National Drug Research Institute

Associations between Government Regulation of Alcohol Availability, Alcohol Use and Health in Australia

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Author's declaration

To the best of my knowledge and belief this thesis contains no material previously published by any other person except where due acknowledgment has been made. This thesis contains no material which has been accepted for the award of any other degree or diploma in any university.

The research presented and reported in this thesis was conducted in accordance with the National Health and Medical Research Council National Statement on Ethical Conduct in Human Research (2007) – updated March 2014. The research received human research ethics approval from the Curtin University Human Research Ethics Committee (EC00262), Approval Numbers HR138/2013 and HR154/2015 and ACT Health Human Research Ethics Committee, Approval Number ETHLR.13.070. Please see Appendix B for ethics approvals.

The work described in this thesis was undertaken by the author and is original. The study designs, ethics approvals, data collection and analysis, writing of manuscripts for publication and writing of the thesis were conducted under the supervision of Professor Tanya Chikritzhs (Primary), Dr Wenbin Liang (Associate) and Professor Steve Allsop (Chair).

William Thomas Gilmore

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Abstract

This thesis by compilation presents a narrative literature review and three original studies focused on using novel approaches to address gaps in alcohol availability scientific research at both individual and population levels. Mental health effects of bar trading hours and sexual health effects of alcohol taxation were the subjects of this research program. The bar trading hour studies capitalised on special trading hour permits available to bars in Perth allowing a proportion to trade past standard closing time (typically midnight). Street intercept surveys of nightlife-goers, a novel method in trading hours research, were used to investigate: (i) association between participant risk of alcohol use disorder (assessed using AUDIT-C) and closing time of the bar where they spent most time that night (standard vs. late), (ii) association between participant alcohol use disorder risk and their blood alcohol concentration (assessed using breathalyser), and (iii) whether preferred bar closing time moderated any association between alcohol use disorder risk and blood alcohol concentration. Logistic and multinomial logistic regression models found evidence that females who typically drank at hazardous levels (score 5-7) preferred late closing bars, and both males with alcohol use disorder (8-12) and females who typically drank at hazardous levels and above (5-12) were more likely to have high-range blood alcohol concentration (males ≥0.1; females ≥0.08 g/100 mL) than their counterparts drinking at lower risk (0-4). Evidence of a moderating effect of trading hours on the association between alcohol use disorder risk and blood alcohol concentration was found among males, such that males with alcohol use disorder and high-range blood alcohol concentration were less likely to prefer late closing bars than males who typically drank at lower risk levels with high-range blood alcohol concentration. The alcohol taxation study capitalised on a change in federal taxation on ready-to-drink alcoholic beverages (27th April 2008), which increased the tax by 70%. Using an interrupted time series design, the study investigated the association between the tax increase and chlamydia rates among young people. Both population rates, as typically used in alcohol pricing research, and test positivity rates, a novel and more sensitive outcome measure, were compared. There was no evidence of association with population-based chlamydia rates, however, there was evidence of immediate and lagged reductions in chlamydia test positivity rates among young males. With the ultimate aim of improving the health and well-being of individuals and communities in mind, this body of published work strengthens the existing evidence base regarding how government regulatory strategies may impact on individual-level and population-level alcohol use and alcohol-related harm. It will contribute to informing future evidence-based alcohol policy debate.

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If I have missed anyone, I sincerely apologise.

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I am lucky to live in a place with such diverse seasons, lands, waters, plants, animals and people. I moved, met my partner, settled and started a family here. I acknowledge and respect Aboriginal Australians' countries, histories, languages, cultures, beliefs and knowledge.

Ngala kaaditj Whadjuk moort keyen kaadak nidja boodja

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List of publications that form this thesis by compilation

Narrative literature review

1. **Gilmore, W.**, Chikritzhs, T., N., Stockwell, T., R., Jernigan, D., Naimi, T., S. and Gilmore, I. (2016). Alcohol: taking a population perspective. *Nature Reviews Gastroenterology & Hepatology*, 13, (7), pp. 426-434.

Original research

2. **Gilmore, W.**, Symons, M., Liang, W., Graham, K., Kypri, K., Miller, P., G. and Chikritzhs, T., N. (2021). Association between nightlife goers' likelihood of an alcohol use disorder and their preferred bar's closing time: A cross-sectional observational study in Perth, Australia. *International Journal of Environmental Research and Public Health*, 18, (24), 13040.

3. **Gilmore W.**, Symons, M., Liang, W., Graham, K., Kypri, K., Miller, P., G. and Chikritzhs, T., N. (2022) Association between bar closing time, alcohol use disorders and blood alcohol concentration: A cross-sectional observational study of nightlife-goers in Perth, Australia. *International Journal of Environmental Research and Public Health*, 19, (12), 7026.

4. **Gilmore, W.**, Chikritzhs, T., N., McManus, H., Kaldor, J., Guy, R. (2020). The association between the Australian alcopops tax and national chlamydia rates among young people – an interrupted time series analysis. *International Journal of Environmental Research and Public Health*, 17, (4), 1343. (In Special Issue: Alcohol Policy and Public Health, guest edited by Professors Charles Parry and Niamh Fitzgerald)

Please see Appendices F and G for other publications and presentations given during enrolment.

Author's contributions to publications

Please see Appendix A for signed statements from all authors.

1. Alcohol: taking a population perspective

Author initials	WG	TC	TS	DJ	TN	IG
Coordination	×					
Conception	×	×				×
Outline	×	×	×	×	×	×
Drafted manuscript	×		×	×	×	
Critically reviewed and edited manuscript	×	×	×	×	×	×
Final approval	×	×	×	×	×	×

2. Association between nightlife goers' likelihood of an alcohol use disorder and their preferred bar's closing time: A cross-sectional observational study in Perth, Australia

Author initials	WG	MS	WL	KG	KK	PM	TC
Coordination	×						
Conception	×		×	×	×	×	×
Design	×	×	×	×	×	×	×
Data collection	×					×	×
Data preparation and analysis	×						
Drafted manuscript	×						
Critically reviewed and edited manuscript		×	×	×	×	×	×
Final approval	×	×	×	×	×	×	×

3. Association between bar closing time, alcohol use disorders and blood alcohol concentration: A cross-sectional observational study of nightlife-goers in Perth, Australia

Author initials	WG	MS	WL	KG	KK	PM	TC
Coordination	×						
Conception	×		×	×	×	×	×
Design	×	×	×	×	×	×	×
Data collection	×					×	×
Data preparation and analysis	×						
Drafted manuscript	×						
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4. Association between the Australian alcopops tax and national chlamydia rates among young people – an interrupted time series analysis

Author initials	WG	TC	HM	JK	RG
Coordination	×				
Conception		×		×	
Design	×	×		×	×
Data collection	×		×		
Data preparation and analysis	×				
Drafted manuscript	×				
Critically reviewed and edited manuscript		×	×	×	×
Final approval	×	×	×	×	×

Table of contents (Note: please also use PDF bookmark panel for quick navigation)

1. Introduction

Alcohol use, facilitated by alcohol availability, is a preventable risk factor that contributes to the burden of disease and disability worldwide (1). The latest Australian estimates found that, accounting for apparent protective health effects of alcohol at low levels, a 'net' 4,276 adults die and 105,505 are hospitalised from alcohol-attributable causes each year (2, 3). Risk of harm generally increases with higher quantities and frequency of use. Acute alcohol intoxication is associated with decreased inhibitions, risk taking behaviours and either unintentional or intentional injury, e.g. poisoning, accidents, self-harm and violence. Longer-term use is associated with cancers; digestive, cardiovascular and infectious diseases, and; neuropsychiatric, endocrine and perinatal conditions (4).

Alcohol availability theory was originally proposed as a population-level model to explain alcohol-related harm (5). It suggested that increased alcohol availability in a population is associated with increased numbers of heavy drinkers leading to increased health and social harms. The theory was subsequently expanded by others in the field to suggest that both increased physical and economic alcohol availability in a community would increase use and disproportionately increase harms by affecting the distribution of drinking patterns (6). Physical availability refers to the ease with which alcohol may be obtained in a population, including the number and trading hours of licensed outlets, purchase age laws and social supply, and economic availability refers to the affordability of alcohol in a population, i.e. cost relative to income (6).

Regulation of alcohol availability is typically coordinated nationally and/or locally by governments (1). Parts of North America and most Nordic countries have partial government alcohol monopolies controlling either the wholesale or retail sale of alcohol. Australia, like many other developed countries, has a fully privatised alcohol market at point of sale, but government has the ability to regulate community alcohol availability through policy and liquor licensing systems. Experimental study designs are rare in alcohol availability research as government policy changes tend not to facilitate randomised controlled trials. Policy changes do, however, create natural experiments that enable quasi-experimental designs e.g. interrupted time series and controlled before and after (7). In terms of evaluating overarching government regulation of alcohol itself, quasi-experimental studies have found privatisation of alcohol monopolies leading to increased alcohol use and related harms and renationalisation reversing the effect (8). The original research in this thesis by compilation

(described in publications 2, 3 and 4) focuses on two key examples of physical and economic alcohol availability: trading hours of licensed outlets and alcohol taxation.

1.1 Trading hours of licensed outlets

The vast majority of international studies conducted on licenced outlet trading hours have focused on injury outcomes, using quasi-experimental designs, and have built a strong evidence base for positive associations between policy changes related to licensed outlet trading hours and short-term alcohol-related outcomes (9-16). There are significant gaps in the trading hours research for outcomes related to longer-term alcohol use, such as alcohol use disorders, liver disease and cancers. This is partly due to limitations of analytical methods, such as interrupted time series analysis, when attempting to investigate causal associations between policy changes and health outcomes with long latency periods vs. those with immediate effect (17).

One study from the 1980s, with a cross-sectional observational design, capitalised on a local licensing decision in Perth, Australia, to allow a proportion of bars to open four hours earlier than standard (6 a.m. vs. 10 a.m., Monday to Saturday) to cater for shift workers. Surveys of drinkers at a sample of both bar types (early vs. standard opening) found a higher proportion of 'problem drinkers' at early opening bars (18). All Perth's bars are now permitted to trade from 6 a.m. but the licensing system now grants a proportion of bars special permits to remain open and trade past standard closing time, particularly popular among bars in nightlife areas and a more typical time for people to be out drinking in licenced venues (standard vs. late opening hours at study initiation: midnight vs. 2 or 3 a.m., Monday to Saturday; 10 p.m. vs. midnight, Sunday) (19). This application-based licensing system, that leaves bars with either standard or late closing times, underpinned two cross-sectional observational studies of Perth nightlife-goers' bar type preference (standard vs. late), alcohol use and risk of alcohol use disorder that form part of this thesis by compilation (described in publications 2 and 3) (20, 21).

1.2 Alcohol taxation

Government regulation that reduces alcohol affordability via pricing and taxation has been identified as a key strategy to reduce alcohol use and alcohol-related harm at the population level. Quasi-experimental studies, and systematic reviews and meta-analyses of these studies, have

demonstrated this association (22, 23). Alcohol-related disorder and disease outcomes are underrepresented in the alcohol pricing research when compared to injury outcomes.

An example of a major alcohol taxation reform that lends itself to quasi-experimental study design is the Australian alcopops tax on ready-to-drink alcoholic beverages (27th April 2008), a 70% federal tax increase on a beverage category favoured by young people. Around the time of the tax increase, alcopops accounted for 20% of retail alcohol sales (24) and typically contained between 5% and 9% alcohol by volume (25). Although there were a handful of examples of alcohol pricing and taxation studies from North America focusing on sexual health outcomes (26-31), no evaluations of the Australian alcopops tax had focused on an alcohol-related disease prevalent among young people. This allowed for the interrupted time series analysis of the alcopops tax and chlamydia rates among young Australians that forms part of this thesis by compilation (described in publication 4) (32).

1.3 Aims and objectives

The aim of this research program was to investigate, in a series of studies using novel methods, associations between economic and physical alcohol availability and health effects underrepresented in alcohol availability and policy evaluation research.

Objectives were to:

1. Comprehensively review the international evidence base for causal associations between: (i) alcohol use and health outcomes, and (ii) government regulation of alcohol availability and both alcohol use and related health effects (described in publication 1).

2. Investigate the associations between: (i) preferred bar closing time and alcohol use disorder risk, and (ii) alcohol use disorder risk, preferred bar closing time and blood alcohol concentrations, among nightlife-goers in Perth, Western Australia (described in publications 2 and 3).

3. Investigate the association between a federal increase in tax on ready-to-drink alcoholic beverages, the 27th April 2008 Australian alcopops tax, and chlamydia rates among young Australians (described in publication 4).

2. Publications

This is a brief introduction to the publications with a summary of each papers' methods and how they have contributed to the research knowledge base:

Publication 1 was a broadly pitched narrative literature review on alcohol epidemiology and policy published in *Nature Reviews Gastroenterology and Hepatology* (4). It was a comprehensive summary of the major studies, narrative reviews, systematic reviews and meta-analyses, available at time of writing, including: (i) global patterns of alcohol use and harm, (ii) health and social effects of alcohol use, (iii) methods used to study health effects arising from regular exposure to alcohol, and (iv) evidence-based regulatory strategies for reducing alcohol use and related harm.

Publications 2 and 3 described original studies focused on mental health effects of alcohol's physical availability via licensed outlet trading hours published in *International Journal of Environmental Research and Public Health* (20, 21). The studies formed part of the Pub Extended Trading Hours Project on which I am an investigator (please see ethics approvals in Appendix B). Street intercept surveys are already an established and validated method of sampling younger at-risk drinkers (33, 34), however, these were the first studies in the alcohol availability research to have used them on a sample of nightlife-goers to investigate licensed outlet trading hour effects.

Two cross-sectional observational studies of nightlife-goers investigated individual-level associations between: (i) alcohol use disorder risk and preference for bars with either standard or late closing times, and (ii) alcohol use disorder risk, preferred bar closing time (standard vs. late) and blood alcohol concentrations. Primary data were collected through street intercept surveys in four nightlife areas of Perth (please see survey schedule in Appendix C). Field workers surveyed nightlife-goers in public places between 8 p.m. and 3 a.m. on Fridays, Saturdays and Sundays on 13 separate occasions between November 2015 and April 2016. Every third person was invited to participate in order to approximate a systematic random sample and a gender quota was introduced to ensure good representation for females. Field workers only recorded a decline after someone had engaged with them and had the purpose of the study explained to them (Response rate = (number agreed ÷ number approached) × 100). The short form of the Alcohol Use Disorders Identification Test (AUDIT-C) was used to identify participants meeting criteria for alcohol use disorder risk based on their typical drinking pattern. Participants provided a breath sample via a breathalyser to

estimate blood alcohol concentration. Licensed venue name where most time had been spent on the night of survey was used to classify and define participant preferred bar. Gender-specific logistic (publication 2) and multinomial logistic regression (publication 3), adjusting for a range of potential confounders, were the statistical models chosen.

Publication 4 described an original study focused on sexual health effects of alcohol's economic availability via federal taxation published in *International Journal of Environmental Research and Public Health* as part of a special issue on alcohol policy and public health (32). The study formed part of the National Alcohol Indicators Project on which I am an investigator (please see ethics approvals in Appendix B). This was the first study in the alcohol availability research with sexual health outcomes to use routinely collected testing data to calculate a more sensitive evaluation measure, test positivity rates, when compared with standard population-based rates.

A quasi-experimental interrupted time series analysis investigated population-level associations between the 27th April 2008 Australian alcopops tax and national chlamydia rates among young people: (i) notification rates, i.e. diagnoses per 100,000 population, and (ii) test positivity rates, i.e. diagnoses per 100 tests. Secondary data of national monthly notifications of chlamydia, from July 2000 to December 2016 were sourced from the National Notifiable Diseases Surveillance System at the Office of Health Protection, Australian Department of Health. To calculate rates, estimated resident population was sourced from the Australian Bureau of Statistics and counts of chlamydia tests were sourced from online publicly available Medicare Benefits Schedule Item Statistics Reports. Population income data were sourced from the Australian Tax Office, and to adjust for inflation, the consumer price index was sourced from the Australian Bureau of Statistics.

Gender and age-specific (15–24-year-olds; 25–34-year-olds) Autoregressive Integrated Moving Average models were fit to the pre-intervention time-period (94 monthly time points) for both chlamydia notification rates and test positivity rates. Models of best fit were then applied to their corresponding full time series while adjusting for independent variables: the intervention month, older Australians (35-year-olds and older) and inflation-adjusted per capita income. Immediate and lagged associations were investigated.

2.1 Alcohol: taking a population perspective

Citation:

Gilmore, W., Chikritzhs, T., N., Stockwell, T., R., Jernigan, D., Naimi, T., S. and Gilmore, I. (2016). Alcohol: taking a population perspective. *Nature Reviews Gastroenterology & Hepatology*, 13, (7), pp. 426-434.

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SCIENCE AND SOCIETY

Alcohol: taking a population perspective

William Gilmore, Tanya Chikritzhs, Tim Stockwell, David Jernigan, Timothy Naimi and Ian Gilmore

Abstract | Alcohol consumption is a global phenomenon, as is the resultant health, social and economic harm. The nature of these harms varies with different drinking patterns and with the societal and political responses to the burden of harm; nevertheless, alcohol-related chronic diseases have a major effect on health. Strong evidence exists for the effectiveness of different strategies to minimize this damage and those policies that target price, availability and marketing of alcohol come out best, whereas those using education and information are much less effective. However, these policies can be portrayed as anti-libertarian and so viewing them in the context of alcohol-related harm to those other than the drinker, such as the most vulnerable in society, is important. When this strategy is successful, as in Scotland, it has been possible to pass strong and effective legislation, such as for a minimum unit price for alcohol.

This Perspectives article might seem an unlikely topic for a clinical journal, but the wider harms of alcohol to health are increasingly being dealt with by gastroenterology and hepatology physicians. They need to know not just how to treat the individual's disease (and sometimes the underlying dependence), but also how to contribute to reducing the huge global burden of alcohol-related harm on individuals, those around them and society in general. We will show that the answers to these issues do not always lie in better health care but in better health. Tellingly, the UK is consistently rated top of the league of a range of developed countries for its health care (for example, in effectiveness and accessibility), but bottom of the league for its population's health[1]. This paradox arises because major threats to public health such as alcohol need concerted policy action, often at a national level, to tackle issues quite independent of health care delivery, such as price, marketing and availability. Our governments are either insufficiently bold or too influenced by the alcohol industry to follow the evidence on these key issues. The public health approach also serves to emphasize that alcohol harm is not just about the small minority of dependent drinkers. The cumulative harm in those consuming alcohol who are not considered 'problem drinkers', whether it be in cancers, heart disease or other illness, is huge and will be missed without a population perspective. Clinicians need to become advocates for the populations they serve as well as for their patients.

This Perspective will outline the scale of the global alcohol problem, the wide-ranging effects of alcohol and the most effective evidence-based strategies to effect a population-level reduction in harm. We will also highlight how clinicians can be good public health advocates and the available downstream strategies they can implement while we wait for governments to take the necessary action.

The scale of the problem

Global alcohol consumption

The quantity and pattern of alcohol use varies enormously between drinkers, between countries and within countries. National consumption level estimates are typically presented as the volume of pure alcohol consumed per adult per year, and the source of these data tends to be official statistics related to the sale of alcohol (for example, taxation records, customs data, surveys of producers and distributors). However, not all alcohol that is available for consumption is recorded in official statistics owing to varying levels of unregulated production, which tends to be particularly high in developing countries, and also unregulated importation[2].

The most recent global data are the 2010 estimates[3] published by the WHO, which take into account recorded alcohol and an estimate of the unrecorded alcohol based on country-specific intelligence. The highest levels of per capita consumption are seen across Eastern Europe and Russia and the lowest levels across the predominantly Islamic countries of North Africa, the Middle East and Southeast Asia (FIG. 1). Annual per capita consumption is 11.6 litres in the UK, 12.2 litres in Australia, 10.2 litres in Canada and 9.2 litres in the USA. Over the past 50 years the UK has seen a marked increase in consumption from relatively low levels compared with some of its neighbouring European countries, such as France and Italy, which have seen substantial decreases from very high levels[3] (FIG. 2).

Data collected through population level surveys have been found to vastly underestimate levels of alcohol use, and are not sufficient to monitor national consumption levels, but they are crucial in informing governments about differing patterns of consumption[2]. When national consumption figures are adjusted to account for numbers of nondrinkers (derived from population surveys), it is generally observed that countries with low levels of adult per capita consumption have relatively high levels of consumption per drinker[3]. Comprehensive reviews of the literature[4,5] highlight that studies drawing on survey data show that a high proportion of the alcohol consumed in a country is consumed by a relatively small number of heavy drinkers (BOX 1), and that as a country's total consumption increases so does the level of heavy drinking. Even among people with 'moderate' levels of consumption, a high proportion of alcohol is consumed during heavy (that is, 'binge') drinking occasions. These reviews[4,5] have also shown how alcohol consumption varies

by age, gender and socioeconomic status in the developed world. Although the gender gap is narrowing, more men drink alcohol than women and among those that do drink, men consume larger quantities and more frequently than women[4,5]. Younger people are more likely to engage in binge drinking whereas older people are more likely to drink daily[4,5]. Those in higher socioeconomic strata are more likely to drink and tend to drink more frequently than those in lower socioeconomic groups[4,5]. For clinicians, staying abreast of which populations are most at risk is important, as they can help to maximize the effect of the preventive approach by targeting high-risk groups as well as entire populations.

Global burden of alcohol consumption

Alcohol is associated with a large range of health conditions and ranks as the fifth leading risk factor for disease and injury worldwide. Among 15–49 year olds, alcohol consumption is the leading risk factor for premature death and disability[6]. Furthermore, in developed nations, alcohol causes similar or greater harm to others than harm to users themselves[7].

The WHO estimates that in 2012, 139 million disability-adjusted life years (DALYs, years of healthy life lost through disability and premature mortality), were attributable to alcohol use globally (5.1% of all DALYs). Injuries (intentional and unintentional) were the top contributor, followed by neuropsychiatric disorders, cardiovascular diseases and gastrointestinal diseases[3]. Similar to levels of alcohol use, the associated burden of disease and injury differs by region of the world, broadly following the global distribution of per capita consumption (FIG. 1). The highest burden is seen across Eastern Europe and Russia and the lowest across North Africa, the Middle East and Southeast Asia[3]. The burden of disease attributable to alcohol is above the global estimate of 5.1% in the UK, Canada and the USA, but below that in Australia[3]. In keeping with the trend in alcohol consumption in the UK (FIG. 2), morbidity and mortality from liver disease and other alcohol-related disorders are also on the increase[8].

Not only is alcohol use associated with health outcomes but there are also wide-ranging social and economic consequences. The annual financial burden of alcohol on society, through the increased costs of health care, policing, absenteeism and other social problems, is difficult to quantify but has been estimated at around CA$14.5 billion in Canada (~$463 per capita)[9], GB£21 billion in the UK (~£40 per capita)[10], AU$35 billion in Australia (~$1,743 per capita)[11] and US$249 billion in the USA (~$807 per capita)[12].

The effects of alcohol

The magnitude of health, social and economic consequences experienced by drinkers themselves, other individuals and society at large is influenced not only by the quantity of alcohol but also the way in which it is consumed (FIG. 3). Individual and societal factors, including alcohol policies and regulations, also have a large influence on the type and magnitude of problems associated with alcohol[3].

The relationship between alcohol consumption, disease and injury is complex. The literature on the health effects of alcohol consumption is dominated by observational rather than experimental studies, and meta-analyses of observational studies make up the bulk of the evidence base showing a consistent dose–response relationship that has led to causation being established through comparative risk assessment[13,14]. Usual practice to establish causality is to obtain credible evidence, ideally from experimental studies, of a plausible biological mechanism to underlie causal associations between alcohol use and disease or injury[15,16]. Experimental 'feeder' studies (in which alcohol is administered to participants) have mainly focused on short-term outcomes, such as serum biomarkers for coronary heart disease or cognitive and psychomotor effects that increase the risk of injury. There have been no long-term randomized controlled

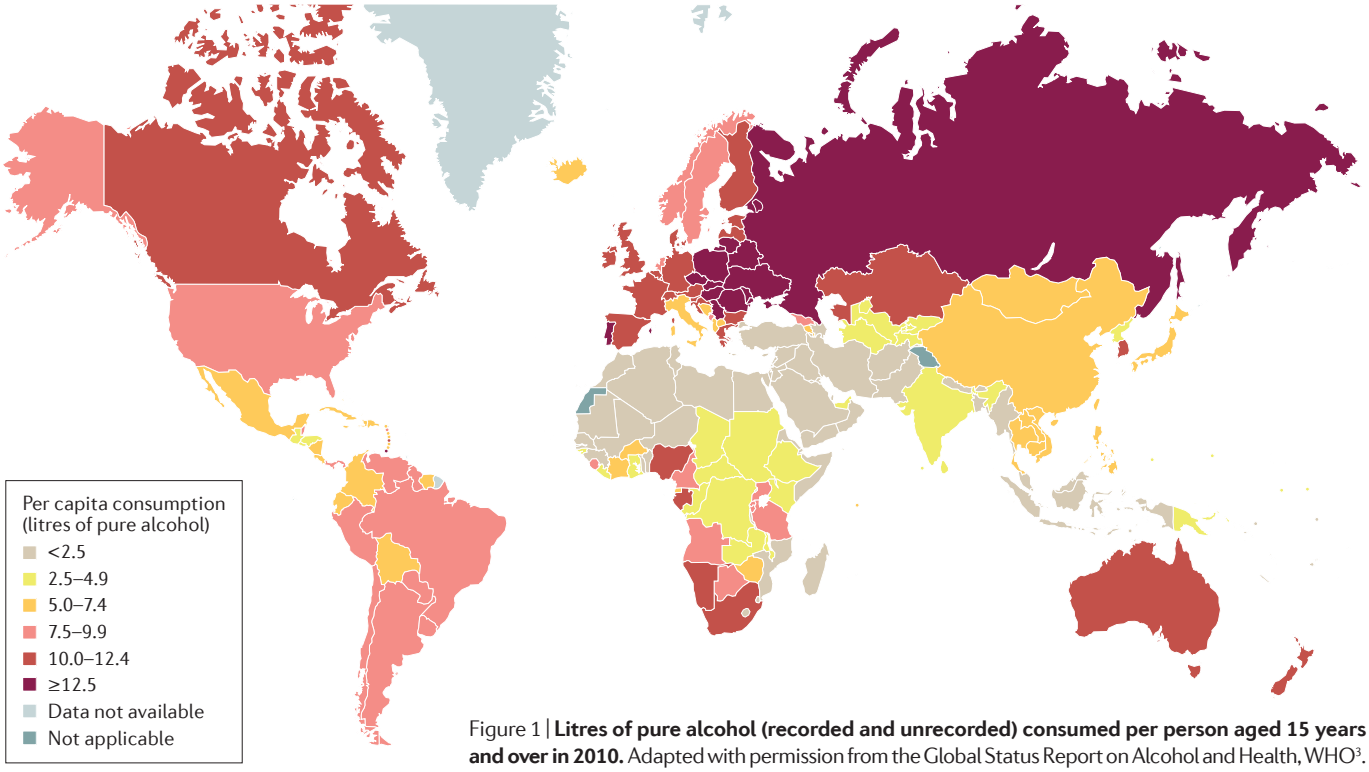

Figure 1 | **Litres of pure alcohol (recorded and unrecorded) consumed per person aged 15 years and over in 2010.** Adapted with permission from the Global Status Report on Alcohol and Health, WHO[3].

