The impact of a minimum unit price on wholesale alcohol supply trends in the Northern Territory, Australia

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Abstract

Objective: The Northern Territory (NT) Government introduced a minimum unit price (MUP) of $1.30 per standard drink (10g pure alcohol) explicitly aimed at reducing the consumption of cheap wine products from October 2018. We aimed to assess the impact of the NT MUP on estimates of beverage-specific population-adjusted alcohol consumption using wholesale alcohol supply data.

Methods: Interrupted time series analyses were conducted to examine MUP effects on trends in estimated per capita alcohol consumption (PCAC) for cask wine, total wine and total alcohol, across the NT and in the Darwin/Palmerston region.

Results: Significant step decreases were found for cask wine and total wine PCAC in Darwin/Palmerston and across the Northern Territory. PCAC of cask wine decreased by 50.6% in the NT, and by 48.8% in Darwin/Palmerston compared to the prior year. PCAC for other beverages (e.g. beer) were largely unaffected by MUP. Overall, PCAC across the Territory declined, but not in Darwin/Palmerston.

Conclusion: With minimal implementation costs, the Northern Territory Government's MUP policy successfully targeted and reduced cask wine and total wine consumption. Cask wine, in particular, almost halved in Darwin/Palmerston where the impact of the MUP was able to be determined and considering other interventions.

Implications for public health: Implementation of a minimum unit price for retail alcohol sales is a cost-effective way to reduce the consumption of high alcohol content and high-risk products, such as cheap cask wine.

Key words: alcohol, liquor, cask wine, floor price, minimum unit price, supply, time series analysis

Globally, alcohol consumption ranks third as a preventable cause of disease and disability accounting for at least three million deaths, many among young people, and more than 5% of disability-adjusted life years annually.[1] The largest proportion of this burden arises from heavy or harmful drinking, whether that occurs as high average daily use or irregular heavy drinking occasions.[2] Effects of heavy drinking extend well beyond the drinker, eroding the wellbeing and safety of others across many aspects of everyday life including family, neighbourhood, workplace, transport, shared public spaces and society at large.[3] The extent and magnitude of negative health and social outcomes varies enormously between populations. Some of the starkest disparities occur between geographically, economically, socially and culturally diverse communities living within the same country.[4,5]

In Australia, an estimated three-quarters of all alcohol consumed is attributable to the top 20% of heaviest drinkers.[6] Alcohol use and attributable harms are highest in the Northern Territory (NT),[7] where the social cost is an estimated AU$1.4 billion annually.[8] About one-third of Territorians are Indigenous (3% nationally) and most (80%) live in remote and very remote areas with high levels of socioeconomic disadvantage.[9] Among them, alcohol-attributable death rates are up to ten times higher than the national average. For non-Indigenous Territorians, the alcohol-attributable death rate is about twice the national average.[7] Over the past 30 years, many strategies have been implemented to address the unacceptably high level of alcohol problems in the Territory.[10] The most recent of these, and the focus of this study, is a government-legislated, territory-wide minimum unit price (MUP) for the retail sale of alcohol.

Population-wide strategies aimed at reducing alcohol-related harm by increasing the price of alcoholic beverages are considered highly effective.[11,12] Large independent meta-analyses have estimated that a 10% overall increase in retail price for alcohol (delivered via tax) reduces demand by about 5%.[13] Almost always delivered in the form of taxation changes, the success of price-based

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strategies is underpinned by the price-sensitive nature of alcohol consumption. Alcohol products are diverse, however, and price elasticity varies by beverage type (e.g. wine is more elastic than beer) and quality, such that within the same beverage type, low-quality, cheap products have higher elasticity.[14]

There is also strong evidence that heavy drinkers prefer and drink greater quantities of cheap beverages compared to low or moderate drinkers, and that heavy drinkers are responsive to price changes.[14-16] This is important to the understanding of potential limitations of price interventions when implemented through mechanisms such as volumetric tax. Although effective from a whole-of-population perspective, average price increases can be undermined by industry practices and are not always delivered to the consumer as intended. When average prices rise, heavy discounting, loss-leading and the sale of poor-quality, low-priced products allow vulnerable heavy drinkers to switch to alternative beverages that offer low cost relative to alcohol content.[14,17,18]

MUP is a price-based population strategy for addressing problematic alcohol use that does not rely on taxation mechanisms for delivery to the consumer. MUP sets the minimum retail (floor) price at which one unit of pure alcohol (e.g. 10 g or 'standard drink') can be sold and prohibits sales under the minimum. MUP thereby targets the cheapest beverages and lifts the price of only those under the minimum price. Proponents of MUP postulate that since the cheapest beverages are preferred and drunk more often by the heaviest drinkers, MUP will lead to reduced consumption that is most concentrated among heavy drinkers.[17-21]

UK modelling studies of MUP impacts on different drinking levels and socioeconomic groups demonstrate its potential for reducing population consumption among the heaviest drinkers.[18,20] Holmes et al.[22] estimated that a £0·45 MUP would cause an immediate decline in total population consumption, more than 70% of it due to reduced consumption by harmful drinkers.

