. We applied a sensitive case definition to identify all injuries with an alcohol involvement, but were unable to determine the extent of alcohol contribution to the injury. Other hospital admissions of injury caused by someone else's use of alcohol but did not drink alcohol themselves (e.g., person injured was a victim and not a perpetrator of alcohol-related assault, or a passenger in a motor vehicle accident) were not within the scope of this study.

The use of hospitalisation data was another limitation, as it only accounted for a fraction of potential injuries (severe cases). Hospitalisation was chosen due to the complete recording of diagnosis codes that enabled accurate indication of both injury and alcohol use. Hospitalisation data were more reliable, being less subject to variations. Secondary diagnoses (where alcohol-related conditions were coded) have historically been under-recorded in ED data and may lead to inaccurate estimation of ARI ED presentations. Results obtained from supplementary analysis of ED data are included in Appendix 5, Data S1. Data in this study did not reflect the prevalence of all alcohol-related harms in the NT, especially non-severe cases that did not seek hospital care or were treated at primary care clinics.

It was possible that Aboriginal peoples were more likely to be admitted from ED due to a lack of transportation to communities, safe accommodation, or the need for further clinical assessments. These factors may have overestimated the ARI hospitalisation rate among the Aboriginal population. Furthermore, it was not possible to definitively quantify the impact of individual alcohol policies as the timeframe of implementation and repeal of certain policies overlapped each other, especially

around 2011–2013. Alcohol policies in the NT have not occurred in isolation and their collective influence on ARI trends was examined. Other public health interventions such as community-based initiatives were not examined in this study.

## 5 | CONCLUSIONS

Alcohol policies implemented between 2007 and 2022 had a more observable impact on ARI hospitalisations in Central Australia compared to the Top End. The trend decline after 2017 in Central Australia was likely contributed by the implementation of alcohol policies between 2017 and 2018 including the BDR v2, MUP, and full coverage of takeaway liquor outlets utilising PALIs, in conjunction with COVID-19 pandemic restrictions. To effectively reduce the high incidence of ARI in the NT, future alcohol policies should prioritise continuity and the involvement of Aboriginal leaders in decision-making, underpinned by comprehensive collection of multidisciplinary alcohol-related harm indicators. Policy-makers should adopt and sustain evidence-based alcohol policies that have demonstrated positive harm reduction outcomes. While this study was specific to the NT, the policy findings could be useful to other jurisdictions seeking to reduce alcohol-related harm.

### AUTHOR CONTRIBUTIONS

Each author certified that their contribution to this work met the standards of the International Committee of Medical Journal Editors.

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### CONFLICT OF INTEREST STATEMENT

The authors declared no potential conflicts of interest with respect to the research, authorship and/or publication of this article.

### DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the Northern Territory Department of Health. Restrictions apply to the availability of these data, which were used under license for this study. Data are available from the corresponding author with permission from the Northern Territory Department of Health.

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## SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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