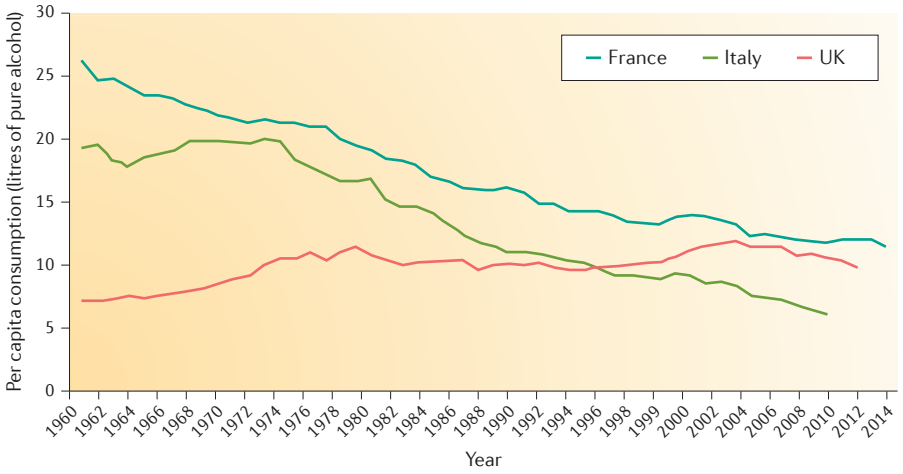

Figure 2 | **Litres of pure alcohol (recorded) consumed per person aged 15 years and over in the UK (1961–2012), France (1961–2014) and Italy (1961–2010).** Adapted with permission from the Global Information System on Alcohol and Health, WHO[139–141].

trials (RCTs) examining risk of death due to alcohol exposure in this field.

For many of the observed social and economic effects associated with alcohol consumption, such as domestic or work-life problems and societal costs, only correlation has been established[4].

Health effects

Alcohol use is associated with a range of health conditions, either directly or as a component cause. These conditions include those that arise in the short-term from acute alcohol intoxication, or in the long-term from cumulative exposure to alcohol. However, some conditions do not fit neatly into these categories. For example, alcoholic gastritis is an acute presentation, but is more common among regular heavy drinkers. Evidence exists for both detrimental and protective effects of alcohol on health outcomes.

Intoxication and poisoning. The short-term intoxicating effect of alcohol has been experienced for as long as it has been consumed. Increased blood alcohol concentration, when the rate of consumption has exceeded the rate at which the liver processes ethanol, causes both mental and physical impairment even at low levels. At high levels, the intoxicating effect can directly culminate in coma or death[17].

Injuries to self and others. The mental and physical impairment caused by alcohol intoxication in the short-term has been causally related to an increased risk of unintentional and intentional injury. A dose–response relationship has consistently been observed for injuries from road traffic crashes, falls, fires, drowning, work-related accidents, violence and self-harm[16,18].

Gastrointestinal and hepatic diseases. Alcohol use has consistently been causally associated with alcoholic gastritis, gastro-oesophageal haemorrhage, both acute and chronic pancreatitis and the development and progression of liver disease (from fatty liver disease through to advanced cirrhosis and associated complications, such as oesophageal varices)[15]. The relationship between increasing average daily alcohol consumption and the incidence of cirrhosis and pancreatitis and subsequent mortality from these diseases is exponential[19,20]. The rise in cirrhosis mortality has been so striking in the UK over the past 20 years that it is likely that the effects of alcohol and obesity, the prevalence of which is also on the rise, combine to produce a 'double hit' on the liver[8]. A protective effect of alcohol use on cholelithiasis has been suggested[21].

Neuropsychiatric conditions. A range of neuropsychiatric conditions directly attributable to heavy alcohol use have been identified, including alcohol dependence syndrome, alcohol withdrawal state, alcoholic myopathy[15] and alcohol-related brain damage[22]. Meta-analyses of observational studies have also confirmed a dose–response relationship between alcohol use and risk of epilepsy[16], including unprovoked epileptic seizures independent of seizures related to alcohol withdrawal[23]. Another neuropsychiatric condition considered to have a partially attributable causal relationship with alcohol use is unipolar depressive disorder; however, this condition is generally not included in burden of disease estimates associated with alcohol due to confounding factors[16,24].

Cardiovascular diseases. Alcohol use has been well-established as a component cause in cardiac arrhythmias, hypertensive disease, coronary heart disease and stroke, with increased risk generally seen for high levels of consumption[16,25]. At low-to-moderate levels of consumption, the evidence is mixed. Meta-analyses of short-term experimental and observational studies conclude that low-to-moderate levels of alcohol consumption are protective against hypertensive disease in women[26,27], coronary heart disease[28–30] and ischaemic stroke in women and men[31], and haemorrhagic stroke in women[31]. However, heavy drinking occasions once a month or more have been shown to negate any protective effect from low-level drinking on coronary heart disease[32], and an RCT published in 2015 reported that regular low levels of alcohol consumption increases the risk of hypertension among women[33]. In addition, Mendelian randomization studies that more closely replicate RCTs than traditional observational studies have called into question the veracity of the apparent protective effects of alcohol against cardiovascular disease, as well as several key hypothesized causal mechanisms[34,35].

Cancers. The International Agency for Research on Cancer classifies alcohol as a group 1 carcinogen (carcinogenic to humans), and considers alcohol to be causally related to cancers of the oral cavity, pharynx, larynx, oesophagus, liver, colon, rectum and female breast. Of these cancers, colorectal and female breast cancers were the most recent to be judged causally related to alcohol in 2007 (REF. 36). The relative risk of developing these cancers increases with any consumption of alcohol and with increasing average daily consumption. Other cancers for which a statistically significant association with alcohol use has been found, but insufficient evidence for causality currently exists, include gastric, pancreatic, lung and prostate cancer[37,38]. In the case of prostate cancer, new evidence assembled in the past several years will probably lead to a consensus on causality in the near future[39,40].

Diabetes. Another condition that 'moderate' average alcohol consumption has been associated with protection against in both experimental and observational studies is type 2 diabetes mellitus. Similar to coronary heart disease, meta-analyses of studies have

displayed a 'J-shaped' curve of association, with an increased risk of type 2 diabetes mellitus only at higher doses[41,42]. Uncertainty surrounds the observed protective effect, with healthy lifestyle choices among moderate drinkers possibly confounding the results[16,25,43].

Perinatal conditions. Fetal alcohol spectrum disorder is a prime example of harm experienced by an individual other than the drinker[17]. High levels of alcohol consumption during pregnancy (particularly the first trimester) have also been linked to spontaneous miscarriage[21], preterm birth and conditions related to preterm birth such as low birth weight[16,44]. Epigenetic mechanisms whereby parental exposure to alcohol can alter subsequent gene expression in their offspring are also emerging[45].

Infectious diseases. In 2008, international experts met in Cape Town to review the evidence regarding the association between alcohol and two infectious diseases, HIV and tuberculosis. They concluded that sufficient evidence exists for a causal association between high levels of alcohol consumption and the incidence of tuberculosis, and the progression of existing tuberculosis and HIV[46]. Meta-analyses and systematic reviews conducted since have confirmed the relationship between alcohol and tuberculosis[47] and HIV[48], and have added community-acquired pneumonia to the infectious diseases that alcohol is considered causally related to[16,49].

Social and economic effects

In addition to the health effects that alcohol is known to have on the individual drinker, a wide range of harms are inflicted on others and the burden on society at large needs to be considered[7]. A bystander, friend, colleague or family member could be injured through violence or an accident[18], or an unborn child harmed by its mother's drinking during pregnancy[17]. Families might be affected financially or through neglect, workplaces by decreased productivity and absenteeism, and whole communities by crime, disorder and the public money spent on alcohol-related health care and policing[11,50]. The epidemiological evidence base surrounding the social and economic effects of alcohol consumption is quite weak[4], but the direct and indirect effects are probably wide-ranging. Consideration of these effects is needed if policy makers are to understand the full scale of the consequences of alcohol use on society.

Box 1 | **Alcohol consumption levels defined?**

Definitions and terminology regarding different levels and patterns of alcohol consumption vary substantially between countries, between studies and over time. Broadly speaking, country definitions align with the existing national drinking guidelines, with 'low' or 'moderate' levels referring to consumption within the limits set for low-risk drinking and 'heavy' levels referring to consumption exceeding those limits. In the UK, this limit, and therefore the threshold limit for 'heavy' drinking, is currently set at 112 g of pure alcohol per week for both men and women[61].

A 'binge' drinking occasion refers to a pattern of consumption over a relatively short period of time that results in impairment. The WHO refers to a 'binge' as heavy episodic drinking, defined as drinking >60 g of pure alcohol on a single occasion[3].

An evolving field of study

Unfortunately, the scientific study of the effects of long-term exposure to alcohol suffers from a number of uncertainties, and current burden-of-disease estimates are probably an underestimation. This underestimate is particularly true for the effects of low levels of alcohol consumption, in which outcomes might have long latency periods, be influenced by multiple risk factors, and have low relative risk estimates compared with other risk factors. The possible confounding effects of other risk factors associated with alcohol consumption that have independent associations with disease risks can lead to underestimation of the disease risks from alcohol use, for example when moderate drinking is associated with a generally moderate lifestyle[51].

Although confounding factors could also result in overestimation of disease risks, many other uncertainties exist that result in an underestimation of risks and, by corollary, an overestimation of the potential health benefits of alcohol. Systematic bias can operate in longitudinal studies in several ways that lead towards alcohol consumers seeming healthy in comparison with abstainers. The definition of the all-important comparison group, 'abstainers', differs widely from study to study and might include people who are only known to have recently abstained, who usually abstain or who are former drinkers. Individuals who greatly reduce their drinking or stop completely often do so for health reasons[52,53]. These issues mean that with passing time, the comparison group of 'abstainers' increasingly fills with less healthy people while drinker groups (particularly low and moderate drinkers) are increasingly made up of relatively healthy survivors. A further complication is that even young adults who become complete abstainers often have poorer health than their peers who become drinkers[54]. There is now greater awareness of the need to control for these kinds of methodological problems in longitudinal studies of the possible health protective effects of low-dose alcohol[52,55,56], but it has been argued that the bulk of epidemiological literature on alcohol remains affected by bias and confounding factors[57], the effect of which has not been fully quantified.

In addition to causing substantial underestimation of the burden of disease from alcohol, the methodological problems described previously pose difficulties for the formulation of national low-risk drinking guidelines. In some countries such as Canada, these guidelines have been set at a level at which the relative risk of all-cause mortality for alcohol consumers equals that of abstainers (135 g of ethanol per week for women and 202 g for men)[58]. The potential risks and benefits of alcohol use below this level are thought to cancel each other out or are a net positive. The approach in Australia was to use absolute risk estimates and discount potential benefits of low-volume alcohol consumption[17,59]. Others have suggested setting limits at the level of drinking at which mortality risk begins to increase, regardless of whether there might be net benefits at this level[60]. As research in this complex area evolves it can be confidently concluded that recommendations for acceptable 'low risk' consumption will become more conservative. For example, the UK alcohol guidelines released in early 2016 recommend that both women and men do not regularly exceed 112 g of ethanol per week and have several drink-free days each week[61]. The Joint Action on Reducing Alcohol Related Harm (RARHA) across European Union member states is the most coordinated international effort to discuss low-risk guidelines to date[62].

Based on the current state of the evidence, any published guidelines relating to alcohol use should discourage drinking alcohol for health benefits, and clinicians should not recommend alcohol consumption to their patients as a means of reducing cardiovascular or other disease risk[57].

Reducing alcohol-related harm

As alcohol is an addictive substance and because the negative consequences of alcohol consumption are often second-hand, with the costs borne by societies as a whole, government regulation is required to discourage problematic consumption and associated behaviour and to protect others from harms caused by drinkers.

Babor *et al.*[4] describe how possibilities for regulating alcohol exist at multiple levels of government. Alcohol policy tends to be decentralized, with responsibilities for different aspects of policy spread among what are sometimes competing government interests, such as health ministries and revenue or finance agencies. Government control over alcohol can extend to the production, export and import of alcoholic beverages; wholesaling and/or retail sale of alcohol; establishment of minimum legal purchase ages for alcohol; measures to reduce drink-driving; restrictions on alcohol marketing; and support and standards for prevention and treatment services and activities. Although the locus of control over alcohol policy-making in many countries lies at the national level, opportunities for regulation at the local level (for example, as is the case in England where local authorities have control of alcohol licensing) are also possible. A divergence of policy within the constituent UK countries provides the chance to compare the impact of different policies[63]. In federal systems, such as the USA, Canada and Australia, control can be divided between national and state or provincial authorities. Natural experiments in the privatisation of government monopolies over retail alcohol sales in the USA, Canada, Finland and Sweden have illustrated the health and safety benefits of government regulation: in general, privatization has led to greater consumption and alcohol-related problems, whereas renationalization has reduced harms[64,65].

Alcohol sales worldwide total approximately US$1 trillion annually[66], and for beer and spirits in particular, a small number of companies dominate global markets[67]. These companies are known to have an active role in alcohol policy formation, and have generally been found to support policies with the weakest evidence of effect, and oppose those likely to have greater effect on reducing consumption and harms[68,69].

The most effective means of reducing excessive alcohol use and related problems at the population level is through policies that reduce the affordability and/or availability of alcohol and restrict alcohol marketing[4,70]. Educational efforts alone that seek to change individuals' drinking behaviour have been largely unsuccessful, and although treatment of alcohol dependence is important, clinical addiction treatment has not been shown to result in population level reductions in harm[4].

Reducing alcohol affordability

Evidence supports reducing the affordability of alcohol as the single strongest intervention to have been evaluated for the reduction of population levels of alcohol related harm. This finding is the conclusion of multiple comprehensive reviews[4,71,72] and is confirmed by several meta-analyses and natural experiments. For example, Wagenaar *et al.*[73] identified 112 high-quality international studies incorporating >200 years of data and generating 1,003 estimates of the relationship between alcohol prices and consumption levels. They concluded that a 10% increase in price led to an average 4.4% reduction in total population consumption. Other studies also suggest that price increases specifically for cheap alcohol will result in greater reductions in the consumption of heavy or harmful drinkers than light or moderate drinkers[74,75].

Unfortunately, in contrast to education and persuasion strategies, across-the-board alcohol pricing and tax increases are among the most unpopular policy options with the general public[76] and are more unpopular in heavier drinking populations[77]. In other words, a greater need for effective pricing policies can render them more politically dangerous for decision-makers. In response to this dilemma, we highlight some more targeted approaches to alcohol pricing, such as minimum unit pricing[74], which might be more palatable to the general public and decision-makers.

The two most common arguments against pricing strategies are that the heaviest and dependent drinkers will be unaffected, and that if affected these drinkers might turn to more dangerous forms of non-beverage alcohol (alcohol-containing substances not intended for consumption). Neither argument stands up to scientific scrutiny and is contradicted by the evidence summarized later. If price increases were leading drinkers simply to substitute beverage alcohol for non-beverage alcohol, it would not be possible to observe the kinds of reductions in alcohol-related mortality and morbidity shown to be associated with tax increases[78,79].

Pricing and taxation strategies need to be the first priority of any comprehensive response to alcohol-related problems. In combination, they can produce increased revenues for government and industry while reducing consumption and harms. The challenge is finding the balance where governments and industry can agree. Societies that allow unfettered access to very cheap alcohol will undermine the effectiveness of other prevention and treatment strategies. However, pricing and taxation strategies rely on control of the unregulated market for their effectiveness, which is not always the case, particularly in low-income and middle-income countries.

Linking alcohol prices to the cost of living.

Mechanisms to periodically adjust taxes and prices to keep up with the cost of living are important to ensure the preventive power of alcohol pricing is not eroded, particularly in regions where alcohol taxes are tied to the volume of the beverage, as they are in many jurisdictions. A lack of adjustment has been a substantial problem in the USA, where the federal tax on beer has been raised

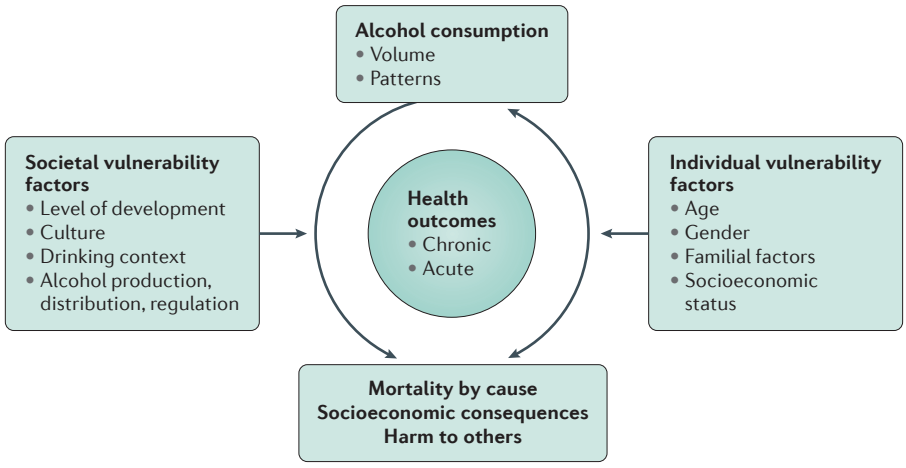

Figure 3 | **Conceptual causal model of alcohol consumption and health outcomes.** Adapted with permission from the Global Status Report on Alcohol and Health, WHO[3].

just once in >50 years[80]. In Canada, raising alcohol excise duty requires the consent of Parliament and has only been done twice in 25 years[81]. The UK Government introduced an alcohol duty escalator in 2008, to keep the excise rate 2% above the rate of inflation, only to abolish it in 2014 (REF. 82). By contrast, in Australia alcohol excise taxes are raised every 6 months with the cost of living so that their real values are maintained[83]. Failure to maintain prices and tax levels allows downward pressure on the price of alcohol and hence upward pressure on population levels of consumption and related harm.

Minimum pricing. Minimum pricing refers to a set price below which alcoholic beverages cannot be legally sold in the retail market. The 10 Canadian provinces are among a handful of jurisdictions that set minimum prices for the sale of alcohol. Usually, these are set independently of alcohol content and do not keep pace with inflation, which guarantees at least a small number of very cheap, high-strength products remain, for example, 8% alcohol by volume beer, 22% fortified wine and 75% spirits[84]. Nonetheless, Canadian researchers have estimated the associations between changes in minimum alcohol prices, consumption and related harms. In these studies it is estimated that a 10% increase in minimum alcohol prices is associated with a 9% reduction in alcohol-related hospital admissions[85], a 32% reduction in wholly alcohol-caused deaths[86] and a 9% reduction in violent crime[87].

Pricing on alcohol content. Ethanol is the ingredient in beverage alcohol that, in a dose–response manner, causes serious health and safety problems. The provincial health officer of British Columbia, Canada, has recommended ethanol-based pricing within each main category of alcoholic beverage[88], and an increasing number of Canadian provinces including Saskatchewan, Ontario, Quebec and Manitoba are now following this recommendation[89]. A marked increase in the minimum prices charged for higher strength beers in Saskatchewan was shown to trigger a shift in consumption from high to low strength wines and beers and an overall reduction in per capita consumption[90].

Minimum unit pricing. A public health ideal, combining both the previous two objectives, would be to have a single set of taxation rates based entirely upon ethanol content and with set minima (that is, minimum unit prices), which would remove the myriad different rates of tax typically applied to alcoholic drinks[91]. The UK proposals[10], passed into law in Scotland but not yet implemented[92], link the minimum price directly to the alcohol content. UK modelling studies have suggested that raising minimum alcohol prices to only 45 pence per unit (a UK unit is defined as 8 g ethanol) would substantially reduce alcohol-related deaths and health care costs[74,93].

Earmarked alcohol taxes. The unpopularity of raising the price of alcohol via taxation to reduce problems can be offset if the rationale provided involves raising revenue to pay for treatment and prevention programmes[91]. Such earmarked or hypothecated taxes have been introduced in a number of countries variously for alcohol, tobacco and gambling. Such special taxes have the twin virtues of reducing harm while generating extra revenues[94]. As demand for alcohol is relatively inelastic, increased taxes will almost invariably result in increased revenues for government[95].

Combining taxation. Thailand has adopted an approach to alcohol taxation that calculates the tax on various types of alcoholic beverages both by alcohol content and as a fixed percentage of the price and then applies the higher of the two as the actual tax. This method results in higher taxes both on the beverages most popular with heavy drinkers (high alcohol content, but low price per drink) and those attractive to young and inexperienced drinkers (low alcohol content, but high price per drink), leading to reduced consumption overall[96,97].

Restricting discounts. Restrictions on discounts can include bans on 'happy hours' in on-premise outlets (pubs and bars) and 'buy one get one free' promotions in off-premise outlets (supermarkets, off-licences, liquor stores). Evidence of effectiveness in this area is limited, with the majority of studies from the USA, but it is a growing area of interest[98,99]. Scotland introduced a total ban on alcoholic beverage discounts in on-premise outlets in 2009 (REF. 100), and on multi-buy discounts in off-premise outlets in 2011 (REF. 101). Modelling by Meng *et al.*[102] estimated that a total ban on off-premise discounts in Scotland would reduce overall alcohol consumption by 3%. Two evaluations of the off-premise multi-buy promotion ban have shown contradicting results. One study found that the ban had no effect on off-premise alcohol purchases[103], and the other that the ban was associated with a 2.6% reduction in off-premise alcohol sales in Scotland[104].

Reducing physical availability

Reducing the physical availability of alcohol relates to increasing the 'convenience cost' of alcohol by regulating the times, places and contexts in which it can be obtained[105]. This approach can range from total or partial prohibition through to secondary supply laws that prevent adults supplying alcohol to underage drinkers. The areas for which most evidence exists for reducing population level harm are restricting trading hours, limiting outlet density and having older minimum purchasing age laws[4].

Restricting trading hours. Strong evidence shows that large changes (for example, adding or subtracting a whole day) in the trading hours of on-premise outlets can influence rates of consumption and harm[4]. The literature on the effects of increasing or reducing trading hours at first seems conflicting. However, a comprehensive review assessed 49 studies on two key criteria: whether a control area was used for comparison and whether baseline data were collected[106]. The majority of studies meeting these criteria found increased hours resulted in increased harms, such as assaults and drink driving offences. A review by Hahn *et al.*[107] concluded that restricting hours of sale by 2 h or more was likely to reduce alcohol-related harms, and since then three additional high-quality studies have demonstrated reductions in violent incidents following small reductions in trading hours[108–110].

Limiting outlet density. The evidence linking the density of different kinds of alcohol outlets (for example, number of outlets per 10,000 residents or per km^2) with rates of both alcohol consumption and alcohol-related harm is mixed. Two systematic reviews assessing studies published before 2009 (REFS 111,112) concluded that limiting alcohol outlet density was an effective measure for reducing alcohol consumption and related harms. Evidence seems to be more developed and strongest for outlets that sell alcohol for on-premise consumption compared with outlets selling alcohol for off-premise consumption. A 2015 systematic review focusing on literature from 2009 to 2014 (REF. 113), although still concluding that restricting outlet density might reduce alcohol-related harms, has been

critical of methods used in outlet density studies and of the conclusions drawn in the earlier reviews. This review is contentious and has been the topic of commentary by other experts in the field[114].

Purchasing age laws. Convincing evidence from studies of the impact of increases and decreases in legal drinking ages show that higher legal drinking ages are associated with fewer road traffic crashes involving young people than lower legal drinking ages[4,115]. Studies have also demonstrated the effectiveness of enforcement strategies that restrict the access of underage drinkers to alcohol[116]. Both the legal age of purchase and the extent to which this law is enforced will limit access by underage drinkers and potentially reduce harm to this specific group who are at a very high risk for a range of alcohol-related problems[117,118].

Restricting alcohol marketing

Alcoholic beverages are promoted extensively around the world. In the USA alone, 14 alcohol companies spent US$3.4 billion on marketing in 2011 (REF. 119) and alcohol companies are among the ten leading advertisers in numerous low-income and middle-income countries[120]. Beyond traditional advertising, contemporary alcohol marketing encompasses point-of-sale advertising, sponsorship of sporting and other events and celebrities, promotional allowances and other incentives to retailers, internet advertising and social media, product placement, and social responsibility programs and messages. Particular products or marketing campaigns might be perceived to target women or vulnerable populations such as young people or low socioeconomic groups[121,122].