As the attention of alcohol policy researchers has only recently turned to MUP, so the evidence for its potential as a public health strategy in the real world is still emerging. MUP is widely applied to off-trade (also known as bottle-shops or off-licence) sales across Canadian provinces and has been the subject of studies covering a range of outcomes in British Columbia and Saskatchewan. These studies provide evidence for immediate effects arising from an increase in MUP of about 10%, including reductions in: total alcohol consumption, deaths, hospitalisations, road crash injuries and assault.[23] Adding to econometric modelling work from the UK, O'Donnell et al.[21] recently documented early effects (over 8 months) of a £0·50 Scottish MUP on off-trade household purchasing behaviour across income groups. They found immediate and significant reductions in total population off-trade purchases concentrated in households that purchased the most alcohol.

Minimum Unit Price in the Northern Territory

The Northern Territory population has long been the focus of tax-based price interventions[24-26] and local area restrictions[27,28] focused on reducing consumption of beverages considered high-risk for alcohol-related health and social problems. Cask wine, which offers high alcohol content for low cost, is frequently implicated as contributing inordinately to alcohol problems among vulnerable drinkers and disadvantaged communities,[29] and is strongly associated with violent assault and hospitalisations for injury.[30] The sale of cheap Australian wines is enabled by the way wine is taxed at the Federal level, i.e. the Wine Equalisation Tax (WET). Wines are taxed according to product price at the last wholesale sale, whereas all other beverages attract excise tax based on alcohol content. Intrinsically, therefore, wine products that are cheap to produce and distribute are afforded a considerable retail price advantage per standard drink.[31]

In a recent move, the Northern Territory Legislative Assembly passed a bill mandating an AU$1.30 minimum retail price per standard drink, intended to "…minimise the harms associated with high-alcohol, low-cost alcoholic beverages". Commencing 1 October 2018, the floor price applied to retail sale and supply of all alcohol products including off-trade, on-trade and on-line sales. According to the Northern Territory Government, "Beer, ciders, and spirits will either see no change in price or the change in price will be small"; however, price increases were anticipated for "…cheap, high alcohol content cask and bottled wine, and fortified wine".[32] MUP therefore specifically targeted wine and wine-based beverages while leaving beer, spirits and other beverage types largely unaffected.

Other policies were also introduced around the same time as MUP including: Police Adjunct Licensing Inspectors (PALIs) and a Banned Drinker Register (BDR). The BDR identifies individuals banned from purchasing alcohol within the Northern Territory and prohibited from being served by licensees.[33] The BDR was in place across the whole territory from 1 October 2017. The register was well established prior to MUP implementation.

PALIs refer to police officers stationed within off-trade outlets (bottleshops) and they are the continuation of a series of formulations by police dating back to 2014. PALIs were only deployed in specific regions including Alice Springs, Katherine and Tennant Creek. No PALIs were deployed in the Darwin/Palmerston area. To our knowledge, there have been no studies of PALI effectiveness. It is likely that the presence of uniformed officers in off-trade outlets enhanced BDR operation and reduced alcohol purchases for some drinkers. To mitigate potential confounding, we therefore focussed on the Darwin/Palmerston area as it was unaffected by PALIs.

The Northern Territory Government reported that between 2012 and 2017, total wines combined accounted for a relatively stable 20% of total pure alcohol supplied in the Territory. In 2017, bottled, cask and fortified wines individually contributed 15.5%, 3.6% and 0.4%, respectively, to total NT pure alcohol sales. Similar proportions were indicated for Darwin/Palmerston, which accounted for about 56% of all alcohol sold across the Territory in 2017.[34]

Our aim was to investigate the effect of MUP on alcohol consumption, focussing on cask wine, total wine and total liquor. The Northern Territory Government's alcohol supply data collection delineates between cask wine, bottled wine and fortified wine, but does not differentiate on the basis of price. The quality and price range for bottled and fortified wines is large but the contribution that cheap bottled wines (marketed as 'cleanskins') and cheap fortified wines (bag in box packaging similar to cask wine or large flagons), made to total wine sales prior to MUP was unknown. In contrast, it is highly likely that all cask wine brands were affected by MUP due to their homogenously low quality and cheap pricing.[27,28] Given this, it is

reasonable to expect that any effect of MUP on alcohol consumption would be readily detected for cask wine but attenuated for bottled wine and fortified wine products with more variable pricing structures. Conversely, we expected the consumption of beverages largely unaffected by MUP, including spirits and beer, to remain unchanged.

Since the Darwin/Palmerston area was less likely than the Northern Territory as a whole to have been affected by potential confounding arising from PALIs, we investigated MUP effects for Darwin/Palmerston separately. We hypothesised that:

H1: Quarterly estimates of *cask wine* consumption would significantly decrease immediately after the introduction of MUP in: i) Darwin/Palmerston and ii) the whole of NT;

H2: Quarterly estimates of *total wine* consumption would significantly decrease immediately after the introduction of MUP in: i) Darwin/Palmerston area and ii) the whole of NT; and

H3: Quarterly estimates of *total liquor* consumption would significantly decrease immediately after the introduction of MUP in: i) Darwin/Palmerston area and ii) the whole of NT.

Methods

Geographic and population data

The Northern Territory comprises a land area of some 1.4 million square kilometres but is sparsely populated with just under 230,000 residents. Darwin is the NT's capital and largest city. Palmerston is a suburb/satellite city adjacent to Darwin. We defined the Darwin/Palmerston area and other townships (Alice Springs, Katherine, Tennant Creek and the remainder of the Territory) according to Australian Bureau of Statistics (ABS), Statistical Area 2 codes as described in an earlier report.[35] Darwin/Palmerston accounts for 50% of the total NT population (https://www.abs.gov.au/).

The quarterly estimated resident population (ERP) matching the regions of interest was also sourced from the ABS (https://www.abs.gov.au). Since our aim was to measure the impact of an intervention rather than estimate per capita alcohol consumption *per se*, we preferred the stability of whole population ERP over 15+ ERP, especially as the age distribution of the NT population had not changed between the 2013 and 2018 Census for residents over the age of 15. ERP served as the denominator for estimating per capita alcohol consumption.

Wholesale alcohol supply and estimated per capita pure alcohol consumption

We used data on quantities of alcohol (litres) supplied by Northern Territory licensed wholesalers to retailers to estimate population-level consumption. Often referred to as 'sales' data, records of alcohol sold by retailers or purchased by retailers from wholesalers are a well-established proxy for quantities of alcohol consumed and the gold-standard for estimating per capita pure alcohol consumption (PCAC) in a population (e.g. WHO, 2000,[36] Loxley, 2016[37]). Sales data can nonetheless be subject to under- or over-estimation depending on the source of error (e.g. stockpiling, informal alcohol production, breakage/spillage, incorrect specification of pure alcohol content).[36]

Previous studies have confirmed the high quality and excellent regional coverage of Northern Territory sales data.[29] Licencing Northern Territory provided data on quarterly alcohol supply volumes (ltrs) from Quarter 1 2013 to Quarter 3 2019 by major beverage category and retailer suburb. Supply volumes were provided to the study as pure alcohol, having been converted using the following conversion factors: cask wine 0.119; bottle wine 0.119; fortified wine 0.185; cider 0.06; standard spirits 0.385; pre-mixed spirits 0.057; full-strength beer 0.048; mid-strength beer 0.035; and low-strength beer 0.03.

We calculated quarterly total litres of pure alcohol for each beverage type by summing all sales records occurring during each quarter. Region-specific quarterly per capita pure alcohol consumption (PCAC) was then estimated by dividing litres of pure alcohol by ERP for the region. Beverage groups were defined as follows: total wine [cask wine + bottled wine + fortified wine]; total non-wine [cider + standard spirits + pre-mixed spirits + full-strength beer + mid-strength beer + low-strength beer]; and total liquor [total wine + total non-wine]. The term 'liquor' was defined as any alcoholic beverage intended for human ingestion.

Banned Drinker Register (BDR)

We obtained official monthly counts of the numbers of people listed on the BDR for Darwin/Palmerston and the Northern Territory as a whole from the Office of the Registrar. These data were considered a complete and reliable record of the number of people on the register by the official authority.[38]

Ethics approval

All data were obtained as a part of the 'Investigating the introduction of the alcohol minimum unit price in the Northern Territory' project.[39] Ethics approval was obtained from the Northern Territory Department of Health and Menzies School of Health Research Human Research Ethics Committee (19-3486) and the Central Australian Human Research Ethics Committee (19-3486).