A substantial and growing body of research literature has found that youth exposure to alcohol marketing is associated with increased likelihood of drinking initiation, and with increased alcohol consumption among young people who have already begun to drink. Published systematic reviews have identified 13 longitudinal studies that have found the association described above; however, the effect sizes reported in these studies are modest[123,124]. All the longitudinal studies to date have examined associations between alcohol marketing exposure and consumption of alcohol in general or consumption by alcohol type. In recognition of the branded nature of alcohol marketing and consumption, some cross-sectional work has focused on exposure and consumption by alcohol brand, finding much stronger associations than longitudinal studies[125].

In comparison with other interventions to reduce alcohol-related harm, advertising and marketing restrictions have consistently been found to be highly cost-effective[71,126,127]. Although no studies to date of which we are aware have examined the effectiveness of specific policy initiatives to reduce alcohol marketing, multiple studies have used modelling to assess the effect of such reductions in alcohol marketing on health outcomes at the population level[126,128].

Self-regulation. The most common form of alcohol marketing regulation worldwide is alcohol industry self-regulation[3]; however, numerous studies from multiple countries have shown this form of regulation to be ineffective either in protecting young people from disproportionate exposure to alcohol marketing[129,130] or in restricting objectionable advertising content[131,132].

Total or partial bans. The most effective and cost-effective approach to reducing alcohol marketing exposure among populations is a total ban on alcohol marketing, which is relatively easy to implement, except when it comes to digital media that cross national borders[126]. The Loi Évin[4,133] law in France, passed in 1991 and named after health minister Claude Évin, offers a model for partial bans by prohibiting all marketing activities and then writing exceptions to that prohibition, thereby requiring that all new marketing innovations be approved by Parliament. Partial bans might include: restrictions on content, such as limitations on lifestyle advertising or restricting marketing communications solely to product qualities; time-specific bans, such as time watersheds permitting alcohol advertising only at certain times of day; audience-specific bans, such as restrictions on marketing in youth venues or in media more likely to be attended by young people than adults; other specific bans relating to the type of beverage, the advertising medium and television channels, such as no advertising of distilled spirits on national free-to-air television, or on channels popular with young people such as MTV © (Viacom International Media Networks Europe); and bans specific to geographical location and events, for instance restricting alcohol advertising in close proximity to schools or playgrounds or at sporting events.

Implementation of anything short of a total ban requires the creation of a monitoring function. Commercial data sources might be useful in assessing the degree to which standards to prevent disproportionate exposure of young people are being followed; however, these data sources can be expensive and require specialized expertise if they are to be properly employed[134]. France provides a model for incentivising public monitoring and enforcement of its ban, through a provision that permits nongovernmental organizations to bring legal action in the courts and be awarded resulting fines when they can show the law is being violated[135].

Counter-advertising. Finally, counter-advertising is an alternative or addition to the regulation of alcohol marketing. Although mandated government counter-advertising has been shown to be effective in reducing youth smoking[136], this approach remains largely untested in the case of alcohol marketing.

Conclusions

Clearly, alcohol causes a huge preventable burden on global health, the biggest single preventable factor in premature death and disability in adults aged 15–49 years (REF. 6), and we have evidence-based strategies to reduce this burden. Whether governments have an appetite for the regulatory measures that work is less clear, and with the increasing influence of global alcohol producers there is need for international action comparable to the WHO Framework Convention on Tobacco Control[137]. Implementing such a framework will require shifting public opinion to allow such action, and here the recognition of alcohol as a major harm to innocent bystanders, particularly children, is key. The emerging data on alcohol as a cause of common cancers will also be important to influence public opinion. Indeed, information and education might be more effective in creating support for effective public health policy rather than directly changing individual behaviour[138]. Scientists and clinicians will most likely have a role in these areas to rebalance our troubled relationship with society's favourite drug.

As we wait for our public health advocacy to be heard and for governments to take the necessary action, what can clinicians do? As well as continuing to advocate for policy action, they should remember that identification and treatment of individuals is effective across the spectrum of problem drinking, from early identification and brief advice through to treatment services for established dependence[4].

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2.2 Association between nightlife goers' likelihood of an alcohol use disorder and their preferred bar's closing time: A cross-sectional observational study in Perth, Australia

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Article

Association between Nightlife Goers' Likelihood of an Alcohol Use Disorder and Their Preferred Bar's Closing Time: A Cross-Sectional Observational Study in Perth, Australia

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Abstract: Introduction and aims: Associations between longer-term alcohol-related conditions and licensed outlet trading hours are not well understood. We investigated the association between nightlife-goers' likelihood of an alcohol use disorder (AUD) and their preference for bars with special permits to remain open 'late' (i.e., spent more time there compared to any other venue) until 2 a.m. or 3 a.m. (Friday; Saturday) or midnight (Sunday) compared to bars with 'standard' closing times of midnight (Friday; Saturday) or 10 p.m. (Sunday). Design and methods: A cross-sectional observational study was conducted in four major nightlife areas of Perth, Australia, in 2015–2016. We conducted weekend street intercept surveys outside bars between 8 p.m. and 3 a.m. and screened participants who reported alcohol use prior to the survey and spent more time in a bar than any other venue type (n = 667) regarding their past year drinking pattern using AUDIT-C (n = 459). We used gender-specific logistic regression models to estimate associations between AUDIT-C categories (1–4, low risk; 5–7, hazardous; 8–12, active AUD) and preference for bars with different closing times (late vs. standard). Results: A large proportion of participants were hazardous drinkers or had active AUD (83% males; 65% females), and over half preferred a late to a standard closing bar. We found evidence of a positive association between preference for late closing bars and hazardous drinking females (OR = 3.48; 95% CI 1.47–8.23; p = 0.01), but not for females with active AUD, male hazardous drinkers, nor males with active AUD. Discussion and conclusions: Our study adds new evidence on associations between likelihood of AUD among nightlife-goers and trading hours. With increasing international relaxation of trading hours, evidence that late closing bars may be preferred by hazardous drinking females will be of concern to policymakers wanting to curb alcohol-related harms in the community.

Keywords: nightlife-goers; bars; on-trade licensed outlets; trading hours; closing times; AUDIT-C; alcohol use disorders; alcohol policy

1. Introduction

In countries where alcohol is a legal and regulated product, government control over availability is most frequently exercised through taxation, minimum legal purchase age, and a licensing system for production, wholesale and retail—regulating how, when and where outlets operate. Decades of accumulated international research, predominantly from North America, Northern Europe and Australasia, have identified that restrictions

on alcohol's economic (i.e., retail price relative to disposable income) and physical (e.g., numbers of outlets, trading hours) availability are key to effectively reducing population-level alcohol consumption and related harms [1].

Availability theory suggests that greater availability will affect harm by affecting the distribution of drinking behaviors, and those harms will differ by population subgroups according to their drinking patterns and behaviors [2]. In response to changes in availability, changes in underlying drinking patterns in a population may lead to changes across a range of alcohol-related harms. For instance, research distinguishes between heavy episodic drinking that results in increased risk of shorter-term harms (e.g., injury from road traffic crashes and violence) and regular heavy use that results in increased risk of longer-term harms (e.g., alcohol dependence and liver cirrhosis) [3].

Studies of alcohol availability effects, particularly physical availability, such as outlet density and trading hours, have tended to focus on shorter-term harms (e.g., assault). By comparison, physical availability effects on potential longer-term harms, such as risk of alcohol use disorders (AUD), have been less well explored. In Australia, for instance, only two outlet density studies have examined longer-term outcomes. A longitudinal study from Victoria found off-trade outlet density was positively associated with hospitalization rates for longer-term alcohol-related conditions [4], and a cross-sectional study from Western Australia found patients' residential proximity to off-trade outlets was associated with increased risk of secondary care contact for anxiety, stress and depression [5].

Systematic reviews have generally concluded that even relatively small extensions or restrictions applied to on-trade (where alcohol is consumed *on* the premises e.g., bars, nightclubs) or off-trade (where alcohol is consumed elsewhere, e.g., liquor stores, supermarkets) outlet trading hours can change population-level alcohol consumption and related harms [6–12]. Moreover, a meta-analysis of six natural experiments that investigated associations between off-trade days of alcohol sale and per capita consumption from North America and Sweden, found an additional day of alcohol sale was associated with a 3.4% increase in per capita consumption [13].

There are few studies of the associations between longer-term alcohol-related problems and licensed outlet trading hours. One German controlled interrupted time series analyses evaluating a state's ban on alcohol sales from off-trade outlets between 10 p.m. and 5 a.m. found reductions in hospitalizations for mental and behavioral disorders due to use of alcohol (ICD10 code: F10; includes acute intoxication, harmful use and dependence) in both male and female adolescents and young adults in the post intervention period, though the effect on males was stronger [14]. To our knowledge, only one study has investigated the association between likelihood of AUD and alcohol outlet trading hours. Conducted in Perth, Australia, almost 40 years ago, the study compared drinkers at bars opening at 6 a.m. or 7 a.m. with drinkers at bars opening later at 10 a.m. Using an abbreviated form of the Michigan Alcoholism Screening Test, the study found that males who drank at early opening pubs were more likely to obtain scores indicative of problem drinking compared to males who drank at later opening bars [15].

Despite a narrowing gap between males and females in terms of their levels of alcohol consumption in Australia, there are still marked differences in their drinking patterns from national surveys of the general population [16] and from national surveys of nightlife-goers [17]. Therefore, it is important to consider possible gender differences in analyses of availability and alcohol use. We investigated the association between likelihood of AUD among nightlife-goers who went 'out' drinking in Perth, Australia, and their preference for bars with different closing times (late vs. standard; spent more time in a late or standard bar compared to any other venue). We hypothesized that those with a drinking pattern indicating hazardous use or active AUD would be more likely to prefer bars with late closing hours to standard closing bars compared to low risk drinkers, and that there would be difference between males and females for these associations. To our knowledge, this is the first nightlife study to investigate whether past year alcohol consumption patterns among nightlife-goers are associated with the trading hours of their preferred bars.

2. Methods

2.1. Street Intercept Surveys

Trained teams of between six and 12 researchers conducted street intercept surveys from November 2015 to April 2016 in metropolitan Perth's four main nightlife precincts: Perth City (five sessions); Northbridge (five sessions); Leederville (two sessions); Fremantle (one session). We avoided major events and public holidays when atypical drinking sessions may occur (e.g., New Year's Eve, Australia Day). Surveys took place in public spaces between 8 p.m. and 3 a.m. on either a Friday (five sessions) or Saturday (six sessions) and between 8 p.m. and midnight on a Sunday (two sessions). To approximate a random sample, field workers invited every third person who walked past them to participate. Field workers recorded non-responses as declines to participate only after a person had engaged with them and had the purpose of the study explained to them. Overall, we achieved a response rate of 89%. Several studies of substance use in nightlife areas have employed a street intercept approach, for example, [18,19], and it has been shown to be effective in recruiting samples of nightlife-goers [20]. We selected survey locations strategically using DLGSCI information, bar websites and Google Maps™ to ensure gender-specific minimum quotas of 200 each for nightlife-goers preferring a late or standard closing bar.

Field workers delivered the survey instrument using Tap Forms™ on smartphones which automatically recorded date and time of survey. After gaining informed consent, participants self-reported gender, birth year and usual occupation. Field workers then asked participants a series of questions related to their drinking behaviors that night prior to survey including: Had they drunk any alcohol? How long had they been drinking? Had they been drinking at licensed venues? Had they been drinking elsewhere prior to drinking at licensed venues (i.e., pre-drinking)? Had they drunk energy drinks? Was it a typical night out for them?

If participants had been drinking at licensed venues, field workers asked them the names of the venues they had attended and about how much time had they spent at each. As described below, we used this question to define whether their preferred bar's hours were late or standard closing. Field workers then asked participants the three Alcohol Use Disorder Identification Test—Consumption (AUDIT-C) questions, assessing frequency of drinking, typical number of drinks consumed on a drinking occasion, and frequency of six or more standard drinks, all over the past year [21]. AUDIT-C is a quick, simple, reliable and well validated tool to screen for hazardous drinking or active AUD based on past year drinking pattern [22–25] and has been used in research studies outside of clinical settings previously, for example, [26].

2.2. Bar's Closing Times

The Perth liquor licensing system allows bars to apply to the Department of Local Government, Sport and Cultural Industries (DLGSCI) for extended trading permits that enable late night (or early morning) alcohol sales. At the time of the current study, standard closing for bars was midnight Monday to Saturday and 10 p.m. Sunday. However, after application and approval for a closing time extension, some were permitted to trade up until 2 a.m. or 3 a.m. Monday to Saturday and to midnight Sunday (late closing).

At the commencement of data collection, legislation change in local liquor licensing was implemented at very short notice [27]. From 20 November 2015, all bars (i.e., not just those with special permits) were allowed to trade up to midnight on Sunday nights rather than closing at 10 p.m. Surveys took place on two Sunday nights in the early months of the study (22 November, 20 December), and because we observed little uptake of these relaxed trading hours on the ground we did not change what constituted late (midnight) vs. standard (10 p.m.) closing bars for these dates. We halted Sunday surveys at the end of 2015 due to the potential for bars to start taking up the newly relaxed trading hours and because it was more difficult to meet survey quotas on quieter Sunday nights.

2.3. Survey Data

Regardless of the time of survey, participants who reported alcohol use may not have visited a licensed venue at all or may have visited a number of different venues on their night out (including restaurants, both standard and late closing bars, nightclubs etc.). Participants surveyed past midnight, therefore, were not necessarily drinkers from late closing bars and vice versa. We defined participants' 'preferred venue' as where they had spent more time that night compared to other venues and assumed this is where they had probably consumed most alcohol. We coded 'preferred bars' according to whether they had standard (0) or late (1) closing using DLGSCI records and cross-checked against bar websites for currency. We found only one bar had its late trading permit revoked during the study period; in this instance bar trading status (late; standard) was coded based on date of survey and date of permit revocation.

We categorized AUDIT-C scores into three groups using the same raw score cut-offs for males and females: 1–4, low risk drinker; 5–7, hazardous drinker; 8–12, drinker with active AUD [28]. We estimated participant age using date of survey and year of birth then categorized into four groups: 18–21; 22–25; 26–29; $\geq$30. We classified occupation according to the Australian and New Zealand Standard Classification of Occupations (plus an 'Other' category to capture students, stay-at-home parents, unemployed etc.) [29] and grouped as follows: manager/professional; technician/trade/laborer; community/personal service; clerical/administrative/sales; other. We dichotomized time of survey into 'before midnight' and 'midnight and after', reflecting the distinction between late and standard closing bars. In order to reflect typical night-time drinking occasions, we categorized day of survey (i.e., Friday, Saturday or Sunday) according to when data collection sessions were initiated, for example, surveys undertaken between 10 p.m. Friday night and 2 a.m. the following morning were all considered a 'Friday' night survey.

2.4. Statistical Analysis

We used Pearson's chi-square tests and independent samples t-tests to explore bivariate associations (Table 1). We used multivariable logistic regression models to investigate whether participant likelihood of AUD was associated with preferring a standard or late closing bar (Table 2). We ran two gender-specific models and adjusted for a range of potential confounders including: age, occupation, day of survey, time of survey, drinking session duration, whether it was a typical night out, pre-drinking and energy drink use using a backward stepwise selection approach. Hosmer and Lemeshow statistics assessed the models' goodness-of-fit. We used SPSS Statistics v27.0 (IBM Corp, Armonk, NY, USA) for all analyses [30].

2.5. Ethics

We conducted this study in accordance with the National Statement on Ethical Conduct in Human Research and the Human Research Ethics Committees at Curtin University approved it (HR154/2015). Participants provided informed consent to field workers who recorded responses in an electronic data collection smartphone application.

Table 1. Gender-specific descriptive statistics and bivariate analyses for participant and survey characteristics by participants' preferred bar's closing time.

Variables [±]	**Male**					**Female**				
	Late		**Standard**			**Late**		**Standard**		
Participant characteristics	*n*	%	*n*	%		*n*	%	*n*	%	
AUDIT-C										
1–4 (low risk)	27	16	27	19	$\chi^2(2) = 1.2$, $p = 0.54$	23	27	29	46	$\chi^2(2) = 10.2$, $p = 0.01$
5–7 (hazardous)	67	39	58	41		48	56	19	30	
8–12 (active AUD)	77	45	55	39		14	16	15	24	
Total	171	100	140	100		85	100	63	100	
Age										
18–21	46	18	24	12	$\chi^2(3) = 7.0$, $p = 0.07$	39	31	19	22	$\chi^2(2) = 8.2$, $p = 0.04$
22–25	73	29	48	24		41	32	25	29	
26–29	56	22	59	29		16	13	24	28	
≥30	76	30	70	35		31	24	18	21	
Total	251	100	201	100		127	100	86	100	
Occupation										
Manager/professional	83	34	77	39	$\chi^2(4) = 8.4$, $p = 0.08$	29	24	28	33	$\chi^2(4) = 3.9$, $p = 0.42$
Technician/trade/labourer	88	36	65	33		8	7	6	7	
Community/personal service	18	7	15	8		25	20	12	14	
Clerical/administrative/sales	24	10	7	4		28	23	22	26	
Other	31	13	33	17		33	27	17	20	
Total	244	100	197	100		123	100	85	100	
Pre-drinking										
No	110	44	108	53	$\chi^2(1) = 3.8$, $p = 0.05$	52	41	53	62	$\chi^2(1) = 8.8$, $p < 0.01$
Yes	140	56	95	47		75	59	33	38	
Total	250	100	203	100		127	100	86	100	
Energy drink use										
No	205	82	185	91	$\chi^2(1) = 8.3$, $p < 0.01$	110	87	79	92	$\chi^2(1) = 1.4$, $p = 0.24$
Yes	46	18	18	9		17	13	7	8	
Total	251	100	203	100		127	100	86	100	
Was it a typical night out?										
No, usually smaller	44	33	32	25	$\chi^2(2) = 2.0$, $p = 0.37$	20	25	16	27	$\chi^2(2) = 2.9$, $p = 0.24$
No, usually bigger	28	21	27	21		13	16	16	27	
Yes	62	46	68	54		46	58	27	46	
Total	134	100	127	100		79	100	59	100	
Drinking session duration (hours)	*n*	Mean (SD)	*n*	Mean (SD)		*n*	Mean (SD)	*n*	Mean (SD)	
	246	4.8 (2.7)	198	5.0 (2.5)	t (442) = 0.9, $p = 0.31$	126	4.5 (2.3)	86	4.4 (2.0)	t(210) = −0.3, $p = 0.48$
Survey characteristics	*n*	%	*n*	%		*n*	%	*n*	%	
Day										
Friday	108	43	48	24	$\chi^2(2) = 21.0$, $p < 0.001$	52	41	19	22	$\chi^2(2) = 10.1$, $p = 0.01$
Saturday	119	47	118	58		64	50	62	72	
Sunday	24	10	37	18		11	9	5	6	
Total	251	100	203	100		127	100	86	100	
Time										
Before midnight	127	51	134	66	$\chi^2(1) = 10.9$, $p = 0.001$	60	47	52	60	$\chi^2(1) = 3.6$, $p = 0.06$
Midnight and after	124	49	69	34		67	53	34	40	
Total	251	100	203	100		127	100	86	100	

[±] Small or big night out are colloquialisms regarding level of perceived intoxication.

Table 2. Results from two gender-specific logistic regression models: Association between AUDIT-C category and participants' preferred bar's closing time (late = 1; standard = 0) adjusting for survey and participant characteristics ±.

Variables ±	**Male (*n* = 306)**					**Female (*n* = 148)**				
Participant characteristics	*n*	OR	LCI	UCI	*p*-Value	*n*	OR	LCI	UCI	*p*-Value
AUDIT-C										
1–4 (low risk) [Ref]	54					52				
5–7 (hazardous)	121	1.06	0.54	2.09	0.87	67	3.48	1.47	8.23	<0.01
8–12 (active AUD)	131	1.31	0.66	2.62	0.44	29	1.23	0.43	3.52	0.70
Age										
18–21	57	2.82	1.26	6.33	0.01	39	0.96	0.33	2.78	0.94
22–25	84	1.48	0.78	2.81	0.23	51	0.73	0.26	2.06	0.55
26–29	76	1.09	0.57	2.08	0.80	25	0.13	0.04	0.49	<0.01
≥30 [Ref]	89					33				
Occupation										
Manager/professional	100	2.11	0.96	4.65	0.07					
Technician/trade/labourer	115	2.02	0.96	4.25	0.06					
Community/personal service	20	1.22	0.41	3.62	0.72					
Clerical/administrative/sales	21	3.46	1.09	10.94	0.03					
Other [Ref]	50									
Survey characteristics										
Day										
Friday	111	1.92	1.14	3.22	0.01	53	3.22	1.43	7.26	<0.01
Saturday [Ref]	163					86				
Sunday	32	0.58	0.26	1.28	0.18	9	2.99	0.60	15.04	0.18

Male model: Hosmer and Lemeshow $\chi^2(8) = 10.3$, $p = 0.25$. Female model: Hosmer and Lemeshow $\chi^2(7) = 1.1$, $p = 0.99$. OR: Odds ratio. L/UCI: 95% lower/upper confidence interval. [Ref]: Reference group. ± Time of survey, duration of drinking session, pre-drinking, energy drink use and whether it was a typical night out were non-contributing variables in both models and removed in the backward stepwise selection approach. Occupation was a non-contributing variable in the female model and was removed in the backward stepwise selection approach.

3. Results

As shown in Table 1, of the 667 participants who reported alcohol use at a licensed venue and preferred a bar to other venue types, 459 completed the AUDIT-C. A large proportion of participants were hazardous drinkers (40% males; 45% females) or had active AUD (42% males; 20% females). Over half of male and female participants preferred a late closing bar to a standard closing bar. Gender-specific bivariate analyses indicated evidence of association between AUDIT-C and bar closing time for females but not males. Hazardous drinking females preferred late closing bars over standard closing bars, but for low risk drinking females and females with active AUD the association was the opposite. Age was associated with preferred bar for female participants, with those in all age groups except 26–29 more likely to prefer later closing. Participants were from a range of occupations, but there was no evidence of association between occupation and bar preference. For males and females, pre-drinking was more common among those preferring late closing bars. Less than a fifth of participants reported energy drink use, with males who used energy drinks more likely to prefer late closing bars. Half reported that it was not a typical night out for them, with males reporting a non-typical night out more likely to prefer late closing bars. In terms of survey characteristics, preference for late closing bars was more likely among those surveyed on Friday nights than on Saturday nights and more likely among those surveyed after midnight than before midnight.

Hosmer and Lemeshow statistics raised no concerns about the goodness-of-fit of the two logistic regression models (Table 2). Model results indicated no evidence of association between males' AUDIT-C category and their preferred bar's closing time. For male participants, the preference for late-closing bars was associated with the following:

the youngest age group (age 18–21); clerical occupations (compared to 'other'); and the survey occurring on Friday night.

Model results for female participants indicated an association between a preference for late closing bars and hazardous drinking (OR = 3.48; 95% CI 1.47–8.23; $p = 0.01$) compared to low risk drinking, but not for active AUD. For females, there was also a positive association between a preference for late closing bars and being surveyed on Friday night compared to Saturday night, but a negative association with being 26–29 years old compared to 30 years and older.

4. Discussion

Female hazardous drinkers were more likely to prefer a late closing bar when compared to female low risk drinkers. We found no evidence to support our hypothesis of a positive association between preference for late closing bars and females with active AUD, male hazardous drinkers or males with active AUD.

International research has demonstrated positive associations between licensed outlet trading hours and population-level per capita alcohol consumption [13], and both male and female adolescent and young adult hospitalizations for mental and behavioral disorders due to use of alcohol (encompassing shorter-term and longer-term harms) [14]. The only study that we are aware of that has focused specifically on the relationship between AUD and patron attendance at bars with extended trading hours found a positive association for males (females were not included in the study) [15]. However, that study investigated the association for *earlier* opening hours rather than *later* closing as in the present study. Our study was partly consistent with those findings but only for female hazardous drinkers (not for the heaviest drinking females nor male participants at all). Sample size for females with active AUD was smaller than for the other AUDIT-C categories and this may have affected statistical power. Gender differences in our findings may be related to other characteristics of bars themselves that we were unable to adjust for, for example, in terms of their target audience, marketing and entertainment. The lack of evidence for association for males may also be explained by the high proportion who said it was not a typical night out. Thus, male attendance (or lack of attendance) at a late closing bar on the night of survey may have been less reflective of their usual pattern.

Licensed outlets' closing times and their associations with harm are a policy issue highly relevant to liquor licensing, health and law enforcement authorities and to the general public.

Our results are directly relevant for Western Australian decision makers in the wake of state-wide Sunday closing time relaxation (from 10 pm to midnight) for bars in 2015 (see methods) and in light of proposals to introduce Sunday trading for liquor stores in regional areas across the state (currently restricted except for cases where extended trading time permits are held), both recommendations coming out of a review of the Western Australian Liquor Control Act in 2013 [26]. At present, applications and decisions relating to extended trading time permits for bars are made by the Department of Local Government, Sport and Cultural Industries on an ad hoc basis, likely with inconsistent reference to research evidence. As international and even national research findings can often be interpreted as unrelated to local contexts, this study may help to fill a local knowledge gap. As well, it may suggest more generally an important link between later closing and hazardous drinking among females.

Limitations

We made several assumptions in assigning participants to late vs. standard closing bars. We assumed that time spent in a bar was positively associated with quantity of alcohol consumed, which may not necessarily be the case. We also assumed spending most time in one venue type meant that the sum of time over the night would be in favor of that venue type, that is, participants who spent two hours in one late closing bar and one hour in each of three standard closing bars will have been assigned as preferring late closing

bars. Furthermore, half of participants were not on a typical night out for them so may have been drinking at venues they did not typically frequent and/or may have gone home earlier or stayed out later than usual.

It is important to note that we were only able to discern evidence of cross-sectional associations between nightlife-goers' heavy drinking and their preference for late closing bars not whether heavier drinking leads to frequenting later closing bars or vice versa. The study also used self-report which may not be the most accurate measure as cognitive ability declines with alcohol intoxication [31]. Finally, our results may not be generalizable to other nightlife areas outside of Perth, Australia.