Statistical analyses

The impact of MUP on quarterly PCAC was examined using interrupted time series (ITS) analysis (itsa command) in Stata 15.[40] ITS analysis is well suited to interventions with clearly defined starting points that target population-level health outcomes.[41] ITS allows simultaneous tests of step (immediate) and slope (gradual) changes in trends.

In keeping with the evidence for immediate MUP effects from past studies, we hypothesised immediate reductions in cask wine and total wine PCAC. Accordingly, MUP variable was coded as a step function (Q1 2013 to Q3 2018 = 0; Q4 2018 to Q3 2019 = 1) with no lag. All models included: a linear time variable to control for any underlying long-term trends; the number of people on the BDR at the end of each quarter; and a quarterly seasonal effects variable (1 = first quarter, 2 = second quarter, 3 = third quarter, 4 = fourth quarter).

Models additionally included a time by MUP interaction term to identify and control for any gradual change in PCAC gradient that may have occurred after the intervention. We note, however, that post-intervention period time points available for analysis were limited to one seasonal cycle. We therefore avoided drawing on slope by time interaction results as evidence for MUP effects and posit only step effects.[42] In order to draw reliable conclusions about gradual change over time, longer post-intervention time series are required, preferably of comparable length to the pre-intervention series.

Results

Unadjusted annual PCAC estimates for cask wine, total wine, total non-wine and total

liquor in Darwin/Palmerston and Northern Territory (whole of territory) are shown in Table 1. Large declines in cask wine PCAC were evident in the 12 months following MUP implementation. Cask wine PCAC in 2018-19 was almost 50% lower in both Darwin/Palmerston and the NT compared to the 12 months preceding MUP (Q4 2017 – Q3 2018). Declines in 2018-19 cask wine PCAC were about four times larger than any previous year-to-year decline. Largest declines in total wine and total liquor PCAC also occurred in 2018-19 for both regions. By comparison, total non-wine PCAC estimates for 2018-19 were relatively similar to levels in previous years for both regions.

Figures 1 and 2 show unadjusted trends in PCAC for cask wine, total wine, total non-wine and total liquor over the study period for Darwin/Palmerston and the NT, respectively. (Figures also show trends for beverages examined in post hoc analyses.) Strong seasonal effects and underlying downward trends were evident throughout several series.

Interrupted time series results are presented in order as they relate to our hypotheses. We also present post hoc models for fortified wine and spirits in Darwin/Palmerston where significant slope changes were identified.

Cask wine PCAC

Adjusted for BDR numbers and seasonal effects, ITS models indicated significant step-change declines in cask wine PCAC for Darwin/Palmerston and the NT. Time by MUP interaction effects was non-significant for both regions (Table 2).

Table 1: Estimated annual PCAC and annual percentage change (italics) by beverage type and region, 2013/14–2018/19.[1]

Beverage	Region	Year (Q4-Q3)					
		2013-2014	2014-2015	2015-2016	2016-2017	2017-2018	2018-2019
Cask wine	Darwin/	0.69	0.74	0.65	0.58	0.57	0.29
	Palmerston	-	*7.53%*	*-12.57%*	*-11.35%*	*-1.65%*	*-48.84%*
	Northern Territory	0.45	0.47	0.43	0.39	0.41	0.20
		-	*3.31%*	*-7.76%*	*-9.29%*	*5.04%*	*-50.57%*
Total wine	Darwin/	2.82	2.75	2.77	2.66	2.49	2.16
	Palmerston	-	*-2.55%*	*0.71%*	*-3.78%*	*-6.64%*	*-13.03%*
	Northern Territory	2.15	2.10	2.11	2.06	2.11	1.66
		-	*-2.66%*	*0.53%*	*-2.31%*	*2.68%*	*-21.44%*
Total non-wine	Darwin/	10.28	9.71	9.55	9.28	8.78	8.27
	Palmerston	-	*-5.59%*	*-1.65%*	*-2.84%*	*-5.34%*	*-5.80%*
	Northern Territory	8.87	8.62	8.63	8.48	8.36	8.10
		-	*-2.83%*	*0.15%*	*-1.74%*	*-1.46%*	*-3.12%*
Total liquor	Darwin/	13.10	12.46	12.31	11.94	11.27	10.43
	Palmerston	-	*-4.94%*	*-1.13%*	*-3.05%*	*-5.63%*	*-7.41%*
	Northern Territory	11.02	10.71	10.74	10.54	10.47	9.76
		-	*-2.79%*	*0.22%*	*-1.86%*	*-0.65%*	*-6.82%*

Table 2: Cask wine PCAC in Darwin/Palmerston and whole of NT: MUP interrupted time series models.