5. Conclusions

Our study adds new evidence to the alcohol physical availability research on associations between longer-term alcohol problems among nightlife-goers and alcohol outlet trading hours. With increasing state, national and international relaxation of trading hours for licensed outlets, evidence that preference for later closing bars is associated with hazardous drinking among females will be of concern to policymakers wanting to curb alcohol-related harms in the community.

Author Contributions: W.G.: Conceptualisation, investigation, methodology, formal analysis, project administration, supervision, writing—original draft, funding acquisition. M.S.: Methodology, writing—review & editing. W.L.: Conceptualisation, investigation, methodology, supervision, writing—review & editing, funding acquisition. K.G.: Conceptualisation, methodology, writing—review & editing, funding acquisition. K.K.: Conceptualisation, methodology, writing—review & editing, funding acquisition. P.M.: Conceptualisation, investigation, methodology, supervision, writing—review & editing, funding acquisition. T.C.: Conceptualisation, investigation, methodology, project administration, supervision, writing—review & editing, funding acquisition. All authors have read and agreed to the published version of the manuscript.

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Institutional Review Board Statement: The study was conducted according to the guidelines of the Declaration of Helsinki, and approved by the Human Research Ethics Committees at Curtin University (protocol code HR154/2015 approved on 11/08/2015).

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The data presented in this study are available on request from the corresponding author subject to ethical approval.

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Conflicts of Interest: P.M. has acted as a paid expert witness on behalf of a licensed venue and a security firm. Other authors declare that they have no conflict of interest.

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2.3 Association between bar closing time, alcohol use disorders and blood alcohol concentration: A cross-sectional observational study of nightlife-goers in Perth, Australia

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Article

Association between Bar Closing Time, Alcohol Use Disorders and Blood Alcohol Concentration: A Cross-Sectional Observational Study of Nightlife-Goers in Perth, Australia

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Abstract: Introduction and aims: Associations between bar trading hours, a government lever for controlling alcohol availability, nightlife-goer intoxication levels and their likelihood of alcohol use disorder (AUD) have not been explored. We investigated whether: (i) participant AUD was associated with blood alcohol concentration (BAC); and, (ii) any association between AUD and BAC was moderated by participant preferred bar (i.e., venue spent most time at) closing time. Design and methods: A cross-sectional observational study using a sample of nightlife-goers who went out drinking in Perth, Western Australia, on weekends in 2015-16. Participants who reported alcohol use that night and spent most time in a bar (n = 667) completed street intercept surveys including AUDIT-C (n = 459) and provided a breath sample to estimate BAC (n = 651). We used gender-specific multinomial logistic regression models to explore associations between participant AUDIT-C score (1–4, lower risk; 5–7, hazardous; 8–12, active AUD), preferred bar type (standard vs. late closing time based on absence or presence of an extended trading permit) and BAC (male: 0–0.049, 0.05–0.099, ≥0.1 g/100 mL; female: 0–0.049, 0.05–0.079, ≥0.08 g/100 mL). Results: Males with active AUD (RR = 3.31; 95% CI 1.30–8.42; $p = 0.01$) and females with hazardous/active AUD (RR = 9.75; 95% CI 2.78–34.21; $p < 0.001$) were both more likely to have high-range BAC than their counterparts typically drinking at lower risk. We also found preferred bar type moderated the association between AUDIT-C score and BAC for some males but no females. Males with active AUD and high-range BAC were less likely to prefer late closing bars than males usually drinking at lower risk and high-range BAC (RR = 0.12; 95% CI 0.02–0.96; $p = 0.046$). Discussion and conclusions: Our study provides evidence of positive associations between AUD and acute intoxication among nightlife-goers and on the moderating effect of bar closing times among males.

Keywords: nightlife-goers; bars; on-trade licensed outlets; alcohol use disorders; AUDIT-C; blood alcohol concentration; BAC; trading hours; closing times; alcohol policy

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1. Introduction

Availability theory proposes that increased alcohol availability in a community will increase alcohol consumption and both short-term and long-term alcohol-related harms, and the distribution of harms will vary according to differing drinking patterns [1]. Stipulating the days and hours that alcohol outlets can trade, via a liquor licensing system, is one government lever for controlling alcohol availability in a community. Systematic reviews [2–8]

and meta-analyses [9] of international research evaluating both community-wide restrictions and extensions to alcohol outlet trading hours have concluded that community-level consumption and related harm are positively associated with outlet trading hours. Associations between bar trading hours, nightlife-goer intoxication levels and their likelihood of alcohol use disorder (AUD) have not been explored.

It might be expected that people with AUD would have high blood alcohol concentrations (BAC) when drinking. Studies of the association between AUD and BAC, to the best of our knowledge, are limited to trauma patients who had BAC calculated from venous blood on presentation and subsequently completed an AUD screen of their usual drinking patterns. Although not tending to be the main focus of these studies, one prospective cohort study of patients admitted to a US trauma centre found evidence of a moderate positive association between AUD and BAC (Spearman's $\rho = 0.45$) [10]. Another, a US retrospective study of admitted intensive care unit trauma patients also found evidence of a positive association between AUD and BAC (Kruskal-Wallis $p < 0.001$) [11].

Research evidence for an association between AUD and outlet trading hours is scant. This is of interest as one might expect that drinkers with AUD may gravitate towards outlets with longer trading hours due to increased alcohol availability. A German study on liquor store trading restrictions between 10 p.m. and 5 a.m. found evidence of positive associations with hospitalisations for mental and behavioural disorders due to alcohol use by younger males (8% reduction) and females (4% reduction) [12]. Studies from Perth, Australia, have found evidence of positive associations between likelihood of AUD and bar trading hours. Based on self-reported past week consumption, a study of male drinkers found those who drank at bars opening at 6 a.m. or 7 a.m. were more likely to have AUD compared to males who drank at bars opening later at 10 a.m. (47% vs. 37%) [13]. A recent nightlife study using the same survey data as the current study found evidence that, based on self-report of past year consumption using AUDIT-C (3 question short form of AUDIT), females drinking hazardously chose to spend most time drinking at 'late' closing bars compared to bars closing at midnight (Friday, Saturday) or 10 p.m. (Sunday) (OR = 3.48; 95% CI 1.47–8.23; $p = 0.01$) [14]. There was no evidence of association for males.

Evidence regarding the association between outlet trading hours and BAC is also scant. An evaluation of restrictions that imposed 3 a.m. alcohol sale cessation across a nightlife area of Brisbane, Australia, found fewer highly intoxicated ($\geq$0.1 g/100 mL BAC) versus moderately intoxicated (0.050–0.099 g/100 mL BAC) nightlife-goers in the month following the restriction compared to the month before (RR = 0.58; 95% CI = 0.43, 0.79) [15]. These findings persisted despite a loophole allowing some premises to trade until 5 a.m. Nightlife research using street intercept survey methodology that includes breathalysing nightlife goers spans North America [16], Europe [17] and Australasia [18]. These studies generally find that average patron BAC increases through the night [19], however, few (if any) have also reported on 'usual' drinking patterns, or likelihood of AUD among participants.

Gender differences in alcohol consumption and experienced harms have been shown to exist in national surveys of nightlife-goers and the general population and in analyses of health data [18,20,21]. Despite a narrowing gap between genders over time, with women catching up with men in their alcohol consumption, it is still men who, on average, consume the most alcohol, have riskier patterns of consumption [20] and who are overrepresented in harm statistics [21]. Alcohol availability studies are therefore enhanced when analyses are able to distinguish by gender [14].

To our knowledge, this is the first study to link BACs and usual drinking patterns of nightlife-goers to the trading hours of the bar they chose to spend most time at on their night out (i.e., their preferred bar). As bar trading hours are the potentially modifiable environmental factor among these variables, this study will be of importance in future government decisions regarding bar trading hour regulations. Using a sample of nightlife-goers who went out drinking in Perth, Western Australia, we aimed to investigate by gender whether: (i) participant likelihood of AUD, based on self-reported past year alcohol use, was associated with BAC, an objective measure of alcohol intoxication; and, (ii) closing

time (standard vs. late) of participant preferred bar moderated (i.e., influenced the strength and/or direction of association [22]) any association between participant AUD and BAC. We hypothesised that: (i) participants with a usual drinking pattern indicating hazardous use or active AUD would be more likely to have a high-range BAC (≥0.1 g/100 mL) on the night of survey compared to typically lower risk drinkers regardless of preferred bar type (standard vs late closing time) (Aim 1); (ii) within categories of AUD risk (lower risk, hazardous, active AUD), participants with a high-range BAC would prefer late closing bars to standard closing bars (Aim 2); and, (iii) gender differences would occur across these associations.

2. Methods

2.1. Street Intercept Surveys

Trained field workers undertook street intercept surveys between November 2015 and April 2016 in metropolitan Perth's major nightlife precincts (Perth City; Northbridge; Leederville; Fremantle). To approximate a random sample, field workers invited every third person in public spaces to participate (8 p.m. to 3 a.m. Friday and Saturday; 8 p.m. to midnight Sunday). We achieved a response rate of 89%, not including passers-by who did not engage with field workers to hear the purpose of the survey. Sample size quotas of 200 by gender and preferred bar type were set. The street intercept approach in this field is well established [14,17,23] and is successful in recruiting samples of nightlife-goers [16].

Following participants' informed consent, field workers entered survey responses on their smartphones in Tap Forms™. Participants self-reported gender, birth year and usual occupation while the survey app captured date and time automatically. Participants answered the three AUDIT-C questions assessing: (i) frequency of drinking; (ii) typical number of drinks consumed on a drinking occasion; and, (iii) frequency of six or more standard drinks, all over the past year [24]. AUDIT-C is a quick, simple, reliable (Cronbach's alpha = 0.7 on another Australian sample in a non-clinical setting [25]) and well validated tool to screen for hazardous drinking or active AUD based on past year drinking pattern [25–29]. Participants provided a breath sample through a calibrated Andatech® AlcoSense® Prodigy Fuel Cell Breathalyser to estimate their BAC (calibration date: 10 September 2015; accuracy: ±0.005 at 0.1 g/100 mL).

The Western Australian liquor licensing system allows bars to apply for extended trading hour permits [30]. Standard closing for bars in 2015 was midnight Monday to Saturday and 10 p.m. Sunday. At the time of study initiation granted permits allowed bars to trade up until 2 a.m. or 3 a.m. Monday to Saturday and until midnight Sunday (i.e., late closing). If participants responded yes to drinking alcohol at one or more licensed venues, field workers asked for venue names and an estimate of how much time was spent at each in order to establish the bar at which they had chosen to spend most time that night. We ceased Sunday field work at the end of 2015 after two nights of surveys because legislation came in to effect relaxing bar trading hours (midnight became 'standard' Sunday closing time) [14,31].

Participants answered other questions related to their drinking behaviours that night including: Had they drunk any alcohol that night (Y/N)? How long had they been drinking (Hours)? Had they been drinking at licensed venues (Y/N)? Had they been pre-drinking (Y/N)? Had they drunk energy drinks (Y/N)? Was it a typical night out for them (Yes; No, smaller than usual; No, bigger than usual)?

2.2. Survey Data

We categorised AUDIT-C scores into three groups using the same raw score cut-offs for males and females: 1–4, lower risk drinker; 5–7, hazardous drinker; 8–12, drinker with active AUD [32]. We further categorised females into two groups due to small numbers in the higher risk categories (5–12, hazardous/active AUD). As male and female BAC distributions were positively skewed, ruling out linear regression, we categorised them. We grouped BAC for males into three levels of intoxication: 0–0.049 g/100 mL;

0.05–0.099 g/100 mL; ≥0.1 g/100 mL, with 0.05 g/100 mL being the drink drive limit in Australia at which a person is deemed legally intoxicated. We grouped BAC for females with lower thresholds due to the different data distribution from males and as females are typically affected by alcohol at a lower BAC than males [33]: 0–0.049 g/100 mL; 0.05–0.079 g/100 mL; ≥0.08 g/100 mL. Records with BAC readings exceeding 0.35 g/100 mL were excluded as erroneous (n = 5) [34]. As it is typical for nightlife-goers to drink at a number of different venues on a night out (e.g., restaurant, bar, nightclub), we used venue names to distinguish venues (i.e., bar vs. other) and the closing time of each bar (standard vs. late) using Department of Local Government Sport and Cultural Industries extended trading permit records and bar websites. We then used venue where most time was spent to define participant 'preferred bar type' and assumed this is where they consumed most alcohol.

We calculated participant age using date of survey and year of birth then categorised into four approximately equal groups based on the distribution of the data: 18–21; 22–25; 26–29; ≥30. We classified occupation according to the Australian and New Zealand Standard Classification of Occupations (plus an 'Other' category to capture students, stay-at-home parents, unemployed) [35] and grouped as follows: manager/professional; technician/trade/labourer; community/personal service; clerical/administrative/sales; other. We dichotomised time of survey into 'before midnight' and 'midnight and after', reflecting the distinction between standard and late closing bars. In order to reflect typical night-time drinking occasions, we categorised day of survey (i.e., Friday, Saturday or Sunday) according to when data collection sessions were initiated, e.g., surveys undertaken between 10 p.m. Friday night and 2 a.m. the following morning were all considered a 'Friday' night survey.

2.3. Statistical Analysis

We used Pearson's chi-square tests and one-way analysis of variance to explore gender-specific bivariate associations between preferred bar type and AUDIT-C score, age, occupation, day of survey, time of survey, drinking session duration, whether it was a typical night out, pre-drinking and energy drink use. We used multinomial logistic regression models with backward stepwise selection approach to investigate associations between AUDIT-C score and BAC and adjusted for the range of potential confounders listed above. We ran six initial gender-specific models to explore the overall association between AUDIT-C score and BAC and the associations by preferred bar type. We then ran two gender-specific models with preferred bar type as an interaction term to determine whether preferred bar type moderated any association between AUDIT-C score and BAC. Likelihood ratio χ^2 tests assessed model goodness-of-fit. We used IBM SPSS Statistics v27.0 (IBM Corp, Armonk, NY, USA) for all analyses [36].

2.4. Ethics

We conducted this study in accordance with the National Statement on Ethical Conduct in Human Research and received ethics approval from Curtin University's Human Research Ethics Committee (HR154/2015). Participants provided informed consent to field workers who recorded responses in a smartphone survey app.

3. Results

Of the 667 participants (males n = 454, females n = 213) who had been drinking and preferred a bar to other venue (e.g., nightclubs), 651 provided a valid BAC, 459 completed the AUDIT-C, 289 preferred standard closing bars and 378 preferred late closing bars (Table 1). Around one-third of male and female participants returned BAC readings of ≥0.1 g/100 mL or ≥0.08 g/100 mL, respectively, regardless of their preference for standard or late closing bars. A large proportion of participants were either typically hazardous drinkers or had active AUD (83% males, 65% females).

Table 1. Gender-specific descriptive statistics and bivariate analyses for participant and survey characteristics by preferred bar type (standard vs. late).

Variables	**Male**							**Female**						
	Standard		**Late**		**Total**			**Standard**		**Late**		**Total**		
Participant Characteristics	**n**	**%**	**n**	**%**	**n**	**%**		**n**	**%**	**n**	**%**	**n**	**%**	
BAC (g/100 mL)														
0–0.049	68	35	89	36	157	35		41	50	47	37	88	42	
0.05–0.079 (female)	-	-	-	-	-	-		15	18	28	22	43	21	
≥0.08 (female)	-	-	-	-	-	-	$\chi^2(2) = 0.6$, $p = 0.75$	26	32	51	40	77	37	$\chi^2(2) = 3.3$, $p = 0.19$
0.05–0.099 (male)	59	30	82	33	141	32		-	-	-	-	-	-	
≥0.1 (male)	67	35	78	31	145	33		-	-	-	-	-	-	
Total	194	100	249	100	443	100		82	100	126	100	208	100	
AUDIT-C score														
1–4 lower risk	27	19	27	16	54	17		29	46	23	27	52	35	
5–12 hazardous/active AUD (f)	-	-	-	-	-	-	$\chi^2(2) = 1.2$, $p = 0.54$	34	54	62	73	96	65	$\chi^2(1) = 5.7$, $p = 0.02$
5–7 hazardous (m)	58	41	67	39	125	40		-	-	-	-	-	-	
8–12 active AUD (m)	55	39	77	45	132	42		-	-	-	-	-	-	
Total	140	100	171	100	311	100		63	100	85	100	148	100	
Age														
18–21	24	12	46	18	70	15		19	22	39	31	58	27	
22–25	48	24	73	29	121	27	$\chi^2(3) = 7.0$,	25	29	41	32	66	31	$\chi^2(3) = 8.2$,
26–29	59	29	56	22	115	25	$p = 0.07$	24	28	16	13	40	19	$p = 0.04$
≥30	70	35	76	30	146	32		18	21	31	24	49	23	
Total	201	100	251	100	452	100		86	100	127	100	213	100	
Occupation														
Manager/professional	65	33	88	36	153	35		6	7	8	7	14	7	
Technician/trade/labourer	15	8	18	7	33	7		12	14	25	20	37	18	
Community/personal service	7	4	24	10	31	7	$\chi^2(4) = 8.4$, $p = 0.08$	22	26	28	23	50	24	$\chi^2(4) = 3.9$, $p = 0.42$
Clerical/administrative/sales	33	17	31	13	64	15		17	20	33	27	50	24	
Other	77	39	83	34	160	36		28	33	29	24	57	27	
Total	197	100	244	100	441	100		85	100	123	100	208	100	

Table 1. *Cont.*

Variables	**Male**							**Female**						
	Standard		**Late**		**Total**			**Standard**		**Late**		**Total**		
Pre-drinking														
No	108	53	110	44	218	48	$\chi^2(1) = 3.8$, $p = 0.05$	53	62	52	41	105	49	$\chi^2(1) = 8.8$, $p < 0.01$
Yes	95	47	140	56	235	52		33	38	75	59	108	51	
Total	203	100	250	100	453	100		86	100	127	100	213	100	
Energy drink use														
No	185	91	205	82	390	86	$\chi^2(1) = 8.3$, $p < 0.01$	79	92	110	87	189	89	$\chi^2(1) = 1.4$, $p = 0.24$
Yes	18	9	46	18	64	14		7	8	17	13	24	11	
Total	203	100	251	100	454	100		86	100	127	100	213	100	
Typical night out? [±]														
No, usually smaller	32	25	44	33	76	29	$\chi^2(2) = 2.0$, $p = 0.37$	16	27	20	25	36	26	$\chi^2(2) = 2.9$, $p = 0.24$
No, usually bigger	27	21	28	21	55	21		16	27	13	16	29	21	
Yes	68	54	62	46	130	50		27	46	46	58	73	53	
Total	127	100	134	100	261	100		59	100	79	100	138	100	
Session duration (Hours)	n	Mean (SD)	n	Mean (SD)	n	Mean (SD)		n	Mean (SD)	n	Mean (SD)	n	Mean (SD)	
	198	5.05 (2.52)	246	4.81 (2.73)	444	4.92 (2.64)	$F(1, 442) = 0.9$, $p = 0.35$	86	4.41 (2.02)	126	4.52 (2.27)	212	4.47 (2.17)	$F(1, 210) = 0.1$, $p = 0.74$
Survey characteristics	n	%	n	%	n	%		n	%	n	%	n	%	
Day														
Friday	48	24	108	43	156	34	$\chi^2(2) = 21.0$, $p < 0.001$	19	22	52	41	71	33	$\chi^2(2) = 10.1$, $p < 0.01$
Saturday	118	58	119	47	237	52		62	72	64	50	126	59	
Sunday	37	18	24	10	61	13		5	6	11	9	16	8	
Total	203	100	251	100	454	100		86	100	127	100	213	100	
Time														
Before midnight	134	66	127	51	261	57	$\chi^2(1) = 10.9$, $p < 0.001$	52	60	60	47	112	53	$\chi^2(1) = 3.6$, $p = 0.06$
Midnight and after	69	34	124	49	193	43		34	40	67	53	101	47	
Total	203	100	251	100	454	100		86	100	127	100	213	100	

f: Female. m: Male. n: Sample size. Not all % totals sum to 100 due to rounding. [±] Small or big night out are colloquialisms regarding level of perceived intoxication.

Gender-specific bivariate analyses indicated evidence of a positive association between female AUDIT-C score and preferred bar type. There was no evidence of association between BAC and preferred bar type for either gender. Of the other participant characteristics, female preferred bar type was positively associated with age and pre-drinking. Male preferred bar type was positively associated with energy drink use. Of the survey characteristics, weekday was positively associated with both male and female preferred bar type, with a higher proportion of Friday night participants preferring late closing bars for both genders. Time of day was positively associated with male preferred bar type but not female. For the following multinomial logistic regression model results, likelihood ratio χ^2 tests gave no cause for concern regarding model goodness-of-fit (Tables 2 and 3).

3.1. AUDIT-C Score and BAC by Preferred Bar Type

Overall, males with active AUD (RR = 3.31; 95% CI 1.30–8.42; $p = 0.01$) and females with hazardous/active AUD (RR = 9.75; 95% CI 2.78–34.21; $p < 0.001$) were more likely to have a high-range BAC than lower risk drinkers (Table 2 and Figure 1). When stratifying by preferred bar type, associations held among males (RR = 13.42; 95% CI 2.47–72.97; $p = 0.003$) and females (RR = 6.18; 95% CI 1.35–28.21; $p = 0.02$) preferring standard closing bars and among females preferring late closing bars (RR = 21.89; 95% CI 3.50–137.10; $p < 0.001$) (Table 2 and Figure 1). For males, high-range BAC was negatively associated with not having pre-drunk when not accounting for preferred bar type but positively associated with usually having a smaller night out among those preferring late closing bars and with drinking session duration regardless of preferred bar type. For females preferring late closing bars, high-range BAC was positively associated with drinking session duration and being surveyed after midnight and negatively associated with younger age groups (18–21; 22–25).

3.2. AUDIT-C Score and Preferred Bar Type on BAC

When preferred bar type was included in gender-specific models as an interaction term (Table 3 and Figure 1), there was evidence of association between AUDIT-C score, preferred bar type and BAC for some males but no females. Males with active AUD and a high-range BAC were less likely to prefer late closing bars to standard closing bars than males drinking at lower risk with a high-range BAC (RR = 0.12; 95% CI 0.02–0.96; $p = 0.046$). For males, high-range BAC was positively associated with drinking session duration and mid-range BAC was positively associated with pre-drinking and drinking session duration. For females, high-range BAC was positively associated with drinking session duration and being surveyed after midnight and negatively associated with both technical and clerical occupations and mid-range BAC was positively associated with usually having a smaller night out and negatively associated with a clerical occupation.

Table 2. Gender-specific multinomial logistic regression models: Association between participant AUDIT-C and BAC by preferred bar type (standard, late, total) adjusting for survey and participant characteristics [±].