Region		β co-eff	95% confidence interval	*p*-value
Darwin/ Palmerston	Time (slope)	-0.0004	-0.005, 0.003	0.837
	MUP (step)	**-0.06**	**-0.06, -0.05**	**<0.001**
	Time x MUP (slope)	-0.01	-0.02, 0.002	0.097
Northern Territory	Time (slope)	-0.001	-0.002, 0.001	0.468
	MUP (step)	**-0.05**	**-0.05, -0.04**	**<0.001**
	Time x MUP (slope)	-0.004	-0.01, 0.0004	0.070

Table 3: Total wine PCAC in Darwin/Palmerston and whole of NT: MUP interrupted time series models.

Region		β co-eff	95% confidence interval	*p*-value
Darwin/ Palmerston	Time (slope)	-0.002	-0.004, 0.0005	0.117
	MUP (step)	**-0.07**	**-0.09, -0.05**	**<0.001**
	Time x MUP (slope)	0.001	-0.01, 0.01	0.749
Northern Territory	Time (slope)	**-0.002**	**-0.002, -0.001**	**<0.001**
	MUP (step)	**-0.12**	**-0.14, -0.11**	**<0.001**
	Time x MUP (slope)	**0.01**	**0.004, 0.01**	**<0.001**

Total wine PCAC

Significant step change declines in total wine PCAC were found for Darwin/Palmerston and the NT. A time by MUP effect, indicative of an upward gradient, was also found for the NT but did not fully offset the immediate MUP step effect that remained significant (Table 3).

Fortified wine

Additional beverage-specific post hoc analyses indicated that the NT-wide time by slope interaction effect detected for total wine PCAC was largely due to a slope change for fortified wine. As shown in Table 4, there were reductions in fortified wine PCAC immediately following MUP (33% for NT) that did not emerge as significant step effects in ITS models (Table 5). This was partly because fortified wine PCAC peaked at the beginning of the series in 2013-14, but by 2016 levels had rapidly declined. Although the sharp early decline had ceased about 24 months prior to MUP, it nevertheless affected the overall pre-intervention gradient. The post-MUP downward slope was therefore less steep than the overall downward gradient in the pre-series and this was detected by ITS as a time by MUP interaction effect. The decline seen at the beginning of the study period is likely attributable to temporary beat locations, a precursor to PALIs that was first introduced in 2012 and was expanded in late 2014.[10]

Total non-wine PCAC

Estimated PCAC for total non-wines included all beers, spirits, pre-mixed and ciders. (Unadjusted PCAC and ITS models for each beverage type are provided in the Supplementary material.) Underlying downward trends over the entire study period were evident for Darwin/Palmerston and the NT, but no significant post-MUP step declines were detected (Table 6).

Spirits

Post-hoc analyses indicated no immediate change in spirits PCAC for Darwin/Palmerston or the NT after MUP. However, for Darwin/Palmerston, significant step and time by slope interaction effects occurred more than six months prior to MUP. Table 7 demonstrates that the significant post-MUP slope increase observed for spirits was a continuation of an upward trend that began in early 2018.

Total liquor PCAC

Table 8 shows model results for MUP effects on total liquor PCAC for Darwin/Palmerston and NT as a whole. There was no evidence of an MUP step effect on total PCAC in Darwin/Palmerston. This suggests that the decline in total wine indicated for Darwin/Palmerston was not sufficiently large to produce a statistically detectable effect on total liquor PCAC for the region. However, an immediate and significant reduction in total liquor PCAC was indicated for the NT overall. Although it is difficult to determine the extent to which PALIs may have contributed to this effect, it is nevertheless in keeping with territory-wide declines found for cask wine and total wine PCAC. These results also demonstrate that total alcohol consumption was in decline across the study period, both in Darwin/Palmerston and across the NT.

Discussion

This study aimed to investigate the impact of MUP policy in the Northern Territory of Australia, on per capita alcohol consumption of cask wine, total wines combined and total liquor consumption, as measured by wholesale alcohol supply. The policy was specifically targeted at reducing consumption of cheap wine products identified by the Northern Territory Government as linked to excessive drinking and serious negative health, social and economic impacts on the Northern Territory community.[32] The study focused primarily on the Darwin/Palmerston region, as it was least likely to have been affected by other initiatives introduced elsewhere in the Territory at about the same time (most especially PALIs).

We found overall support for our hypotheses. In the year immediately after MUP was introduced, there were substantial declines in the estimated consumption of beverages specifically targeted by MUP, including cask wine and total wine. These declines occurred in the Darwin/Palmerston region as well as territory-wide. Further, we found little evidence that MUP directly affected the consumption of beverages not targeted by MUP (e.g. beer).

In support of the first hypothesis, we found MUP associated with an immediate reduction in estimated cask wine consumption in Darwin/Palmerston and throughout the Territory. Cask wine is a beverage preference for Australia's heaviest alcohol consumers[6]

Figure 1: Trends in estimated PCAC in Darwin/Palmerston, Q1 2013 to Q3 2019.

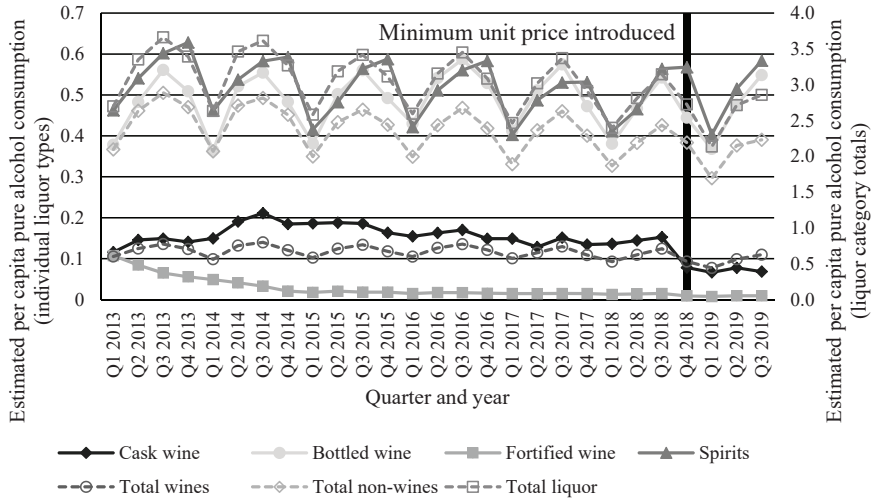

Figure 2: Trends in estimated PCAC in Northern Territory, Q1 2013 to Q3 2019.

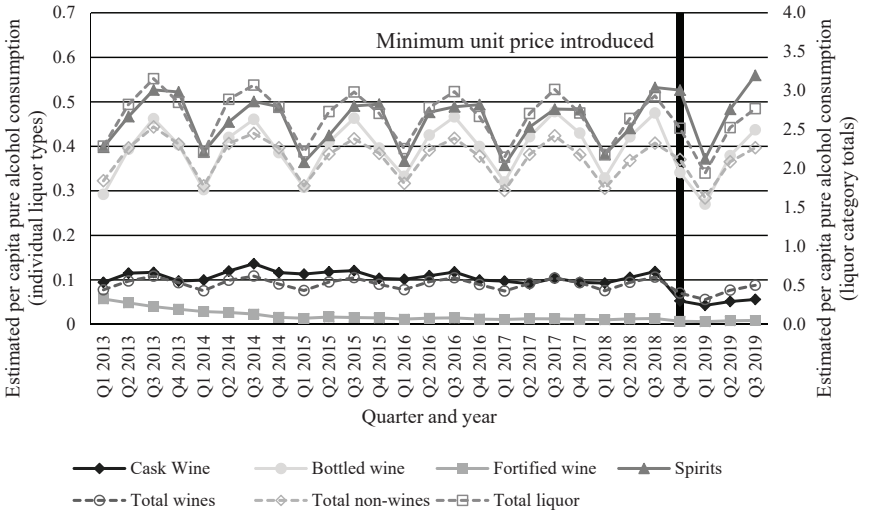

Table 4: Estimated annual fortified wine PCAC and annual percentage change (italics) by region, 2013/14-2018/19.

Region	Year (Q4-Q3)					
	2013-2014	2014-2015	2015-2016	2016-2017	2017-2018	2018-2019
Darwin and Palmerston	0.18	0.08	0.07	0.06	0.06	0.04
	-	*-57.09%*	*-13.00%*	*-11.21%*	*-5.76%*	*-37.21%*
Northern Territory	0.11	0.06	0.05	0.05	0.05	0.03
	-	*-45.68%*	*-11.01%*	*-12.91%*	*-0.87%*	*-36.48%*

Table 5: Fortified wine PCAC in Darwin/Palmerston and whole of NT: MUP interrupted time series models.