Variables [±]	**Male**										**Female**									
	BAC 0.05–0.099 g/100 mL					**BAC ≥ 0.1 g/100 mL**					**BAC 0.05–0.079 g/100 mL**					**BAC ≥ 0.08 g/100 mL**				
	n	**RR**	**LCI**	**UCI**	***p*-Value**	**n**	**RR**	**LCI**	**UCI**	***p*-value**	**n**	**RR**	**LCI**	**UCI**	***p*-Value**	**n**	**RR**	**LCI**	**UCI**	***p*-Value**
Standard closing time models	Likelihood ratio $\chi^2(6) = 26.8$, $p < 0.001$										Likelihood ratio $\chi^2(6) = 13.6$, $p = 0.04$									
AUDIT-C score																				
1–4 lower risk [Ref]	10					2					5					3				
5–12 haz/active AUD (f)	-	-	-	-	-	-	-	-	-	-	5	2.06	0.41	10.33	0.38	11	6.18	1.35	28.21	0.02
5–7 hazardous (m)	19	1.17	0.40	3.41	0.77	17	5.07	0.95	27.05	0.06	-	-	-	-	-	-	-	-	-	-
8–12 active AUD (m)	13	1.35	0.42	4.36	0.61	26	13.42	2.47	72.97	<0.01	-	-	-	-	-	-	-	-	-	-
Typical night out?																				
No, usually smaller											6	9.25	1.33	64.32	0.02	3	1.33	0.22	8.09	0.76
No, usually bigger											2	1.47	0.17	12.64	0.72	3	0.52	0.10	2.75	0.44
Yes											3					8				
Session duration	42	1.24	1.00	1.54	0.053	45	1.41	1.13	1.76	<0.01										
Late closing time models	Likelihood ratio $\chi^2(14) = 43.0$, $p < 0.001$										Likelihood ratio $\chi^2(12) = 38.1$, $p < 0.001$									
AUDIT-C score																				
1–4 lower risk [Ref]	5					5					6					3				
5–12 haz/active AUD (f)	-	-	-	-	-	-	-	-	-	-	17	3.22	0.79	13.12	0.10	24	21.89	3.50	137.10	<0.001
5–7 hazardous (m)	24	0.93	0.21	4.12	0.93	13	1.06	0.24	4.76	0.94	-	-	-	-	-	-	-	-	-	-
8–12 active AUD (m)	18	2.10	0.50	8.81	0.31	19	1.07	0.24	4.87	0.93	-	-	-	-	-	-	-	-	-	-
Age																				
18–21											9	0.56	0.09	3.61	0.54	4	0.03	0.003	0.29	<0.01
22–25											7	0.25	0.04	1.46	0.12	10	0.07	0.01	0.48	<0.01
26–29											1	0.32	0.02	5.36	0.43	3	0.36	0.03	4.54	0.43
≥30 [Ref]											6					10				
Pre-drinking																				
No	11	0.16	0.06	0.46	<0.001	14	0.39	0.13	1.13	0.08										
Yes [Ref]	36					23														

Table 2. *Cont.*

Variables ±	**Male**										**Female**									
	BAC 0.05–0.099 g/100 mL					**BAC ≥ 0.1 g/100 mL**					**BAC 0.05–0.079 g/100 mL**					**BAC ≥ 0.08 g/100 mL**				
	n	**RR**	**LCI**	**UCI**	***p*-Value**	**n**	**RR**	**LCI**	**UCI**	***p*-value**	**n**	**RR**	**LCI**	**UCI**	***p*-Value**	**n**	**RR**	**LCI**	**UCI**	***p*-Value**
Typical night out?																				
No, usually smaller	17	2.14	0.67	6.90	0.20	17	3.92	1.16	13.22	0.03										
No, usually bigger	8	0.86	0.26	2.91	0.81	8	1.28	0.35	4.67	0.71										
Yes	22					12														
Session duration	47	1.17	0.89	1.54	0.26	37	1.50	1.14	1.98	<0.01	23	1.48	1.04	2.10	0.03	27	1.64	1.12	2.38	0.01
Time																				
Before midnight [Ref]	20					18					14					11				
Midnight and after	27	3.07	1.15	8.23	0.03	19	1.86	.65	5.31	0.24	9	1.21	0.32	4.50	0.78	16	7.26	1.58	33.31	0.01
Total models	Likelihood ratio $\chi^2(8) = 55.6$, $p < 0.001$										Likelihood ratio $\chi^2(18) = 51.0$, $p < 0.001$									
AUDIT-C score																				
1–4 lower risk [Ref]	18					9					10					5				
5–12 haz/active AUD (f)	-	-	-	-	-	-	-	-	-	-	21	3.26	1.09	9.73	0.03	32	9.75	2.78	34.21	<0.001
5–7 hazardous (m)	45	1.31	0.61	2.80	0.49	32	1.76	0.70	4.47	0.23	-	-	-	-	-	-	-	-	-	-
8–12 active AUD (m)	36	1.12	0.50	2.54	0.78	58	3.31	1.30	8.42	0.01	-	-	-	-	-	-	-	-	-	-
Occupation																				
Manager/professional											1	0.25	0.02	3.97	0.33	3	0.47	0.05	4.87	0.53
Technician/trade/labourer											8	0.32	0.06	1.67	0.18	7	0.11	0.02	0.64	0.01
Community/personal service											7	0.52	0.12	2.22	0.52	8	0.39	0.09	1.80	0.23
Clerical/administrative/sales											6	0.13	0.03	0.62	0.13	6	0.07	0.01	0.37	<0.01
Other [Ref]											9					13				
Pre-drinking																				
No	38	0.40	0.22	0.73	<0.01	39	0.52	0.28	0.97	0.04										
Yes [Ref]	61					60														

Table 2. *Cont.*

Variables ±	Male										Female									
	BAC 0.05–0.099 g/100 mL					BAC ≥ 0.1 g/100 mL					BAC 0.05–0.079 g/100 mL					BAC ≥ 0.08 g/100 mL				
	n	RR	LCI	UCI	*p*-Value	n	RR	LCI	UCI	*p*-value	n	RR	LCI	UCI	*p*-Value	n	RR	LCI	UCI	*p*-Value
Typical night out?																				
No, usually smaller											11	3.71	1.05	13.04	0.04	10	2.23	0.56	8.85	0.25
No, usually bigger											5	0.59	0.16	2.13	0.42	7	0.55	0.15	2.05	0.38
Yes											15					20				
Session duration	99	1.21	1.04	1.40	0.01	99	1.43	1.23	1.67	<0.001	31	1.21	0.90	1.61	0.21	37	1.50	1.10	2.03	<0.01
Time																				
Before midnight [Ref]											18					18				
Midnight and after											19	2.58	0.83	8.06	0.10	13	4.46	1.36	14.62	0.01

f: Female. m: Male. n: Sample size. RR: Risk ratio. L/UCI: 95% lower/upper confidence interval. [Ref]: Reference group. ± energy drink use and weekday were non-contributing variables in all models, whether it was a typical night out was a non-contributing variable in the male standard model, drinking session duration was a non-contributing variable in the female standard model, age and whether it was a typical night out were non-contributing variables in the male late model, pre-drinking was a non-contributing variable in the female late model, occupation, whether it was a typical night out and time of survey were non-contributing variables in the male combined model, pre-drinking was a non-contributing variable in the female combined model. These non-contributing variables were removed in the backward stepwise selection approach.

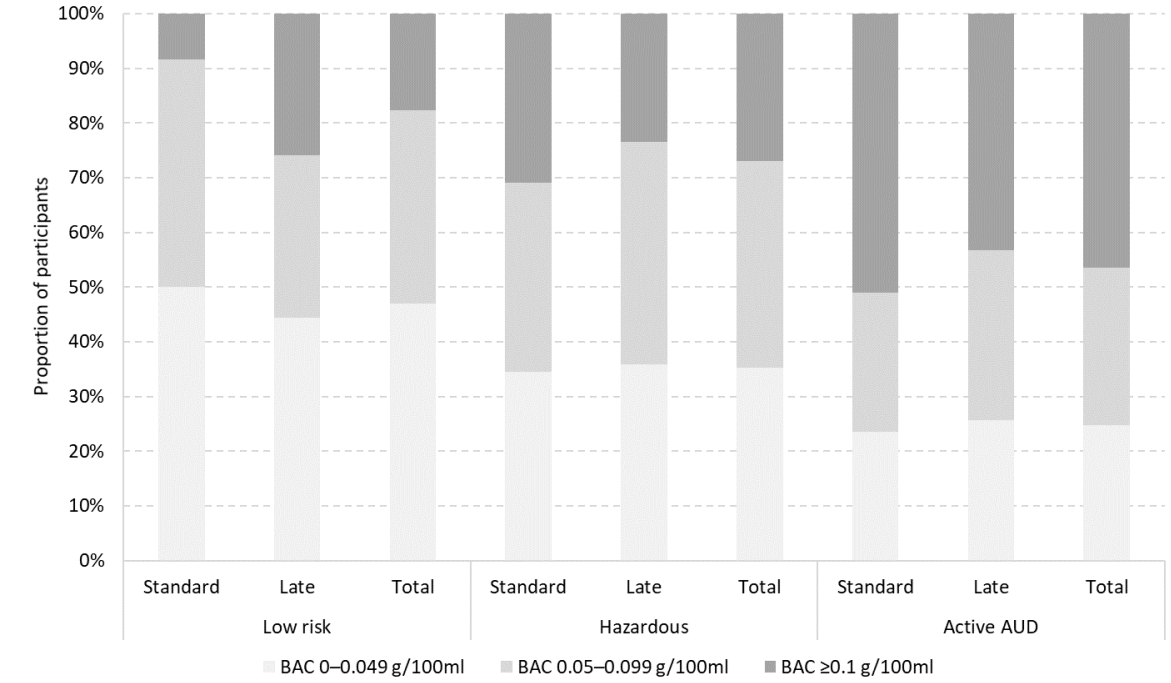
Table 3. Gender-specific multinomial logistic regression models: Two-way interaction effect between AUDIT-C and preferred bar type (standard vs. late) on BAC adjusting for survey and participant characteristics ±.

Variables ±	Male										Female									
	BAC 0.05–0.099 g/100 mL					BAC ≥0.1 g/100 mL					BAC 0.05–0.079 g/100 mL					BAC ≥0.08 g/100 mL				
	n	RR	LCI	UCI	*p*-Value	n	RR	LCI	UCI	*p*-Value	n	RR	LCI	UCI	*p*-Value	n	RR	LCI	UCI	*p*-Value
AUDIT-C by preferred bar type																				
5–12 × Late (f)	-	-	-	-	-	-	-	-	-	-	16	2.26	0.24	21.09	0.48	21	2.45	0.19	31.86	0.49
5–7 × Late (m)	26	1.29	0.28	5.96	0.74	15	0.18	0.02	1.40	0.10	-	-	-	-	-	-	-	-	-	-
8–12 × Late (m)	23	1.06	0.21	5.41	0.95	32	0.12	0.02	0.96	0.046	-	-	-	-	-	-	-	-	-	-

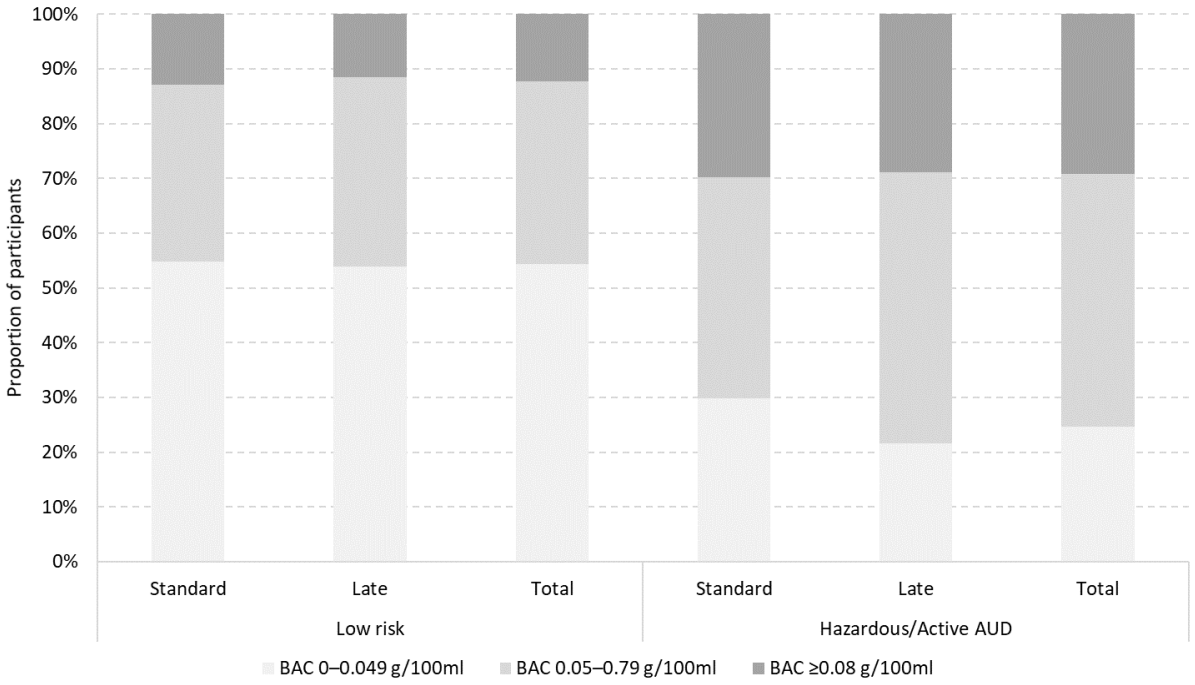
Table 3. *Cont.*

Variables ±	**Male**										**Female**									
	BAC 0.05–0.099 g/100 mL					**BAC ≥0.1 g/100 mL**					**BAC 0.05–0.079 g/100 mL**					**BAC ≥0.08 g/100 mL**				
	n	**RR**	**LCI**	**UCI**	***p*-Value**	**n**	**RR**	**LCI**	**UCI**	***p*-Value**	**n**	**RR**	**LCI**	**UCI**	***p*-Value**	**n**	**RR**	**LCI**	**UCI**	***p*-Value**
AUDIT-C score																				
1–4 lower risk [Ref]	18					9					10					5				
5–12 hazardous/active AUD (f)	-	-	-	-	-	-	-	-	-	-	21	1.88	0.37	9.58	0.45	32	6.22	1.14	33.79	0.03
5–7 hazardous (m)	45	1.15	0.39	3.38	0.80	32	5.09	0.94	27.68	0.06	-	-	-	-	-	-	-	-	-	-
8–12 active AUD (m)	36	1.10	0.34	3.62	0.87	58	12.05	2.16	67.28	<0.01	-	-	-	-	-	-	-	-	-	-
Preferred bar type																				
Standard [Ref]	42					45					12					18				
Late	57	0.92	0.26	3.28	0.90	54	5.52	0.88	34.73	0.07	23	1.50	0.28	7.94	0.63	27	0.81	0.09	7.04	0.85
Occupation																				
Manager/professional											1	0.19	0.01	3.21	0.25	3	0.39	0.04	4.22	0.44
Technician/trade/labourer											8	0.26	0.05	1.45	0.12	7	0.09	0.01	0.55	<0.01
Community/personal service											7	0.54	0.12	2.42	0.42	8	0.41	0.09	1.96	0.27
Clerical/administrative/sales											6	0.12	0.02	0.58	<0.01	6	0.06	0.01	0.33	<0.01
Other [Ref]											9					13				
Pre-drinking																				
No	38	0.39	0.21	0.72	<0.01	39	0.53	0.28	1.00	0.05										
Yes [Ref]	61					60														
Typical night out?																				
No, usually smaller											11	4.22	1.17	15.28	0.03	10	2.44	0.61	9.76	0.21
No, usually bigger											5	0.64	0.17	2.35	0.50	7	0.57	0.15	2.13	0.40
Yes											15					20				
Session duration	99	1.22	1.04	1.42	0.01	99	1.46	1.25	1.70	<0.001	31	1.24	0.91	1.67	0.17	37	1.55	1.13	2.13	<0.01
Time																				
Before midnight [Ref]											18					18				
Midnight and after											19	2.57	0.81	8.16	0.11	13	4.62	1.39	15.32	0.01

Male model: Likelihood ratio $\chi^2(14) = 62.1$, $p < 0.001$; Female model: Likelihood ratio $\chi^2(22) = 54.4$, $p < 0.001$. f: Female. m: Male. n: Sample size. RR: Risk ratio. L/UCI: 95% Lower/upper confidence interval. [Ref]: Reference group. ± age, energy drink use, and weekday were non-contributing variables in both models, occupation, whether it was a typical night out and time of survey were non-contributing variables in the male model, pre-drinking was a non-contributing variable in the female model. These non-contributing variables were removed in the backward stepwise selection approach.



(**a**) Male



(**b**) Female

Figure 1. Proportion of male and female participants according to BAC (g/100 mL) by AUDIT-C score (lower risk, hazardous, active AUD) and preferred bar type (standard vs. late).

4. Discussion

In nightlife areas of Perth, male bar patrons with active AUD were around three times as likely to have a BAC reading exceeding 0.099 g/100 mL than males usually drinking at lower risk. Females with usual drinking patterns indicative of hazardous use or active AUD were around ten times as likely to have a BAC exceeding 0.079 g/100 mL than their lower risk drinking counterparts. These findings that increased risk of AUD was associated with increased BAC among nightlife-goers (when not adjusting for the closing times of their

preferred bars) are as we expected. This is the first nightlife study to have explored this association, but there is evidence among trauma patients that those with higher likelihood of AUD will have a higher BAC on presentation [10,11].

After differentiating participants according to their preferred bar type, we found there was a strong positive association between AUDIT-C score and BAC for males from standard closing bars but no evidence of association for males from late closing bars. For females, there was evidence of a strong positive association between AUDIT-C score and BAC for females from late closing and standard closing bars. We had expected that regardless of preferred bar type, participants typically drinking at hazardous levels or with AUD would be more likely to have a high-range BAC on a night out. In terms of the gender differences, we found by preferred bar type, it is important to note that venues across and within each bar type (standard vs. late), despite having certain similarities in how they function by virtue of their liquor licensing classification, may differ from each other in many ways. A wide range of contextual factors (e.g., bar size, live entertainment, dancefloor, drink promotions, entry and serving practices) may influence what clientele a bar attracts. These are potential confounders that we were unable to adjust for, but collection of such contextual information should be considered in future studies.

We found preferred bar type moderated the association between AUDIT-C score and BAC for some males but no females. Males with active AUD with a high-range BAC on their night out were less likely to prefer late closing bars to standard closing bars than males usually drinking at lower risk who had a high-range BAC. As late trading increases the hours of alcohol availability thus giving more opportunity for intoxication, we had expected that within categories of AUD risk, participants preferring late closing bars would be more likely to have a high-range BAC. Among male nightlife-goers drawn to late trading bars, it is those with typically lower risk drinking patterns who are more likely to reach BACs $\geq$ 0.1 g/100 mL than those with AUD. It may be that males with AUD are less influenced by trading hours when out drinking to intoxication compared to male lower risk drinkers who are on a big night out. Half of males reported that it was not a typical night out for them, and this may go part way to explaining the slightly unexpected findings. Regarding no evidence of association for females in the interaction model, as well as the lack of contextual differences between bars included in the models that may explain gender differences, sample size was approximately half that of males and this may have affected statistical power.

Despite an inclination towards relaxation of outlet trading hours by liquor licensing authorities globally, there is mounting evidence that it may lead to increased consumption and harm. In Western Australia, at least, there have been recent examples of bar trading hours easing on Sundays and there are plans for easing of Sunday liquor store restrictions in remote areas [31]. Extended trading hour permits for bars in Western Australia fall create a loophole in liquor licensing laws and provide bars with permits an exemption to the rule. This study provides new evidence of an association between outlet closing times and alcohol consumption that is of relevance to decision makers—male nightlife-goers, albeit typically lower risk drinkers, who are highly intoxicated when out drinking prefer late closing bars with extended trading hour permits.

Limitations

When classifying participants as preferring standard vs. late closing bars, we assumed that time spent in a venue was positively associated with quantity of alcohol consumed. However, a participant classified as preferring a standard closing bar, for example, may have spent an hour and a half drinking two units of alcohol in a standard closing bar and one hour drinking one unit in each of three late closing bars. It is also important to note that half of participants reported not being on a typical night out, with around a quarter reporting usually having a bigger night out and a quarter usually having a smaller night out. We have only presented evidence of cross-sectional associations between nightlife-goers' AUDIT-C score, the closing time of their preferred bar and their BAC not the directions of

these associations. BAC was the only objective measure collected and as cognitive ability declines with alcohol intoxication [37] we must be cautious with measures collected via self-report. Finally, our findings may not be generalisable to nightlife areas in other cities.

5. Conclusions

Our study provides evidence of positive associations between alcohol use disorders and acute intoxication among nightlife-goers and on the moderating effect of bar closing times among males.

Author Contributions: W.G.: conceptualisation, investigation, methodology, formal analysis, project administration, supervision, writing—original draft, funding acquisition M.S.: methodology, writing—review and editing W.L.: conceptualisation, investigation, methodology, supervision, writing—review and editing, funding acquisition K.G.: conceptualisation, methodology, writing—review and editing, funding acquisition K.K.: conceptualisation, methodology, writing—review and editing, funding acquisition P.M.: conceptualisation, investigation, methodology, supervision, writing—review and editing, funding acquisition T.C.: conceptualisation, investigation, methodology, project administration, supervision, writing—review and editing, funding acquisition. All authors have read and agreed to the published version of the manuscript.

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Institutional Review Board Statement: The study was conducted according to the guidelines of the Declaration of Helsinki, and approved by the Human Research Ethics Committees at Curtin University (protocol code HR154/2015 approved on 11 August 2015).

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The data presented in this study are available on request from the corresponding author subject to ethical approval.

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Conflicts of Interest: P.M. has acted as a paid expert witness on behalf of a licensed venue and a security firm. Other authors declare that they have no conflict of interest.

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2.4 Association between the Australian alcopops tax and national chlamydia rates among young people – an interrupted time series analysis

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Article

The Association between the Australian Alcopops Tax and National Chlamydia Rates among Young People—an Interrupted Time Series Analysis

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Abstract: A national tax increase, which became known as the "alcopops tax", was introduced in Australia on the 27th April 2008 on ready-to-drink alcoholic beverages, which are consumed predominantly by young people. The affordability of alcohol has been identified as the strongest environmental driver of alcohol consumption, and alcohol consumption is a well-known risk factor in the spread of sexually transmitted infections via its association with sexual risk-taking. We conducted a study to investigate whether there was any association between the introduction of the tax and changes in national chlamydia rates: (i) notification rates (diagnoses per 100,000 population; primary outcome and standard approach in alcohol taxation studies), and (ii) test positivity rates (diagnoses per 100 tests; secondary outcome) among 15–24 and 25–34-year-olds, using interrupted time series analysis. Gender- and age-specific chlamydia trends among those 35 and older were applied as internal control series and gender- and age-specific consumer price index-adjusted per capita income trends were controlled for as independent variables. We hypothesised that the expected negative association between the tax and chlamydia notification rates might be masked due to increasing chlamydia test counts over the observation period (2000 to 2016). We hypothesised that the association between the tax and chlamydia test positivity rates would occur as an immediate level decrease, as a result of a decrease in alcohol consumption, which, in turn, would lead to a decrease in risky sexual behaviour and, hence, chlamydia transmission. None of the gender and age-specific population-based rates indicated a significant immediate or lagged association with the tax. However, we found an immediate decrease in test positivity rates for 25–34-year-old males (27% reduction—equivalent to 11,891 cases prevented post-tax) that remained detectable up to a lag of six months and a decrease at a lag of six months for 15–24-year-old males (31% reduction—equivalent to 16,615 cases prevented) following the tax. For no other gender or age combination did the change in test positivity rates reach significance. This study adds to the evidence base supporting the use of alcohol taxation to reduce health-related harms experienced by young people and offers a novel method for calculating sexually transmitted infection rates for policy evaluation.

Keywords: alcohol policy; taxation; ready-to-drink beverages; alcopops; young people; chlamydia; interrupted time series analysis; autoregressive integrated moving average.

1. Introduction

Price changes, most commonly through taxation, have been studied more than any other governmental alcohol control policy with regard to their effect on consumption and related harms [1].

Through this research, the affordability of alcohol has been identified as the strongest environmental driver of alcohol consumption and related harms, particularly assaultive and road traffic injuries, both at the population-level and specifically among heavy drinkers and young people [1,2]. Natural experiments of alcohol price increases and decreases internationally, and systematic reviews and meta-analyses of these experiments, have confirmed this association [3,4].

Two national taxes introduced in Australia in the 2000s had significant but opposing effects on the price of ready-to-drink alcoholic beverages (RTDs), a category most commonly involving a pre-mixed and packaged combination of white or dark spirit and soft drink, which are consumed predominantly by young people [5,6]. In Australia, alcohol taxation falls entirely within the responsibility of the federal government; to our knowledge, there were no other substantial national tax changes or state/territory-level price changes (e.g., minimum unit price) for alcohol over the observation period [7]. First, under the goods and services tax (GST) introduced on the 1st July 2000, the tax rate on RTDs, previously the same rate as straight spirits, was reduced by 40% from $56.27 to $33.22 per litre of pure alcohol [8,9]. After the popularity and sales of RTDs increased in the intervening years and because of public concern over levels of alcohol consumption among young people, a 70% tax increase was introduced on the 27th April 2008 to bring the tax on RTDs back into line with straight spirits (from $39.36 to $66.67 per litre of pure alcohol) [10,11]. This targeted tax increase (commonly known as the "alcopops tax") led some to argue that focusing on only one beverage type would merely lead to a substitution effect, whereby drinkers affected by the tax would simply switch to another beverage type, thereby rendering the tax ineffective as a public health intervention [9,12]. As it turned out, alcohol sales data from government and market research sources confirmed that both RTD sales and total alcohol sales began to decline immediately following the tax and continued to decline for at least two years. Increases in straight spirits sales were evident after the tax, but only fractionally offset the reduction in RTD sales [11,13,14]. Similar tax increases specific to RTDs were introduced across Europe in the 2000s, although few papers are published regarding their effects. In Germany, alcohol sales data indicated considerable subsequent reductions in RTD sales, with some evidence of partial substitution to straight spirits, but no overall reduction in total alcohol sales [15].

To date, all five studies that have evaluated the impact of RTD taxes on alcohol-related harms among young people have been conducted in Australia (across four states) and have examined associations with levels of emergency department (ED) attendance or hospitalisation [8,16–19]. Three studies conducted by a research group in the state of Queensland found no association between the alcopops tax and ED attendance or hospitalisation among 15–29-year-olds [17–19]. A New South Wales (NSW) study found that lowering the price of RTDs via the GST was associated with an increase in ED attendances among 18–24-year-old females. The subsequent increase in price due to the alcopops tax was associated with a decrease in ED attendances among 15–17, 18–24 and 25–49-year-old males and females, with the strongest association for 18–24-year-old females [8]. As the introduction of the alcopops tax coincided with the 2008 global financial crisis (GFC), which may have impacted disposable income, another important driver of alcohol consumption [20], the NSW study controlled for the effects of the GFC using monthly liquor retail turnover data [8]. A study of weekend nighttime ED injury attendances among males in Western Australia (WA) and Victoria also found significant associations with the alcopops tax. In WA, the new tax was associated with immediate decreases in injury among 12–19-year-olds and delayed decreases among 20–29-year-olds. In Victoria, immediate decreases in injury rates were seen among 15–19-year-olds with delayed decreases among 20–29-year-olds [16].

Alcohol use, particularly heavy drinking, is a well-known risk factor in sexually transmitted infection (STI) transmission via its association with sexual risk-taking, such as condomless sex and multiple casual partners [21,22]. Studies in the US and Canada have indicated subsequent reductions in STI rates following alcohol tax increases [23–28]. Evaluations of multiple tax increases on beer across the 50 US states in the 1980s and 1990s found decreases in gonorrhoea [25–27], syphilis [26] and

AIDS [25] rates. An evaluation of the increase in real beer prices across the 10 Canadian provinces over the same period found decreases in chlamydia and gonorrhoea rates [28].

The most recent US studies examining the effects of a 2009 alcohol tax increase in Illinois and a 2011 alcohol tax increase in Maryland found reductions in chlamydia [24] and gonorrhoea [23,24] rates.

Despite using robust controlled interrupted time series [23,24,26,27] and interrupted time series designs [25,28], none of these studies controlled for the frequency of STI tests. The commonly accepted approach for estimating harm rates in studies of this nature is to rely on formal estimates of resident population. All studies of the association between alcohol price changes and STIs to date have relied on the resident population to estimate STI rates [23–28]. However, trends in chlamydia diagnoses are strongly correlated with the number of tests that occurred in that population during the same period and do not necessarily reflect the underlying prevalence in the population [29]. Testing behaviour itself can be influenced, for example, by sexual health promotion campaigns and is not equally spread across the population—considerable variation exists by age, gender and socio-economic status [30]. Therefore, when attempting to evaluate a policy, a more sensitive measure of trend in chlamydia rates might be achieved by applying counts of chlamydia tests rather than resident population numbers as a measure of exposure (i.e., denominator), similar to methods used in national STI surveillance reports [31] and sentinel surveillance systems [29,32].