Region		β co-eff	95% confidence interval	*p*-value
Darwin/Palmerston	Time (slope)	**-0.01**	**-0.01, -0.003**	**<0.001**
	MUP (step)	-0.001	-0.01, 0.01	0.851
	Time x MUP (slope)	**0.01**	**0.001, 0.01**	**0.029**
Northern Territory	Time (slope)	**-0.003**	**-0.004, -0.001**	**<0.001**
	MUP (step)	-0.002	-0.01, 0.001	0.137
	Time x MUP (slope)	**0.003**	**0.001, 0.01**	**0.017**

and has been previously identified as a highly problematic product throughout the Northern Territory.[10]

In support of our second hypothesis, we found significant step reductions in total wine consumption, both in Darwin/Palmerston and territory-wide. In addition, although other non-wine beverages (e.g. beer) displayed downward trends over the whole study period, they were not associated with MUP. It therefore appears that MUP legislation reduced consumption of cheap wine products in general as intended, while beverage groups not directly targeted by MUP were largely unaffected.

We found partial support for our third hypothesis as declines in total liquor consumption were evident for the Northern Territory overall but not for Darwin/Palmerston. We suspect that the lack of significant change in total liquor consumption for Darwin/Palmerston was largely due to a combination of wine's relatively small contribution to total liquor consumption (20%) and only one post-MUP seasonal cycle being available for analysis (limiting statistical power). It is possible that a substitution to beverages not targeted by MUP may have contributed, although this is unlikely to a large extent, as we did not find significant increases in total non-wine beverage consumption post-MUP.

In relation to our finding that total liquor consumption declined across the Northern Territory as a whole, although in keeping with a large fall in total wine consumption (and absence of change for non-wines), we cannot be certain of the extent to which PALIs may have contributed. To date, the effectiveness of PALIs is unknown but their activity has likely contributed in various ways to reduced alcohol purchases.

Alcohol interventions that use price as a lever for change are not impervious to some drinkers who seek out opportunities to mitigate price increases through substitutions. Our results show little evidence of transference between beverages targeted and not targeted by MUP. Nevertheless, we note media reports of some drinkers substituting with non-liquor alcohol products (such as methylated spirits or mouthwash), and a subsequent response by government in collaboration with retail outlets to remove such items from supermarket shelves and place them 'behind the counter'. Although reports of non-liquor substitution practices had largely disappeared within two months of MUP introduction, we were not able to identify accessible data that could shed further light on the timing and extent of these behaviours.[35]

Table 6: Total non-wine PCAC in Darwin/Palmerston and whole of NT: MUP interrupted time series models.

Region		β co-eff	95% confidence interval	*p*-value
Darwin/Palmerston	Time (slope)	**-0.02**	**-0.02, -0.01**	**-0.02, -0.01**
	MUP (step)	0.01	-0.11, 0.13	-0.11, 0.13
	Time x MUP (slope)	-0.04	-0.09, 0.003	-0.09, 0.003
Northern Territory	Time (slope)	**-0.01**	**-0.01, -0.005**	**<0.001**
	MUP (step)	-0.03	-0.09, 0.03	0.296
	Time x MUP (slope)	-0.01	-0.02, 0.01	0.500

Table 7: Spirits PCAC in Darwin/Palmerston and whole of NT: interrupted time series models of MUP and pre-MUP effects.

Time point	Region	β co-eff	95% confidence interval	*p*-value
Oct-Dec 2018	Darwin/Palmerston			
	Time (slope)	-0.004	-0.005, -0.003	<0.001
	MUP (step)	0.01	-0.02, 0.05	0.499
	Time x MUP (slope)	0.02	0.01, 0.03	0.001
	Northern Territory			
	Time (slope)	-0.002	-0.003, -0.001	0.001
	MUP (step)	0.008	-0.04, 0.05	0.709
	Time x MUP (slope)	0.01	-0.001, 0.03	0.073
Jan-Mar 2018	Darwin/Palmerston			
	Time (slope)	-0.004	-0.004, -0.003	<0.001
	Jan 2018 (step)	0.04	0.02, 0.07	0.003
	Time x Jan 2018 (slope)	0.01	0.005, 0.02	0.001
	Northern Territory			
	Time (slope)	-0.002	-0.003, -0.001	0.002
	Jan 2018 (step)	0.03	-0.001, 0.05	0.057
	Time x Jan 2018 (slope)	0.01	0.002, 0.02	0.009

Table 8: Total liquor PCAC in Darwin/Palmerston and whole of NT: MUP interrupted time series models.

Region		β co-eff	95% confidence interval	*p*-value
Darwin/Palmerston	Time (slope)	**-0.02**	**-0.03, -0.01**	**<0.001**
	MUP (step)	-0.06	-0.019, 0.08	0.401
	Time x MUP (slope)	-0.04	-0.10, 0.01	0.106
Northern Territory	Time (slope)	**-0.009**	**-0.01, -0.01**	**<0.001**
	MUP (step)	**-0.15**	**-0.22, -0.09**	**<0.001**
	Time x MUP (slope)	0.003	-0.02, 0.02	0.769

Implications

These findings show that MUP effectively reduced estimated cask wine and total wine per capita consumption in Darwin/Palmerston and across the Northern Territory. This was achieved at virtually no cost to the public purse. These findings are in line with evidence from prior MUP interventions and modelling studies, which have indicated that MUP effectively reduces alcohol consumption and related harms.[18,20,23,43-45] Policy makers should consider implementing MUP nationally or in other Australian jurisdictions so that the most problematic alcoholic beverages, consumption patterns, and harms can be targeted with minimal implementation cost.

Strengths and limitations

We have addressed issues concerning potential confounding arising from PALIs and BDR using study design and analytical measures, but we note that future work may improve our understanding of their potential for independent effects on population-level alcohol consumption. It is likely that the presence of other initiatives attenuated the impact of MUP in some areas, container

size restrictions on the sale of wine in Alice Springs being a probable example of this.[10,28]

Our use of wholesale alcohol supply to estimate per capita alcohol consumption brings both strengths and limitations. Further research is needed to examine if the decline in wholesale supply was associated with a decline in consumption among those who engage in harmful drinking behaviours. Sales data do not provide information on the age or gender of drinkers or the distribution of drinking patterns in a population, so we were unable to determine precisely how MUP may have influenced drinking behaviours and drinker groups. Sales data are also subject to an unknown degree of error, which may lead to the under- and over-estimation of population consumption due to factors such as stockpiling, breakage, and legal and illegal unrecorded alcohol, such as black-market or home-brewed alcohol.[36] That said, we have no reason to suspect any variation in the magnitude of error over time in the data used in this study. As a proxy for actual levels of alcohol consumed in a population, however, sales data are highly sought after and are far superior to self-report surveys, which typically account for only a proportion of all alcohol known to be sold.[46]

Conclusions

The findings from this study indicate that MUP was successful at immediately reducing the amount of cask wine and total wine estimated to have been consumed in Darwin/Palmerston without affecting other beverages. MUP was targeted at the consumption of cheap wine, especially cask wine, for which per capita consumption almost halved in the first 12 months after the policy was introduced. Further research examining longer-term trends is warranted. This research demonstrates that MUP was an effective policy that targeted problematic beverage types, with almost no implementation costs.

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Supporting Information

Additional supporting information may be found in the online version of this article:

Supplementary Table 1: Litres of pure alcohol content of bottle wine supplied per capita, by region and year.

Supplementary Table 2: Time series models for per capita pure alcohol content of bottle wine supplied per capita, by region and year.

Supplementary Table 3: Litres of pure alcohol content of fortified wine supplied per capita, by region and year.

Supplementary Table 4: Time series models for per capita all fortified wines wholesale supply, Darwin and Palmerston and statewide.

Supplementary Table 5: Litres of pure alcohol content of cider supplied per capita, by region and year.

Supplementary Table 6: Time series models for per capita all cider wholesale supply, Darwin and Palmerston and statewide.

Supplementary Table 7: Litres of pure alcohol content of spirits supplied per capita, by region and year.

Supplementary Table 8: Time series models for per capita all spirits wholesale supply, Darwin and Palmerston and statewide.

Supplementary Table 9: Litres of pure alcohol content of premixed spirits supplied per capita, by region and year.

Supplementary Table 10: Time series models for per capita all pre-mix wholesale supply, Darwin and Palmerston and statewide.

Supplementary Table 11: Litres of pure alcohol content of full-strength beer supplied per capita, by region and year.

Supplementary Table 12: Time series models for per capita Full strength beer wholesale supply, Darwin and Palmerston.

Supplementary Table 13: Time series models for per capita beer wholesale supply, Northern Territory.

Supplementary Table 14: Litres of pure alcohol content of mid-strength beer supplied per capita, by region and year.

Supplementary Table 15: Time series models for per capita all mid-beer wholesale supply, Darwin and Palmerston and statewide.

Supplementary Table 16: Litres of pure alcohol content of light beer supplied per capita, by region and year.

Supplementary Table 17: Time series models for per capita all light beer wholesale supply, Darwin and Palmerston and statewide.