From reports in the literature of significant government investment in chlamydia awareness and screening programs in Australia from 2005 [33,34] and large increases in both chlamydia tests per 100,000 population (112% among 15–34-year-olds from 2005 to 2010) and chlamydia diagnoses per 100,000 population (43% among 15–29-year-olds from 2006 to 2010) [29] within the observation period, we hypothesised that any negative association between the alcopops tax and population-based chlamydia rates might be masked and thought to compare the results with test-based rates. We hypothesised that the association between the tax change and test-based chlamydia rates would occur as an immediate level decrease following the alcopops tax. We postulated the causal mechanism to occur via an overall reduction in young people's alcohol consumption thereby reducing sexual risk-taking behaviour and the transmission of chlamydia. We proposed the impact model "a priori based on existing literature and knowledge of the intervention and the mechanism by which it is expected to act on the outcome" [35]. Given other alcohol policy evaluation studies on STI rates (e.g., [23]), the abrupt and permanent nature of the intervention [36], evidence for an immediate, significant and sustained decline in RTD consumption unaccounted for by substitution [13,37] and the short window period (2–7 days) between chlamydia exposure and developing viral DNA detectable via polymerase chain reaction [38], the specification of a step function was requisite.

The aim of this study was to investigate the association between the alcopops tax and national chlamydia rates: (i) notification rates (diagnoses per 100,000 population; primary outcome), and (ii) test positivity rates (diagnoses per 100 tests; secondary outcome) among young people using interrupted time series analysis. Gender-specific chlamydia trends in older people were applied as an internal control series. Gender and age-specific consumer price index (CPI)-adjusted income trends were also controlled for as independent variables. Chlamydia was chosen as the outcome variable in this study as it is the most prevalent STI among young Australians [39].

To our knowledge, this is the first alcohol taxation study to have investigated: (a) the association between RTD pricing, a beverage type favoured by young people, and chlamydia rates at a national level, and (b) the use of chlamydia test counts as an alternative denominator to resident population counts, when estimating rates.

2. Materials and Methods

2.1. Chlamydia Notification Data

Across all Australian states and territories, chlamydia has been a notifiable disease since 1998, and involves mandatory reporting by laboratories (and, in some jurisdictions, doctors) to health

departments [31]. Notifications are collated by the National Notifiable Diseases Surveillance System (NNDSS). For this analysis, national monthly notifications of chlamydia, from July 2000 to December 2016 for persons aged 15 years and older were sourced from the NNDSS. Notifications were coded for state/territory of residence, diagnosis month/year, age group (five-year bands) and gender. Monthly trends of notification counts are provided in the Supplementary Materials Figure S1.

The NNDSS defines the diagnosis month/year as the earliest known to have occurred among symptom onset date, specimen collection date or notification date. As chlamydia is most often asymptomatic, particularly in females [31], the diagnosis month/year tends to reflect specimen collection or notification date rather than symptom onset date (Figure 1).

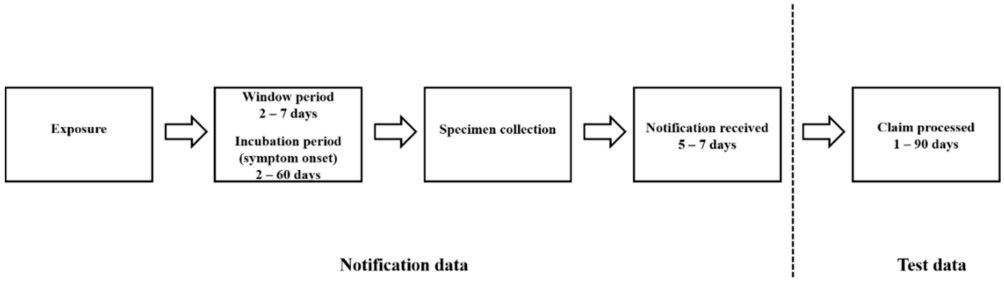


Figure 1. Flowchart from chlamydia exposure to notification (Notification data) and the subsequent financial claim processing of test data (Test data). National Notifiable Diseases Surveillance System defines diagnosis month/year as earliest known of symptom onset date, specimen collection date and notification date. Diagnosis month/year tends to reflect specimen collection or notification date rather than symptom onset date due to the asymptomatic nature of most chlamydia cases.

2.2. Denominator Data: Resident Population and Chlamydia Test Data

Quarterly national estimated resident population by age group and gender from Quarter 3 (Q3) 2000 to Q4 2016 were sourced from the Australian Bureau of Statistics (ABS). Monthly resident population was estimated using linear interpolation within age group and gender. These data were applied as the primary denominator for monthly chlamydia notification rates and trends are provided in the Supplementary Materials Figure S2.

National monthly counts of chlamydia tests were sourced from online publicly available Medicare Benefits Schedule (MBS) Item Statistics Reports for July 2000 to December 2016 by state/territory of residence, test month/year, age group (ten-year bands) and gender. These chlamydia test counts represented tests undertaken in general practice and did not include tests undertaken in public sexual health clinics. In Australia, General Practitioners (GPs) perform the majority of chlamydia tests, as evidenced by the proportion of notifications from this setting. From 2000 to 2010, 75% of chlamydia notifications in NSW (the most populous state/territory) came from general practice settings and this remained stable over time [40]. Notification data were precisely matched to test data age groups (15–24, 25–34, > = 35). Test month/year signified when the financial claim for testing was processed by Medicare, rather than date of the procedure (Figure 1). The following MBS item codes were extracted: 69316, 69317, 69319, 69369, 69370. A 19-month gap in chlamydia-specific test reports occurred from November 2005 to May 2007, due to chlamydia being temporarily grouped into a multiple test MBS item code [41]; linear interpolation within age group and gender was applied to manage data for this period. These data were applied as a secondary denominator to estimate monthly chlamydia test positivity rates and trends are provided in the results.

2.3. Outcome Measures: Population-Based and Test Positivity Rates

The primary outcome measure for chlamydia was defined as the national monthly total of gender and age-specific (males 15–24; males 25–34; females 15–24; females 25–34) notifications per 100,000 population in that month. The secondary outcome measure for chlamydia was the monthly total

of gender and age-specific notifications per 100 chlamydia tests conducted in that month. The chlamydia series included data from July 2000 to December 2016.

As chlamydia notification data were based on either specimen collection or notification dates and chlamydia test data were based on claim process dates, there was likely to be a lag of at least one month between the datasets (Figure 1). Adjustments were made in order that the timing of notification and test reports matched as closely as possible. There was scant published information on Medicare processing times and there may have been variability over the observation period. In 2013/14, the Department of Human Services (DHS) took an average of 15.5 days to process medical services submitted to Medicare, with 98% processed within three months [42]. An independent audit of DHS in 2017 noted that processing for 70% of pathology services was not automated and required manual intervention, potentially slowing processing times [43]. On this basis, we concluded that notification data best aligned with test data that were processed one month later (e.g., January notifications aligned with February tests and so on).

2.4. Socio-Economic Data

Annual per capita total income data by age group and gender (males 18–24; males 25–34; females 18–24; females 25–34) were sourced from the Australian Tax Office (ATO) from financial year (FY) 2000–01 to FY 2016–17. As per capita income data were only available annually from the ATO, monthly data were estimated from July 2000 to December 2016 using linear interpolation within age group and gender. In addition, as per capita income had not been adjusted for inflation, quarterly CPI data from Q3 2000 to Q4 2016 were sourced from the ABS. The monthly CPI was estimated using linear interpolation. With December 2016 set as the reference point, monthly ratios of CPI were calculated. Monthly per capita income by age group and gender was multiplied by these CPI ratios to convert income to real prices to be applied in time series models as independent variables to control for the effect of the GFC on disposable income. These data are provided in the Supplementary Materials Figure S3.

2.5. Ready-to-Drink Beverage Consumption Data

Annual per capita consumption of alcohol by beverage type from 2002–03 to 2015–16 was sourced from the ABS [37]. These data were graphed to assist in the interpretation of the results and are provided in the Supplementary Materials Figure S4.

2.6. Statistical Analysis

Autoregressive integrated moving average (ARIMA) models were fit to the pre-intervention time-period (94 monthly time points) for the primary and secondary outcome measures. To limit analyst subjectivity, SPSS Statistics' version 25 expert modeller function, allowing seasonal terms, was used to select best fitting models automatically. The function ensured that model fit was both statistically adequate and the most parsimonious to minimise the likelihood of incorrect inferences [44]. Models of best fit were then applied to their corresponding full time series, while controlling for independent variables. Adequate model fit was confirmed by Stationary R-squared, Ljung-Box Q statistics and inspection of residual autocorrelation and partial autocorrelation function plots.

2.6.1. Independent Variables

Intervention time points were included in all models as dummy independent variables. For chlamydia models, time points from July 2000 to April 2008 before the introduction of the alcopops tax were coded 0 and time points from May 2008 to December 2016 were coded 1. Australian surveys pre- and post-tax reported that RTDs are consumed primarily by young people (aged under 25 years) and considerably less frequently by middle aged and older drinkers [5,6]. In 2007, RTDs were the preferred choice among 14–19-year-old males (37% RTDs, 36% beer, 20% straight spirits, 6% wine) and females (43% RTDs, 33% straight spirits, 18% beer, 6% wine). Preference switched to beer for males (59% beer,

25% wine, 8% straight spirits, 6% RTDs) and wine for females (66% wine, 19% spirits, 13% beer, 9% straight spirits, 9% RTDs) among 40–49-year-olds [6]. Given this, gender-specific chlamydia rates for those aged 35 and older, those much less likely to be affected by the alcopops tax, were included as an internal control. Age- and gender-specific CPI-adjusted per capita income were also included in models as independent variables to control for the effect of the GFC on disposable income.

2.6.2. Lagged Associations

The hypothesised association between the tax change and chlamydia rates may not have been immediately detectable. Lagged associations could occur for many reasons, including the asymptomatic nature of most chlamydia cases [31], and differences between genders in healthcare-seeking behaviour [30,45]. Therefore, lagged associations occurring at three and six months were considered in addition to an immediate association.

2.6.3. Sensitivity Analyses

In order to gauge sensitivity in notification and test month alignment, a two-month realignment was also conducted (e.g., January notifications aligned with March tests and so on). In order to test whether there was a significant level increase in test counts following the alcopops tax that could potentially contribute to a level decrease in test positivity rates, models were fit and applied to gender and age-specific test counts while controlling for gender-specific test counts for those aged 35 and older.

2.7. Ethics

This study was conducted in accordance with the National Statement on Ethical Conduct in Human Research and was approved by Human Research Ethics Committees at Curtin University (HR138/2013) and Australian Capital Territory Health (ETHLR.13.070).

3. Results

3.1. Descriptive Statistics

Descriptive statistics for monthly chlamydia notification rates per 100,000 population (primary outcome) and test positivity rates (secondary outcome) by age group and gender are presented in Table 1. Monthly notification rate trends per 100,000 population (primary outcome) and test positivity rates (secondary outcome) by age group and gender are presented in Figures 2 and 3. Trends in chlamydia rates varied across gender and age groups, and between the primary and secondary outcome measures.

3.1.1. Primary Outcome Measure

From July 2000 to December 2016, there were 960,694 chlamydia notifications (Table 1). Of these, 555,782 (58%) were among females and 848,844 (88%) were among those under 35 years old. Median monthly notification rates per 100,000 population were highest among 15–24-year-old females pre- (90 per 100,000) and post- (173 per 100,000) alcopops tax. Monthly notification rate trends per 100,000 population (Figure 2) were highest among the 15–24 age group and lowest among the 35 and older age group. Among 15–24-year-olds, the population-based rates were markedly and consistently higher for females compared to males, but trends were similar with a steady increase until 2011, at which point they levelled off. For those aged 25–34 years and 35 and older there were steady increases in population-based notification rates without any obvious decline or levelling off apparent from visual inspection.

3.1.2. Secondary Outcome Measure

Median monthly chlamydia test positivity rates (Table 1) were highest among 15–24-year-old males pre- (22 per 100 tests) and post- (19 per 100) alcopops tax. Monthly test positivity rates (Figure 3)

demonstrated markedly different trends and reversed gender ratios compared to rates generated per 100,000 population. Similar to the primary outcome measure, test positivity rates were highest among the 15–24 age group and lowest among those 35 and older; however, rates were consistently higher among males than females for all age groups. Among males aged 15–24 and 25–34 years old, trends appeared relatively stable until around 2008, at which point visual inspection suggested a declining trend until 2016. Among males 35 and older, trends were relatively stable over the observation period. There were relatively steady decreases in test positivity rates among females of all ages over the observation period.

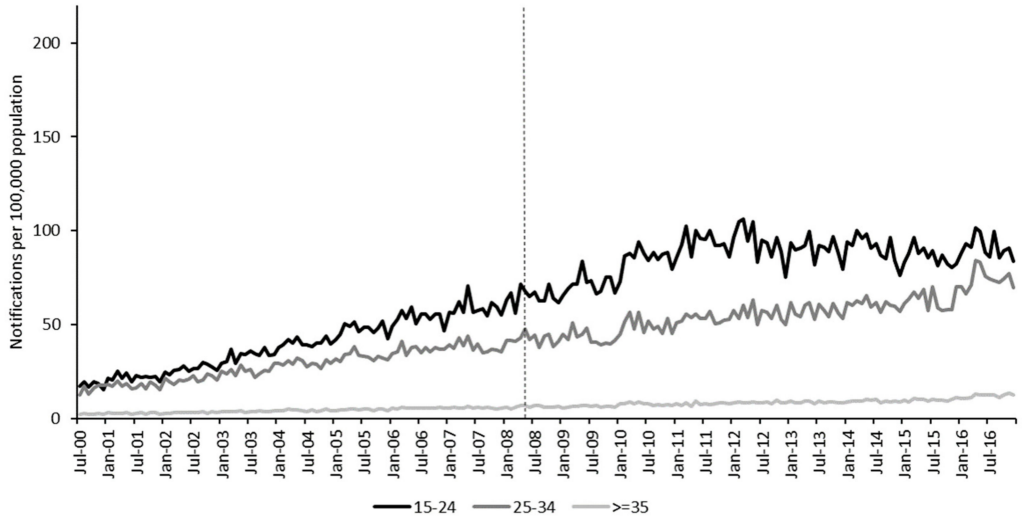
Trends in monthly chlamydia test counts (Figure 4) were markedly and consistently higher for females compared to males for all age groups. Among males, test counts were highest for those 35 and older and lowest for 15–24-year-olds. Trends in test counts for males of all ages increased steadily until 2008, at which point there appeared to be an increase in slope. Males aged 15–24 years old then levelled off around 2012. Among females aged 25–34 years and 35 and older, there were steady increases in test counts over the observation period. For females aged 15–24 years old, test count trends had a steady increase until around 2012, at which point they levelled off. Supplementary Materials include monthly trends of chlamydia notification counts and estimated resident population (Figures S1 and S2), CPI-adjusted per capita total income (Figure S3) and annual per capita consumption of alcohol by beverage type (Figure S4). Trends in annual per capita consumption of RTDs show a marked reduction in consumption between 2007–08 and 2008–09, followed by a steady decline through to 2016.

Table 1. Descriptive statistics for monthly chlamydia rates per 100,000 (primary outcome) and per 100 tests (secondary outcome) pre- and post-alcopops tax intervention (27th April 2008), by age group and gender.

Age	Gender	Notifications		Pre-Alcopops Tax Jul 2000 to April 2008 *(N = 94)*		Post-Alcopops Tax May 2008 to Dec 2016 *(N = 104)*	
		n	%	Median	IQR	Median	IQR
Per 100,000 population							
15–24	Male	195,986	20.4	39.6	26.0–53.0	88.0	81.5–93.4
	Female	385,047	40.1	89.5	62.4–110.1	173	159–187
25–34	Male	135,960	14.2	29.3	20.5–35.5	56.0	49.2–61.4
	Female	131,851	13.7	27.8	20.3–36.3	55.3	47.9–59.7
35 and older	Male	72,966	7.6	4.0	3.1–5.3	8.4	7.3–9.4
	Female	38,884	4.1	2.1	1.6–2.6	4.3	3.7–4.9
Total		960,694	100	18.3	12.6–23.2	36.3	33.1–38.4
Per 100 tests							
15–24	Male	195,986	20.4	21.8	20.1–23.5	18.9	17.3–22.1
	Female	385,047	40.1	15.4	13.8–16.9	11.0	10.0–12.6
25–34	Male	135,960	14.2	14.2	13.0–15.3	11.3	10.2–12.6
	Female	131,851	13.7	6.9	6.1–7.8	4.3	4.0–4.9
35 and older	Male	72,966	7.6	6.4	6.0–7.0	5.4	4.9–6.2
	Female	38,884	4.1	2.8	2.3–3.2	1.7	1.6–2.0
Total		960,694	100	10.9	10.0–11.8	7.8	7.0–9.0

n = number of notifications; *N* = number of time points; IQR = interquartile range. Notification data were aligned with test data that were processed one month later.

(**a**) **Male**



(**b**) **Female**

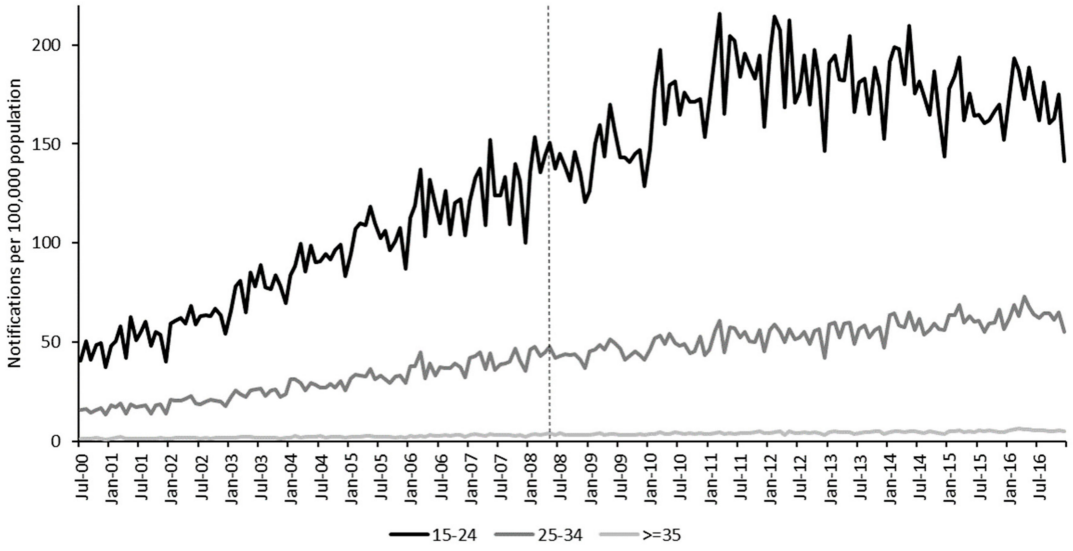
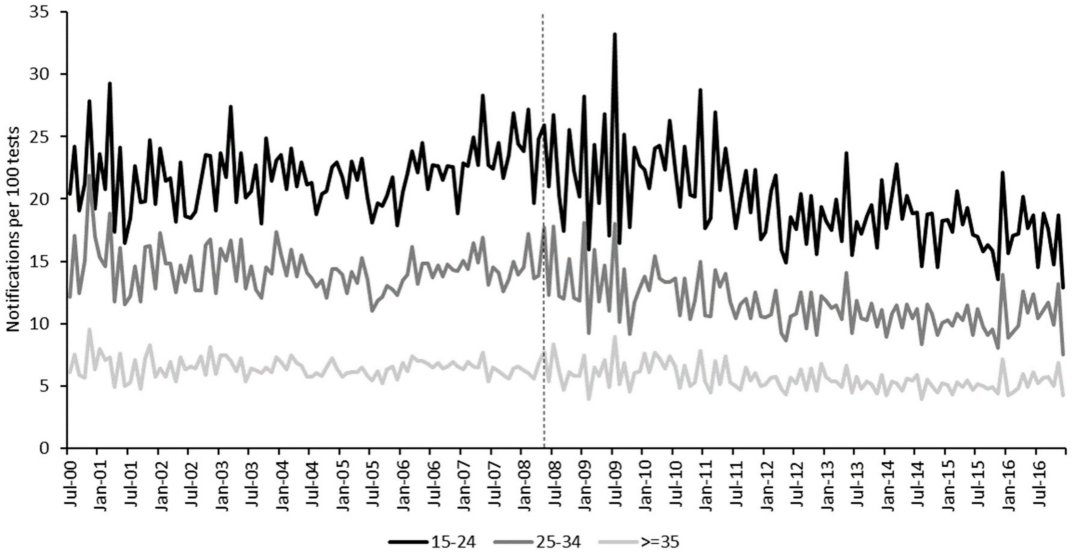


Figure 2. Monthly chlamydia notification rates per 100,000 population (primary outcome) by gender and age group, July 2000 to December 2016. Alcopops tax intervention point indicated by vertical dotted line at May 2008.

(**a**) **Male**



(**b**) **Female**

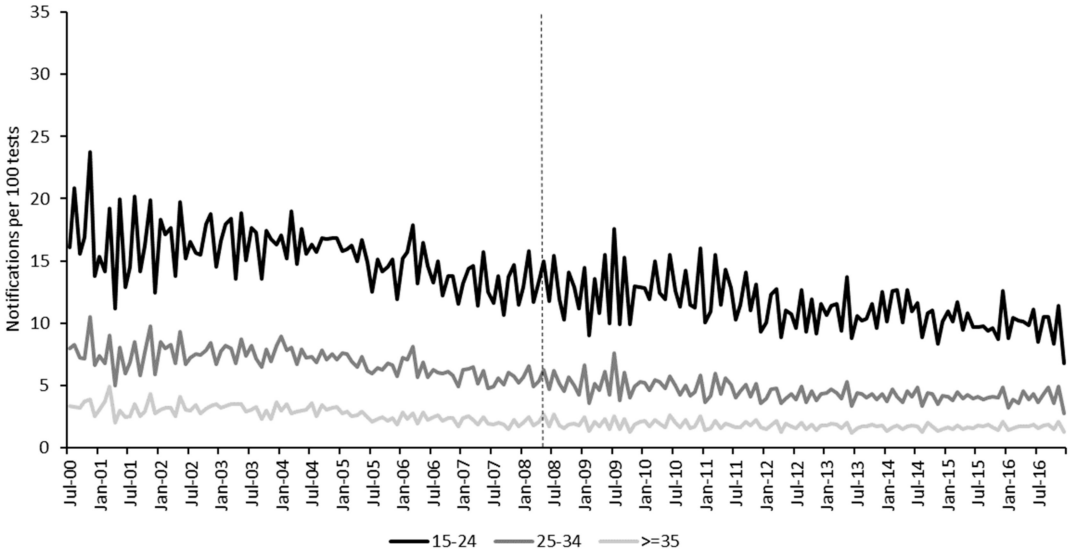
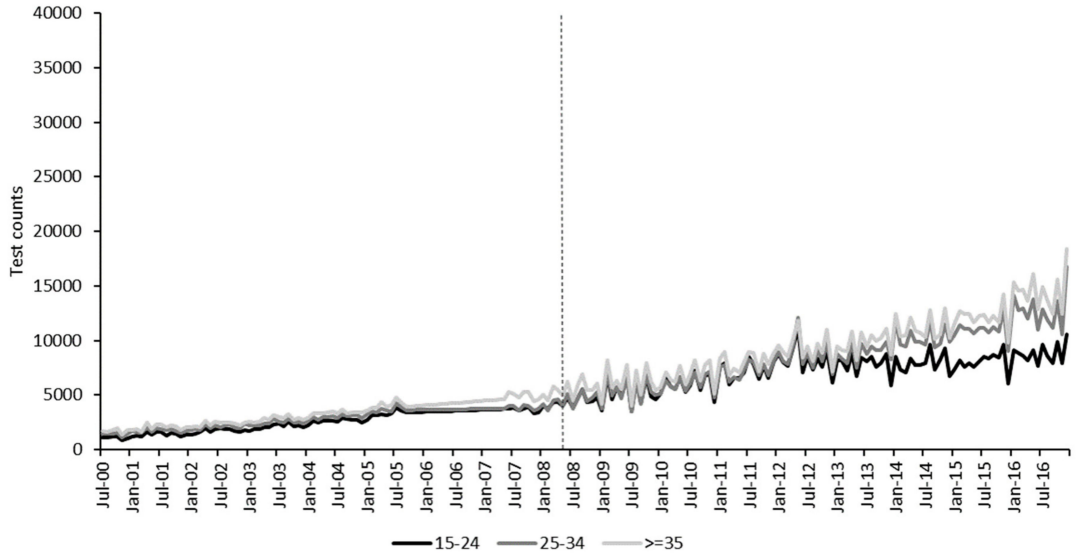


Figure 3. Monthly chlamydia test positivity rates (secondary outcome) by gender and age group, July 2000 to December 2016. Alcopops tax intervention point indicated by vertical dotted line at May 2008. Notification data were aligned with test data that were processed one month later.

(**a**) **Male**



(**b**) **Female**

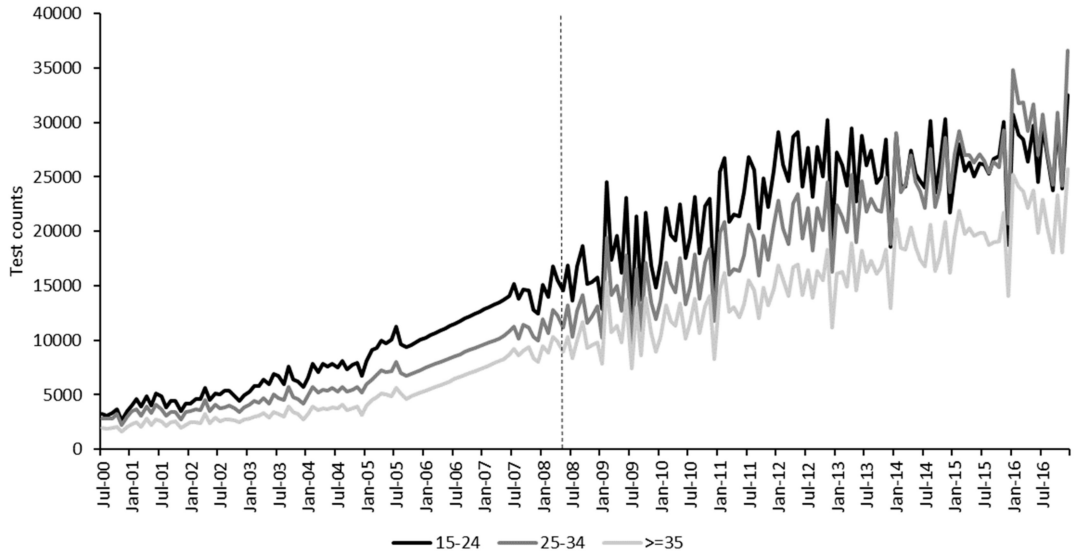


Figure 4. Monthly chlamydia test counts by gender and age group, July 2000 to December 2016. Alcopops tax intervention point indicated by vertical dotted line at May 2008. Test counts interpolated within age group and gender between November 2005 and May 2007 due to missing data. Test counts shifted back by 1 month to represent date of service better (rather than date processed).

3.2. ARIMA Models

3.2.1. Primary Outcome Measure

ARIMA model results for the primary outcome, chlamydia notification rates per 100,000, are shown in Table 2. All models demonstrated an adequate fit. None of the gender and age-specific population-based rates indicated a significant immediate or lagged association with the alcopops tax.

3.2.2. Secondary Outcome Measure

ARIMA model results for the association between the alcopops tax and monthly chlamydia test positivity rates are shown in Table 3. All models demonstrated an adequate fit. We found an immediate decrease in test positivity rates for 25–34-year-old males (−0.726, SE = 0.311, $p = 0.02$; 27% reduction) that remained detectable up to a lag of six months—on average, 112 fewer chlamydia notifications per month following the alcopops tax, from May 2008 to December 2016. Among 15–24-year-old males, a decrease in test positivity rates was detected at a six month lag (−1.439, SE = 0.688, $p = 0.04$; 31% reduction)—on average, 182 fewer notifications per month from November 2008 to December 2016. There were no significant immediate or lagged associations with the alcopops tax for females in either age group.

3.2.3. Sensitivity Analyses

Results from sensitivity analyses based on a two-month realignment of the test to the notification month supported our findings for the secondary outcome and are presented in the Supplementary Materials Table S1. The parameter estimates for 15–24-year-old males almost reached significance for an immediate association (−1.221, SE = 0.618, $p = 0.05$). Results from sensitivity analyses on the association between the alcopops tax and test counts were not significant for any gender or age combination. They supported our findings for the secondary outcome and are presented in the Supplementary Materials Table S2.

Table 2. Autoregressive integrated moving average (ARIMA) model results of the association between introduction of the alcopops tax and monthly chlamydia notification rates per 100,000 population (primary outcome) by age group and gender, July 2000 to December 2016.

							Immediate			**3 Month Lag**			**6 Month Lag**		
Age	Gender	Model	SR^2	Q	df	*p*	Est	SE	*p*	Est	SE	*p*	Est	SE	*p*
15–24	Male	$(0,1,1)$ $(0,1,1)_{12}$	0.61	13.65	16	0.63	0.004	0.003	0.22	0.003	0.003	0.35	0.002	0.003	0.61
	Female	$(0,1,1)$ $(0,1,0)_{12}$	0.45	19.99	17	0.28	-0.002	0.005	0.71	−0.002	0.005	0.73	−0.001	0.005	0.84
25–34	Male	$(0,1,1)$ $(0,1,0)_{12}$	0.45	19.24	17	0.32	-0.002	0.004	0.60	−0.004	0.005	0.41	−0.004	0.005	0.34
	Female	$(0,0,0)$ $(0,1,0)_{12}$	0.25	27.73	18	0.07	-0.032	0.027	0.23	−0.036	0.027	0.18	−0.021	0.027	0.44

*$p < 0.05$. All ARIMA models controlled for gender-specific chlamydia rates for the 35 and older age group and age- and gender-specific total income. All time series were log-transformed before modelling. Stationary R^2 for immediate effect models. Ljung-Box test (Q) based on first 18 autocorrelation lags of the pre-alcopops tax model residuals.

Table 3. ARIMA model results of the association between introduction of the alcopops tax and monthly chlamydia test positivity rates (secondary outcome) by age group and gender, July 2000 to December 2016.

							Immediate			**3 Month Lag**			**6 Month Lag**		
Age	Gender	Model	SR^2	Q	df	*p*	Est	SE	*p*	Est	SE	*p*	Est	SE	*p*
15–24	Male	$(0,0,2)$ $(1,0,0)_{12}$	0.69	21.19	16	0.17	−0.865	0.688	0.21	−1.181	0.689	0.09	−1.439*	0.688	0.04
	Female	$(0,0,0)$ $(1,0,0)_{12}$	0.80	33.91*	17	0.01	−0.307	0.436	0.48	−0.199	0.448	0.66	−0.196	0.456	0.67
25–34	Male	$(0,0,0)$ $(1,0,0)_{12}$	0.80	16.67	17	0.48	−0.726*	0.311	0.02	−0.970*	0.306	<0.01	−1.168*	0.304	<0.001
	Female	$(1,0,1)$ $(1,0,0)_{12}$	0.90	18.08	15	0.26	−0.192	0.161	0.23	−0.136	0.161	0.40	−0.197	0.160	0.22

*$p < 0.05$. ARIMA models controlled for gender-specific chlamydia rates for the 35 and older age group and age- and gender-specific total income. Notification data were aligned with test data that were processed one month later. Stationary R^2 for immediate effect models. Ljung-Box test (Q) based on first 18 autocorrelation lags of the pre-alcopops tax model residuals.

4. Discussion

We were unable to detect an association between the alcopops tax and our primary outcome measure of chlamydia notification rates based on population denominators. However, chlamydia rates estimated on the basis of the number of tests conducted were markedly different to the population-based trends and we found a significant association, in the expected direction, between the alcopops tax and test positivity rates among males aged between 15 and 24 (31% reduction, six month lag) and between 25 and 34 (27% reduction, immediate) years old. The results remained largely unchanged in the sensitivity analyses. We estimate a total of 16,615 chlamydia cases were prevented over eight years among 15–24-year-old males and 11,891 cases were prevented over eight and a half years among 25–34-year-old males following the alcopops tax and its impact on alcopop prices. These estimates of cases that were prevented are conservative, as most chlamydia infections are asymptomatic and not diagnosed. Among 15–29-year-olds in Australia, it is estimated that for every notification, there are 3.5 cases that go undiagnosed [31]. If untreated, chlamydia potentially leads to reproductive and neonatal morbidity, such as pelvic inflammatory disease, infertility, ectopic pregnancy, preterm labour, low birth weight and perinatal mortality [46,47]. Current national primary care guidelines suggest annual testing of all sexually active people under 30 years old [48]. More frequent testing is recommended for higher-risk gay and bisexual men and sex workers [48].

What is clear from the results is that taking the frequency of tests into account when estimating chlamydia rates substantially altered the trends compared to rates based on resident population. Test positivity rates were consistently higher among males than females for all age groups because fewer chlamydia tests were conducted in males than females and, thus, tests in males were more likely to be positive. Test counts increased considerably over the observation period, reflecting greater awareness and screening programs in general practice [34,49]. Models built on notifications per 100,000 population did not detect any association between the tax and chlamydia rates. Sensitivity analyses on the association between the alcopops tax and test counts were not significant for any gender or age combination, supporting our findings for the secondary outcome. This suggests that the test data may be a better proxy of the affected population than resident population and test positivity rates may be a more sensitive and appropriate means for evaluating alcohol policy effects than population-based notification rates, which do not take into account test patterns and differences in test behaviour across the population [29,30].

Our finding that the alcopops tax significantly reduced chlamydia test positivity rates among males aged 15–24 (lagged) and 25-34 (immediate) adds to the findings from studies from New South Wales [8], Western Australia and Victoria [16], all of which showed reductions in injury rates among males in these age groups following the introduction of the tax. It is of interest that we did not find an association between the alcopops tax and chlamydia test positivity rates among females, as the NSW study found that both the GST and alcopops tax had strong negative associations with ED attendances in 18–24-year-old females [8]. The Queensland studies found no association between the alcopops tax and ED attendance or hospitalisation among 15–29-year-olds for either gender [17–19].

In the years between the GST and the alcopops tax (when prices declined), although a greater proportion of females among 14–19-year-olds drank at risky levels on single occasions (>50g) than males (>70g), a greater proportion of males among 20–29 and 30–39-year-olds drank at risky levels on single occasions than females [6]. According to industry sources, RTDs based on dark spirits and typically sold in cans (e.g., bourbon whiskey and cola) made up three quarters of the alcopop market [50]. Young and underage males (14–19 years old) who engage in single occasion risky drinking (>70g) have a strong preference for these dark spirit-based RTDs (74%) [51]. Young and underaged females also have a preference for RTDs when drinking at risky levels (> 50g) but they generally choose white spirits that are typically sold in bottles (78%). Males in their twenties tend to move away from RTDs and more towards regular strength beer and straight spirits; nevertheless, consumption of dark spirit-based RTDs remains prevalent, with 58% of 20–24 and 44% of 25–29-year-old males preferring them when engaging in risky drinking occasions. Female RTD consumption also declines with age

but is still reported as a preferred beverage on risky drinking occasions by 63% of 20–24 and 42% of 25–29-year-olds [51]. Although the overall trends in chlamydia test positivity rates appeared similar for the two age groups in both genders—stable and then declining from 2008 for males and an overall steady decrease for females—there was notably larger monthly variability during the 18 months immediately after the tax, which may have reduced statistical power. It is also likely that the 15–24 year age group in both genders is more heterogenous in its drinking and sexual behaviours compared to the 25–34 year age group, as it includes teenagers and likely a proportion of high risk underage drinkers (<18 years old) who may take longer to respond to policy change. The test data applied in our study were only available in pre-set age groups, thereby limiting our ability to separate teenagers and those in their early twenties (71% of 15–24 male notifications were among 20–24-year-olds) and those in their late twenties and early thirties (66% of 25–34 male notifications were among 25–29-year-olds) for analysis. Lagged associations on chlamydia test positivity rates among 15–24 and 25–34-year-old males following the alcopops tax may have been related to the asymptomatic nature of most chlamydia cases [31], which can delay testing and detection. Males are also less likely than females to present to a GP with a sexual health complaint, although more likely to be symptomatic when they do attend, and less likely than females to follow through with an STI test should a GP request one [30,45].

In order to accurately inform future decision making, alcohol policies and their effects on public health must be well evaluated using robust study designs and sensitive measures. When randomised controlled trials are not feasible, interrupted time series analysis offers a strong alternative study design. Using a novel approach to constructing STI rates in an alcohol taxation study, we found evidence of an association between the alcopops tax and chlamydia test positivity rates among 15–24 and 25–34-year-old males; this association would have remained undetected had we relied only on standard methods. Other strengths of this study were its national focus, use of high quality mandatory notification data, application of an internal control series (males and females > = 35 years), adjustment for gender and age-specific CPI-adjusted per capita income to control for the effect of the GFC on disposable income, and sensitivity analyses.

Despite the strong study design, we note a number of limitations. This is an ecological study and, as such, it may not reflect the behaviour of individuals. The publicly available chlamydia test data represented tests undertaken in general practice settings and did not include tests undertaken at public sexual health clinics [31]. However, the majority of tests are conducted in general practice, as evidenced by the higher proportion of notifications from this setting [40]. Assumptions were necessary to align the notification and test data as closely as possible in the calculation of chlamydia test positivity rates, and having the test service date rather than the claim process date would have allowed for more accurate alignment. Missing data from the chlamydia test series required interpolation and data were only available in ten-year age groups thereby limiting our ability to separate out teenage/underage drinkers. Longer national chlamydia notification time series would have facilitated evaluation of the GST in addition to the alcopops tax (e.g., [8])– if significant increases in chlamydia test positivity rates were found among males following the GST it would have strengthened our findings. We also considered gonorrhoea as a potential outcome measure, as national data collection has been mandated for longer than chlamydia, but it was deemed not suitable for this evaluation as it is mainly concentrated in gay and bisexual men, and young Aboriginal people living in remote areas of Australia [31]. A geographic control would have strengthened the analysis; however, the intervention was introduced nationwide. There may have been other confounding factors, such as community-level sexual health promotion campaigns that may have increased safer sex practices, that we were unable to control for. Unfortunately, sexual risk behaviour data were not available by gender and age group around the time of the alcopops tax, however, there are reports of small but significant increases in condom use by heterosexual men in their most recent sexual encounter between national surveys taken in 2001–02 (25%) and 2012–13 (29%) [52].

5. Conclusions

The 2008 alcopops tax was an attempt to remedy a regulatory loophole created by the introduction of the GST in 2000 and to reduce sales of ready-to-drink beverages to vulnerable young people. This study adds to the evidence base supporting the use of alcohol taxation to reduce health-related harms experienced by young people and offers a novel method in calculating sexually transmitted infection rates for policy evaluation.

Supplementary Materials: The following are available online at http://www.mdpi.com/1660-4601/17/4/1343/s1. Figure S1: Monthly chlamydia notification counts by gender and age group, July 2000 to December 2016. Alcopops tax intervention point indicated by dotted line at May 2008, Figure S2: Monthly estimated resident population by gender and age group, July 2000 to December 2016. Alcopops tax intervention point indicated by dotted line at May 2008. Quarterly estimated resident population was interpolated within age group and gender to achieve monthly data points, Figure S3: Monthly CPI-adjusted per capita total income ($) by age group and gender, July 2000 to Dec 2016. Alcopops tax intervention point indicated by dotted line at May 2008, Figure S4: Annual litres of pure alcohol consumed per capita by beverage type, 2002-03 to 2015-16. Alcopops tax intervention point indicated by dotted line at 2007-08, Table S1: ARIMA model results of the association between introduction of the alcopops tax and monthly chlamydia test positivity rates (secondary outcome) by age group and gender with a two-month realignment of test to notification month, July 2000 to December 2016, Table S2. ARIMA model results of the association between introduction of the alcopops tax and monthly chlamydia test counts by age group and gender, July 2000 to December 2016.

Author Contributions: T.C. and J.K. conceived the study idea. W.G., T.C., J.K. and R.G. designed the study. W.G. and H.M. collected study data. W.G. prepared, analysed and interpreted study data and drafted the manuscript. T.C., J.K., H.M. and R.G. contributed to interpretation of data and edited manuscript for intellectual content. All authors have read and agreed to the published version of the manuscript.

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Please see Appendix D for supplementary materials for publication 4.

3. Discussion

This thesis by compilation presented four peer-reviewed publications, a narrative literature review (4) and three original studies (20, 21, 32) focused on using novel approaches to address gaps in alcohol availability scientific research at both individual and population levels. Two specific forms of alcohol availability were the subject of this research program: licensed outlet trading hours (physical) and federal alcohol taxation (economic). The health outcomes chosen, mental health (alcohol use disorders) and sexual health (chlamydia), were underrepresented in alcohol availability and policy evaluation research when compared with injury outcomes. The novel methods used in these studies have allowed for associations to be revealed that may not have been had more traditional research methods been used. The studies have contributed new evidence to the body of national and international research on associations between alcohol availability, alcohol use and alcohol-related health effects.

The narrative literature review (4) was the first paper to be published in this research program, and there have been reviews published since that add to the overall weight of evidence that supports restricting the physical and economic availability of alcohol for public health. For example, the latest systematic review on alcohol prices, taxes and alcohol use concluded that there was overwhelming evidence for the negative association between alcohol prices and taxes and alcohol use (35). There have also been several more recent systematic reviews on licensed outlet trading hour effects that generally concluded there was a positive association between trading hours and both alcohol use and alcohol-related acute and short-term harms (10, 12, 13, 16).

Findings from the trading hour effect studies (20, 21) were that: (i) females who typically drank hazardously preferred late closing bars (no associations demonstrated for males or other categories of females); (ii) males with an active alcohol use disorder and females who typically drank hazardously or had an active alcohol use disorder were more likely to have a high blood alcohol concentration when surveyed (no associations demonstrated for other categories of males or females), and (iii) males who were typically low risk drinkers but had high blood alcohol concentration when surveyed preferred late closing bars more than males with an active alcohol use disorder and a high blood alcohol concentration (no associations demonstrated for females or other categories of males). The latter finding was somewhat unexpected. It appears that male nightlife-goers with alcohol use disorders who are intoxicated are in fact less influenced by trading hours

than males who usually drink at low levels but are drinking to intoxication on what is probably a big night out for them. Future work to investigate this finding may include some qualitative interviews of drinkers asking their views about how important bar choice (including opening hours) is for influencing their own and other's drinking behaviour (including quantity consumed).

These were the first international trading hour studies to use street intercept surveys. Examining trading hour effects at the individual-level rather than at the population-level, as typically used in licensed outlet trading hour studies (9-16), made it possible to investigate associations between individuals' self-reported typical alcohol use and their related risk of alcohol use disorder, a snapshot objective measure of their alcohol use on a night out and the type of bar they prefer to spend time at on a night out (standard vs. late closing time). Although 208 participants did not complete the AUDIT-C, it is noteworthy that participants who did not complete it were similar to those who did, including: mean age (29 vs. 27), proportion male (69% vs. 68%) and mean blood alcohol concentrations (0.075 vs. 0.074 g/100 mL) respectively. An assumption common to both studies was that the longer the time spent in a bar meant the more alcohol consumed. Half of nightlife-goers were not on a typical night out and may have been exhibiting atypical behaviour. Also, despite the venues studied being similar in that they had the same functional liquor licence, the bars may have had individual characteristics that attracted a particular type of patron. These studies were conducted in nightlife areas of one Australian city, Perth, however, the findings may be generalisable to nightlife areas in other cities with similar drinking cultures and regulatory approaches to licensed outlet trading hours.

Findings from the alcohol taxation effect study (32) were that after the 27th April 2008 alcopops tax increase there were immediate and delayed reductions in chlamydia test positivity rates among 25–34-year-old and 15–24-year-old males, respectively, with a conservative estimate of 28,500 chlamydia cases prevented over the following eight and a half years. There was no evidence of an effect on any population-based rates. There was also no evidence of an effect on test positivity rates among females, consistent with market share data and national surveys showing that ready-to-drink beverages, particularly dark spirits with mixers served in cans, are most popular among males.

This was the first national-level evaluation of the alcopops tax and the first international alcohol pricing study to test a more sensitive measure of community sexual health than population-based rates. Evidence of associations between the alcopops tax and chlamydia rates would have remained

undetected if only standard methods used in similar international alcohol pricing/taxation evaluations with sexual health outcomes had been relied upon (26-31). A population-level quasi-experimental interrupted time series analysis is the strongest research design for causal inference in intervention evaluation short of a randomised controlled trial (36). Although the study design is strongest with a geographic control, an internal control using older Australians unlikely to be affected by the tax was included as well as an adjustment for gender and age-specific income trends. Analysis involved making certain assumptions, such as the issue of temporal alignment of tests and results, but associations held under sensitivity analysis. The data sources restricted the analysis to ten-year age groups, but it is recommended that future evaluations of the alcopops tax, regardless of the outcome studied, disaggregate age further where possible. An earlier alcopops tax decrease, on 1st July 2000, was unfortunately not covered by the chlamydia time series, but could be included as a second intervention time point in future evaluations, e.g. (37).

In Australia, as in many other countries where alcohol is legally and readily available, alcohol use is deeply embedded in the social and cultural contexts of everyday life (38). What's more, the alcohol industry is part of our society in that it provides a considerable revenue stream for governments via taxes, and creates a range of employment opportunities throughout production, import/export and sales (1). The international evidence base that both increased and reduced alcohol availability are associated with respective changes in alcohol use and related health effects has been growing for some 50 years (39), yet there are still many international examples of where governments relax rather than restrict physical and economic alcohol availability. For example, the UK government removed alcohol trading hour restrictions in 2005 allowing for 24-hour liquor licence applications across England and Wales (40). Also, the US and Canada, unlike Australia, have examples of federal alcohol excise tax rates not having kept up with inflation for decades (4). Finding more novel and robust approaches to studying alcohol availability effects while broadening the focus on outcomes to include more chronic and long-term health and social issues, will help build more effective arguments for decision makers focused on improving the health and wellbeing of their communities.

3.1 Conclusion

This research program generated a body of original peer-reviewed published work that strengthens the international evidence base regarding how government regulatory strategies focused on alcohol

availability affect both mental and sexual health. With the ultimate aim of improving the health and well-being of individuals and communities in mind, the outputs of this research program support restricting bar trading hours (even where restrictions reduce trading by only a few hours) and the 2008 alcopops tax implementation and will contribute to informing future evidence-based alcohol policy debate.

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Appendix A: Authors' contribution statements

National Drug Research Institute
Preventing harmful drug use in Australia
Curtin University
GPO Box U1987
Perth Western Australia 6845

30th July 2018

To Whom It May Concern,

I, William Thomas Gilmore, contributed the following to the publication *Gilmore W, Chikritzhs T, Stockwell T, Jernigan D, Naimi T, and Gilmore I (2016). Alcohol: taking a population perspective. Nature Reviews Gastroenterology & Hepatology, 13(7), 426-434.* As first author, I coordinated the work, drafted the outline, drafted a substantial portion of the manuscript, critically reviewed the manuscript, edited the manuscript and approved the final version to be published.

	WG	TC	TS	DJ	TN	IG
Coordination	×					
Conception	×	×				×
Outline	×	×	×	×	×	×
Drafted manuscript	×		×	×	×	
Critically reviewed and edited manuscript	×	×	×	×	×	×
Final approval	×	×	×	×	×	×

Yours faithfully,

I, as a co-author, endorse that this level of contribution by the candidate and co-authors indicated above is appropriate.

Professor Tanya Chikritzhs
Curtin University

Professor Tim Stockwell
University of Victoria

Professor David Jernigan
Boston University

Professor Timothy Naimi
Boston University

Professor Sir Ian Gilmore
University of Liverpool

National Drug Research Institute

Preventing harmful drug use in Australia

Curtin University
GPO Box U1987
Perth Western Australia 6845

1 August 2022

To Whom It May Concern,

I, William Thomas Gilmore, contributed the following to the publication *Gilmore, W.; Symons, M.; Liang, W.; Graham, K.; Kypri, K.; Miller, P.; Chikritzhs, T. Association between Nightlife Goers' Likelihood of an Alcohol Use Disorder and Their Preferred Bar's Closing Time: A Cross-Sectional Observational Study in Perth, Australia. Int. J. Environ. Res. Public Health 2021, 18, 13040.* As first author, I coordinated the work, contributed to study design and data collection, prepared and analysed study data, and drafted the manuscript.

	WG	MS	WL	KG	KK	PM	TC
Coordination	×						
Conception	×		×	×	×	×	×
Design	×	×	×	×	×	×	×
Data collection	×					×	×
Data preparation and analysis	×						
Drafted manuscript	×						
Critically reviewed and edited manuscript		×	×	×	×	×	×
Final approval	×	×	×	×	×	×	×

Yours faithfully,

I, as a Co-Author, endorse that this level of contribution by the candidate and co-authors indicated above is appropriate.

Dr Martyn Symons, National Drug Research Institute,
Curtin University

Dr Wenbin Liang, School of Public Health, Fujian
Medical University

Prof Kathryn Graham, Institute for Mental Health Policy
Research, Centre for Addiction and Mental Health

Prof Kypros Kypri, School of Medicine and Public Health, University of Newcastle

Prof Peter Miller, Centre for Drug Use, Addictive and Anti-Social Behaviour Research, Deakin University

Prof Tanya Chikritzhs, National Drug Research Institute, Curtin University

National Drug Research Institute
Preventing harmful drug use in Australia
Curtin University
GPO Box U1987
Perth Western Australia 6845

1 August 2022

To Whom It May Concern,

I, William Thomas Gilmore, contributed the following to the publication *Gilmore, W.; Symons, M.; Liang, W.; Graham, K.; Kypri, K.; Miller, P.; Chikritzhs, T. Association between Bar Closing Time, Alcohol Use Disorders and Blood Alcohol Concentration: A Cross-Sectional Observational Study of Nightlife-Goers in Perth, Australia. Int. J. Environ. Res. Public Health 2022, 19, 7026.* As first author, I coordinated the work, contributed to study design and data collection, prepared and analysed study data, and drafted the manuscript.

	WG	MS	WL	KG	KK	PM	TC
Coordination	×						
Conception	×		×	×	×	×	×
Design	×	×	×	×	×	×	×
Data collection	×					×	×
Data preparation and analysis	×						
Drafted manuscript	×						
Critically reviewed and edited manuscript		×	×	×	×	×	×
Final approval	×	×	×	×	×	×	×

Yours faithfully,

I, as a Co-Author, endorse that this level of contribution by the candidate and co-authors indicated above is appropriate.

Dr Martyn Symons, National Drug Research Institute,
Curtin University

Dr Wenbin Liang, School of Public Health, Fujian
Medical University

Prof Kathryn Graham, Institute for Mental Health Policy
Research, Centre for Addiction and Mental Health

Prof Kypros Kypri, School of Medicine and Public Health, University of Newcastle

Prof Peter Miller, Centre for Drug Use, Addictive and Anti-Social Behaviour Research, Deakin University

Prof Tanya Chikritzhs, National Drug Research Institute, Curtin University

National Drug Research Institute
Preventing harmful drug use in Australia
Curtin University
GPO Box U1987
Perth Western Australia 6845

26th June 2020

To Whom It May Concern,

I, William Thomas Gilmore, contributed the following to the publication *Gilmore, W., Chikritzhs, T., McManus, H., Kaldor, J., Guy, R. (2020). The association between the Australian alcopops tax and national chlamydia rates among young people – an interrupted time series analysis.*17 (4), 1343. As first author, I coordinated the work, contributed to study design, collected, prepared and analysed study data, and drafted the manuscript.

	WG	TC	HM	JK	RG
Coordination	×				
Conception		×		×	
Design	×	×		×	×
Data collection	×		×		
Data preparation and analysis	×				
Drafted manuscript	×				
Critically reviewed and edited manuscript		×	×	×	×
Final approval	×	×	×	×	×

Yours faithfully,

I, as a Co-Author, endorse that this level of contribution by the candidate and co-authors indicated above is appropriate.

Prof Tanya Chikritzhs, National Drug Research Institute, Curtin University

Dr Hamish McManus, Kirby Institute, University of New South Wales

Prof John Kaldor, Kirby Institute, University of New South Wales

Prof Rebecca Guy, Kirby Institute, University of New South Wales

Appendix B: Ethics approvals

MEMORANDUM

Curtin University

To:	Prof Tanya Chikritzhs
	National Drug Research Institute (NDRI)
CC:	
From	Professor Peter O'Leary, Chair HREC
Subject	Ethics approval
	Approval number: HR154/2015
Date	07-Aug-15

Office of Research and Development
Human Research Ethics Office

TELEPHONE 9266 2784
FACSIMILE 9266 3793
EMAIL hrec@curtin.edu.au

Thank you for your application submitted to the Human Research Ethics Office for the project: 5227
Pub extended trading hours: effects on drunkenness and alcohol-related harm

Your application was reviewed by Human Research Ethics Committee at Curtin University at their meeting on the 4/08/2015

Thankyou for providing the additional information requested by the Human Research Ethics Committee. The information you provided was satisfactory and your proposal is now approved.

Please note the following conditions of approval:

1. Approval is granted for a period of four years fror **11-Aug-15** to **11-Aug-19**
2. Research must be conducted as stated in the approved protocol.
3. Any amendments to the approved protocol must be approved by the Ethics Office.
4. An annual progress report must be submitted to the Ethics Office annually, on the anniversary of approval.
5. All adverse events must be reported to the Ethics Office.
6. A completion report must be submitted to the Ethics Office on completion of the project.
7. Data must be stored in accordance with WAUSDA and Curtin University policy.
8. The Ethics Office may conduct a randomly identified audit of a proportion of research projects approved by the HREC.

Should you have any queries about the consideration of your project please contact the Ethics Support Officer for your faculty, or the Ethics Office at hrec@curtin.edu.au or on 9266 2784. All human research ethics forms and guidelines are available on the ethics website.

Professor Peter o'Leary
Chair, Human Research Ethics Committee

Curtin University

Research Office at Curtin

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Perth Western Australia 6845

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Facsimile +61 8 9266 3793
Web research.curtin.edu.au

07-Jun-2022

Name: Tanya Chikritzhs
Department/School: National Drug Research Institute (NDRI)
Email: T.N.Chikritzhs@curtin.edu.au

Dear Tanya Chikritzhs

RE: Annual report acknowledgment
Approval number: HR154/2015

Thank you for submitting an annual report to the Human Research Ethics Office for the project **Pub extended trading hours: effects on drunkenness and alcohol-related harm**.

The Human Research Ethics Office acknowledges the project is ongoing and approval will remain current until 01-Aug-2023.

Special Condition of Approval Extension.

It is the responsibility of the Chief Investigator to ensure that any activity undertaken under this project adheres to the latest available advice from the Government or the University regarding COVID-19.

Any special conditions noted in the original approval letter still apply.

Standard conditions of approval

1. Research must be conducted according to the approved proposal
2. Report in a timely manner anything that might warrant review of ethical approval of the project including:
   - proposed changes to the approved proposal or conduct of the study
   - unanticipated problems that might affect continued ethical acceptability of the project
   - major deviations from the HREC approved protocol procedures and/or regulatory guidelines
   - serious adverse events
3. Amendments to the proposal must be approved by the Human Research Ethics Office before they are implemented (except where an amendment is undertaken to eliminate an immediate risk to participants)
4. An annual progress report must be submitted to the Human Research Ethics Office on or before the anniversary of approval and a completion report submitted on completion of the project
5. Personnel working on this project must be adequately qualified by education, training and experience for their role, or supervised
6. Personnel must disclose any actual or potential conflicts of interest, including any financial or other interest or affiliation, that bears on this project
7. Changes to personnel working on this project must be reported to the Human Research Ethics Office
8. Data and primary materials must be retained and stored in accordance with the Western Australian University Sector Disposal Authority (WAUSDA) and the Curtin University Research Data and Primary Materials policy
9. Where practicable, results of the research should be made available to the research participants in a timely and clear manner
10. Unless prohibited by contractual obligations, results of the research should be disseminated in a manner that will allow public scrutiny; the Human Research Ethics Office must be informed of any constraints on publication
11. Ethics approval is dependent upon ongoing compliance of the research with the Australian Code for the Responsible Conduct of Research, the National Statement on Ethical Conduct in Human Research, applicable legal requirements, and with Curtin University policies, procedures and governance requirements
12. The Human Research Ethics Office may conduct audits on a portion of approved projects.

Yours sincerely

Professor Sharyn Burns
Chair, Human Research Ethics Committee

Curtin University

Memorandum

To	Professor Tanya Chikritzhs, NDRI
From	Professor Stephan Millett, Chair, Human Research Ethics Committee
Subject	Protocol Approval **HR 138/2013**
Date	18 September 2013
Copy	

Office of Research and Development
Human Research Ethics Committee

TELEPHONE 9266 2784
FACSIMILE 9266 3793
EMAIL hrec@curtin.edu.au

Thank you for your application submitted to the Human Research Ethics Committee (HREC) for the project titled "*National Alcohol Indicators Project (NAIP)*". The Committee notes the prior approval by Curtin University HREC (HR146/2009) and has reviewed your application consistent with Chapter 5.3 of the *National Statement on Ethical Conduct in Human Research*.

- You have ethics clearance to undertake the research as stated in your proposal.
- The approval number for your project is **HR 138/2013.** *Please quote this number in any future correspondence.*
- Approval of this project is for a period of four years **19-09-2013** to **19-09-2017**.
- Annual progress reports on the project must be submitted to the Ethics Office.
- If you are a Higher Degree by Research student, data collection must not begin before your Application for Candidacy is approved by your Faculty Graduate Studies Committee.

- The following standard statement **must be** included in the information sheet to participants:

  This study has been approved by the Curtin University Human Research Ethics Committee (Approval Number HR 138/2013). The Committee is comprised of members of the public, academics, lawyers, doctors and pastoral carers. If needed, verification of approval can be obtained either by writing to the Curtin University Human Research Ethics Committee, c/- Office of Research and Development, Curtin University, GPO Box U1987, Perth, 6845 or by telephoning 9266 2784 or by emailing hrec@curtin.edu.au.

Applicants should note the following:

It is the policy of the HREC to conduct random audits on a percentage of approved projects. These audits may be conducted at any time after the project starts. In cases where the HREC considers that there may be a risk of adverse events, or where participants may be especially vulnerable, the HREC may request the chief investigator to provide an outcomes report, including information on follow-up of participants.

The attached **Progress Report** should be completed and returned to the Secretary, HREC, C/- Office of Research & Development annually.

Our website https://research.curtin.edu.au/guides/ethics/non_low_risk_hrec_forms.cfm contains all other relevant forms including:

- Completion Report (to be completed when a project has ceased)
- Amendment Request (to be completed at any time changes/amendments occur)
- Adverse Event Notification Form (If a serious or unexpected adverse event occurs)

Stephan Millett
Human Research Ethics Committee

Curtin University

Office of Research and Development

GPO Box U1987
Perth Western Australia 6845

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Web research.curtin.edu.au

02-Jun-2017

Name: Tanya Chikritzhs
Department/School: National Drug Research Institute (NDRI)
Email: T.N.Chikritzhs@curtin.edu.au

Dear Tanya Chikritzhs

RE: Amendment approval
Approval number: HR138/2013

Thank you for submitting an amendment request to the Human Research Ethics Office for the project **National Alcohol Indicators Project (NAIP)**.

Your amendment request has been reviewed and the review outcome is: **Approved**

The amendment approval number is HR138/2013-02 approved on 02-Jun-2017.

The following amendments were approved:

1. Addition of a non-identifiable national dataset on sexually transmitted infection (chlamydia and gonorrhoea) testing and diagnoses, 1993-2016, held at the Kirby Institute, University of New South Wales.
2. Addition of co-investigators to the ethics protocol: Eveline Lensvelt (Curtin, 259952K) William Gilmore (Curtin, 251991D)

Any special conditions noted in the original approval letter still apply.

Standard conditions of approval

1. Research must be conducted according to the approved proposal
2. Report in a timely manner anything that might warrant review of ethical approval of the project including:
   - proposed changes to the approved proposal or conduct of the study
   - unanticipated problems that might affect continued ethical acceptability of the project
   - major deviations from the approved proposal and/or regulatory guidelines
   - serious adverse events
3. Amendments to the proposal must be approved by the Human Research Ethics Office before they are implemented (except where an amendment is undertaken to eliminate an immediate risk to participants)
4. An annual progress report must be submitted to the Human Research Ethics Office on or before the anniversary of approval and a completion report submitted on completion of the project
5. Personnel working on this project must be adequately qualified by education, training and experience for their role, or supervised
6. Personnel must disclose any actual or potential conflicts of interest, including any financial or other interest or affiliation, that bears on this project

7. Changes to personnel working on this project must be reported to the Human Research Ethics Office
8. Data and primary materials must be retained and stored in accordance with the Western Australian University Sector Disposal Authority (WAUSDA) and the Curtin University Research Data and Primary Materials policy
9. Where practicable, results of the research should be made available to the research participants in a timely and clear manner
10. Unless prohibited by contractual obligations, results of the research should be disseminated in a manner that will allow public scrutiny; the Human Research Ethics Office must be informed of any constraints on publication
11. Ethics approval is dependent upon ongoing compliance of the research with the Australian Code for the Responsible Conduct of Research, the National Statement on Ethical Conduct in Human Research, applicable legal requirements, and with Curtin University policies, procedures and governance requirements
12. The Human Research Ethics Office may conduct audits on a portion of approved projects.

Should you have any queries regarding consideration of your project, please contact the Ethics Support Officer for your faculty or the Ethics Office at hrec@curtin.edu.au or on 9266 2784.

Yours sincerely

Dr Catherine Gangell
Manager, Research Integrity

Curtin University

Research Office at Curtin

GPO Box U1987
Perth Western Australia 6845

Telephone +61 8 9266 7863
Facsimile +61 8 9266 3793
Web research.curtin.edu.au

08-Aug-2022

Name: Tanya Chikritzhs
Department/School: National Drug Research Institute (NDRI)
Email: T.N.Chikritzhs@curtin.edu.au

Dear Tanya Chikritzhs

RE: Annual report acknowledgment
Approval number: HR138/2013

Thank you for submitting an annual report to the Human Research Ethics Office for the project **National Alcohol Indicators Project (NAIP)**.

The Human Research Ethics Office acknowledges the project is ongoing and approval will remain current until 11-Sep-2023.

Special Condition of Approval Extension.

It is the responsibility of the Chief Investigator to ensure that any activity undertaken under this project adheres to the latest available advice from the Government or the University regarding COVID-19.

Any special conditions noted in the original approval letter still apply.

Standard conditions of approval

1. Research must be conducted according to the approved proposal
2. Report in a timely manner anything that might warrant review of ethical approval of the project including:
   - proposed changes to the approved proposal or conduct of the study
   - unanticipated problems that might affect continued ethical acceptability of the project
   - major deviations from the HREC approved protocol procedures and/or regulatory guidelines
   - serious adverse events
3. Amendments to the proposal must be approved by the Human Research Ethics Office before they are implemented (except where an amendment is undertaken to eliminate an immediate risk to participants)
4. An annual progress report must be submitted to the Human Research Ethics Office on or before the anniversary of approval and a completion report submitted on completion of the project
5. Personnel working on this project must be adequately qualified by education, training and experience for their role, or supervised
6. Personnel must disclose any actual or potential conflicts of interest, including any financial or other interest or affiliation, that bears on this project
7. Changes to personnel working on this project must be reported to the Human Research Ethics Office
8. Data and primary materials must be retained and stored in accordance with the Western Australian University Sector Disposal Authority (WAUSDA) and the Curtin University Research Data and Primary Materials policy
9. Where practicable, results of the research should be made available to the research participants in a timely and clear manner
10. Unless prohibited by contractual obligations, results of the research should be disseminated in a manner that will allow public scrutiny; the Human Research Ethics Office must be informed of any constraints on publication
11. Ethics approval is dependent upon ongoing compliance of the research with the Australian Code for the Responsible Conduct of Research, the National Statement on Ethical Conduct in Human Research, applicable legal requirements, and with Curtin University policies, procedures and governance requirements
12. The Human Research Ethics Office may conduct audits on a portion of approved projects.

Should you have any queries regarding consideration of your project, please contact the Ethics Office at hrec@curtin.edu.au or on 9266 9223.

Yours sincerely

Professor Sharyn Burns
Chair, Human Research Ethics Committee

ACT Government
Health

ACT Health
Human Research Ethics and Governance Office
Low Risk Sub-Committee

Professor Tanya Chikritzhs
National Drug Research Institute
Curtin University
GPO Box U1987
Perth WA 6845

Dear Professor Chikritzhs

ETHLR.13.070

Thank you for your letter of 2 February 2018, requesting amendments relating to:

National Alcohol Indicators Project (NAIP)

At its meeting of 14 February 2018, the Committee approved:

- Protocol amended to cover the use of ACT sexually transmitted infection (STI) data sourced from the National Notifiable Diseases Surveillance System to undertake a national alcohol policy evaluation

This information is now recorded on the Committee's files.

Yours sincerely,

Professor Paul Gatenby AM
MBBS PhD FRACP FRCPA
Chairman
ACT Health Human Research Ethics Committee
Low Risk Sub-Committee

14 February 2018

Research Ethics and Governance Office
Human Research Ethics Committee
Low Risk Sub-Committee

Professor Tanya Chikritzhs
National Drug Research Institute
Curtin University
Building 609 Level 2
Bentley WA 6102

ACT reference	ETHLR.13.070
Study Title	National Alcohol Indicators Project (NAIP)

This submission has been assessed under the usual guidelines for research ethics and site governance. Australian, State and Territory Government and relevant institution COVID-safety guidelines must be followed.

Dear Professor Chikritzhs,

Thank you for your correspondence dated 15 March 2021, providing a progress report and extension request for the above referenced study.

At its meeting of 7 April 2021, the Committee noted the report and approved an extension of the study for three (3) years to April 2024.

ACT Health Human Research Ethics Committee is constituted according to the National Statement on Ethical Conduct in Human Research 2007 and is certified for single review of multi-centre clinical trials. ACT Health HREC operates in compliance with applicable regulatory requirements and the principles of the International Conference on Harmonization Guidelines on Good Clinical Practice.

The approval has been recorded on the Committee's files.

Yours sincerely,

August Marchesi
Senior Director
Research Ethics and Governance

7 April 2021

Appendix C: Nightlife survey schedule (Publications 2 and 3)

Section 1: Personal details

1.1 Date_____

1.2 Time_____

1.3 Gender

1 Male

2 Female

1.4 Agreed to be surveyed

1 Yes

2 No (finish this record, complete Section 6, then go to next patron)

1.5 Postcode _____

1.6 Occupation_____

1.7 Year of birth _____

Section 2: Current night out

2.1 How many hours have you been 'going' for (prompt with "How long ago did you first start your night out/ what time was it when you started your evening")?

_____[hours]

2.2 Where have you spent time tonight (please mark all locations)?

1 Private home (own, friends, acquaintances)
2 Sporting club (e.g., football/cricket club)
3 Sports event (e.g., at the races)
4 Restaurant
5 Reception centre/function room (e.g., for wedding)
6 Hotel/pub/bar
7 Nightclub
8 Rave/dance party
9 Music festival/concert
10 Gaming venue
11 Public location (e.g., park, beach, street)
12 Other (please specify)_____

2.3 What is your main reason for going out tonight (one response only)?

1 Catch-up with/socialise with friends
2 See a band/DJ/other performance
3 Special event/celebration (e.g. birthday)
4 Work function
5 Normal night out
6 To get drunk/intoxicated
7 Pickup/find a partner
8 Other (please specify)_____

2.4 Have you consumed any alcohol tonight?

1 Yes

2 No (Skip to 2.11)

2.5 If yes, what alcoholic beverages have you consumed tonight (please mark all that apply)?

1 Full strength beer

2 Light beer

3 Wine

4 Champagne

5 Cider

6 White spirits

7 Dark spirits

8 Liqueur

9 Alcopops/Ready-to-drinks

10 Shots

11 Cocktails

12 Other (please specify)_____

2.6 Approximately how many standard drinks have you consumed tonight?

_____ [standard drinks]

2.7 Have you drunk any alcohol at any licensed venues tonight?

1 Yes

2 No (Skip to 2.11)

2.8 If yes, what is the name of the licensed venue where you have been drinking tonight? If more than one then tell me in order starting from the most recent i.e. name the one you've just come from first?

_____ [insert name/s]

2.9 If yes, what is the name of the venue where you've spent most of your time tonight?

_____ [insert name]

2.10 If yes, about how many hours were you at this venue?

_____ [hours]

2.11 What is the name of the venue where you usually drink when you go out?

_____ [insert name]

2.12 How much would you say you've spent on buying drinks at licensed venues tonight?

$_____ [insert amount]

2.13 Did you drink any alcohol before going out to licensed venues tonight e.g., in a private home or other private setting?

1 Yes

2 No (Skip to 2.17)

2.14 If yes, where did you consume alcohol before going out to licensed venues tonight (please mark all that apply)?

1 Own home

2 Friends/acquaintance home

3 Private function (e.g. wedding, other private event)

4 Public location (e.g. park, beach, street)

5 Car

6 Other (please specify)_____

2.15 If yes, how many standard drinks did you have?

_____ [standard drinks]

2.16 If yes, why did you drink before going out to licensed venues (please mark all that apply)?

1 Price (it's cheaper)
2 More convenient
3 Don't want to go out too early
4 Chance to catch up with friends before
5 To get intoxicated before going out
6 For fun
7 Other (please specify)_____

2.17 Have you consumed any energy drinks tonight (e.g., Red Bull, V)?

1 Yes
2 No (Skip to 2.22)

2.18 If yes, how many energy drinks have you consumed (approximate number of 250ml cans)?

_____ [cans]

2.19 If yes, did you mix these energy drinks with alcohol?

1 Yes
2 No (Skip to 2.21)

2.20 If yes, what was your main reason for mixing energy drinks with alcohol?

1 No specific reason
2 To stay awake/party for longer
3 The social aspect (it's something I do with my friends)
4 It's a special occasion/celebration
5 I like the feeling/buzz
6 I like the taste/ it's my preferred mixer
7 To feel less drunk
8 To increase/accelerate intoxication
9 Other (please specify)_____

2.21 Have you consumed any other drugs tonight (i.e., illicit drugs, or pharmaceutical drugs that were not prescribed to you)?

1 Yes

2 No (Skip to 2.23)

2.22 If yes, what other drugs have you consumed tonight (please mark all that apply)?

1 Ecstasy

2 Cocaine

3 Methamphetamine

4 Ice

5 Pharmaceutical stimulants (e.g., dexamphetamine)

6 Ketamine

7 LSD

8 GHB/GBL/1,4B

9 Benzodiazepines

10 Heroin/other opiates

11 Cannabis

12 Tobacco

13 Mephedrone

14 Other (please specify)_____

2.23 Can you rate how intoxicated you feel from your alcohol and other drug consumption tonight (on a scale of 0 to 10)?

_____ (0 totally sober – 10 falling down drunk)

2.24 Breathalyser reading: _____ g/100 mL

Section 3: Usual drinking levels in the past 12 months

AUDIT-C 3 questions (3.1 to 3.3)

3.1 How often did you have a drink containing alcohol in the past year?

1 Never
2 Monthly or less
3 Two to four times a month
4 Two to three times per week
5 Four or more times a week

3.2 How many drinks did you have on a typical day when you were drinking in the past year?

1 1 or 2
2 3 or 4
3 5 or 6
4 7 to 9
5 10 or more

3.3 How often did you have six or more drinks on one occasion in the past year?

1 Never
2 Less than monthly
3 Monthly
4 Weekly
5 Daily or almost daily

3.4 What is the estimated maximum number of standard drinks you have consumed on a single occasion in the past year?

_____ [standard drinks]

Section 4: Aggression / offending / alcohol-related consequences

4.1 Have you witnessed any verbal or physical aggression in/around licensed venues during the past 12 months (mark all that apply)?

1 No, witnessed no aggression (Skip to 4.3)

2 Yes, verbal

3 Yes, physical

4.2 If yes, can you recall the name of the venue(s)? [Prompt if necessary with 'Was it your usual venue or a venue you are attending tonight?']

_____ [insert name/s]

4.3 How many times have you been involved in any verbal aggression in/around licensed venues during the past 12 months (if none, skip to 4.9)?

_____ [number]

4.4 How many times have you been involved in any physical aggression in/around licensed venues during the past 12 months (if none, skip to 4.9)?

_____ [number]

4.5 If yes, can you recall the name of the venue(s) where it happened? [prompt if necessary with 'Was it your usual venue or a venue you are attending tonight?']

_____ [insert name/s]

4.6 If yes, who was this with the last time this happened (mark all that apply)?

1 Partner

2 Close friend/s

3 Acquaintance/s

4 Stranger/s

5 Security

6 Other (please specify)_____

4.7 If yes, can you rate how intoxicated you were from alcohol and other drug consumption on that occasion (on a scale of 0 to 10)?

_____ (0 totally sober – 10 falling down drunk)

4.8 If yes, had you consumed any illicit drugs on this occasion?

1 Yes

2 No

4.9 In the past 12 months, has anyone kept trying to hit on you when you had clearly given them the message that you were not interested in/around a licensed venue?

1 Yes

2 No

4.10 In the past 12 months did you experience unwanted sexual attention in/around a licensed venue?

1 Yes

2 No

4.11 On the last night you went out, did you experience unwanted sexual attention in/around a licensed venue?

1 Yes

2 No

4.12 Have you had any accidents related to alcohol intoxication, (e.g. fell down stairs) during the past 12 months (if yes, when was the last time)?

1 No, not in the last 12 months
2 Yes, Tonight
3 Yes, In the last week
4 Yes, In the last fortnight
5 Yes, In the last month
6 Yes, More than a month ago

4.13 Have you injured yourself or anyone else when drinking during the past 12 months (if yes, when was the last time)?

1 No, not in the last 12 months (Skip to 4.15)
2 Yes, Tonight
3 Yes, In the last week
4 Yes, In the last fortnight
5 Yes, In the last month
6 Yes, More than a month ago

4.14 If you injured someone else, who?

1 Self
2 Partner
3 Close friend/s
4 Acquaintance/s
5 Stranger/s
6 Dealer/s
7 Other (please specify)_____

4.15 How many times have you been refused service, entry or kicked out of a licensed venue for being too intoxicated during the past 12 months?

_____ [number]

4.16 Have you committed any property damage 'while under the influence' (over the limit) of alcohol during the past 12 months (if yes, when was the last time)?

1 No, not in the last 12 months
2 Yes, Tonight
3 Yes, In the last week
4 Yes, In the last fortnight
5 Yes, In the last month
6 Yes, More than a month ago

4.17 Have you driven 'while under the influence' (over the limit) of alcohol during the past 12 months (if yes, when was the last time)?

1 No, not in the last 12 months
2 Yes, Tonight
3 Yes, In the last week
4 Yes, In the last fortnight
5 Yes, In the last month
6 Yes, More than a month ago

Section 5: The rest of the night

5.1 Approximately how many more standard drinks of alcohol do you think you will drink tonight?

_____ [standard drinks]

5.2 Do you plan to visit any other venues tonight?

1 Yes

2 No (skip to 5.4)

5.3 If yes, what is the name of the venue(s) where you intend to go tonight?

_____ [insert name/s]

5.4 Do you plan to consume any energy drinks tonight?

1 Yes

2 No (skip to 5.7)

5.5 If yes, will you combine these energy drinks with alcohol?

1 Yes

2 No (skip to 5.7)

5.6 If yes, what is your main reason for mixing energy drinks with alcohol later tonight?

1 No specific reason

2 To stay awake/party for longer

3 The social aspect (it's something I do with my friends)

4 It's a special occasion/celebration

5 I like the feeling/buzz

6 I like the taste/ it's my preferred mixer

7 Other (please specify)_____

5.7 Do you plan to consume illicit drugs tonight?

1 Yes

2 No (skip to 5.9)

5.8 If yes, what drugs do you plan to consume tonight (please mark all that apply)?

1 Ecstasy

2 Cocaine

3 Methamphetamine

4 Ice

5 Pharmaceutical stimulants (e.g., dexamphetamine)

6 Ketamine

7 LSD

8 GHB/GBL/1,4B

9 Benzodiazepines

10 Heroin/other opiates

11 Cannabis

12 Tobacco

13 Mephedrone

14 Other (please specify)_____

5.9 How do you plan to get home tonight?

1 Drive a car/other vehicle

2 Get a lift with a partner/family/friend

3 Catch taxi

4 Catch public transport

5 Walk

6 Ride bike

7 Other (please specify)_____

8 Don't know

5.10 If drive, how would you rate you your ability to drive home?

_____ (0-10, 0 = not a chance; 10= best performance)

5.11 Would you say this is a typical night out for you?

1 Yes

2 No, I usually have smaller nights

3 No, I usually have bigger nights

Section 6: Field worker notes

6.1 Signs of intoxication:

1 Loss of coordination
2 Slurred speech
3 Spilling drinks
4 Staggering or falling over
5 Glassy/red eyes
6 Indicated illicit drug use
7 Boisterous/loud
8 Confused
9 Disjointed responses
10 Giggly
11 Talking very quickly
12 Very slow/dopey responses
13 Hyperactive

6.2 Rating of intoxication:

_____ 1 (totally sober) - 10 (falling down drunk)

6.3 Location _____

6.4 Field worker initials _____

6.5 Reason for not proceeding with survey/finishing early (if applicable) _____

Appendix D: Supplementary materials (Publication 4)

Supplementary Materials

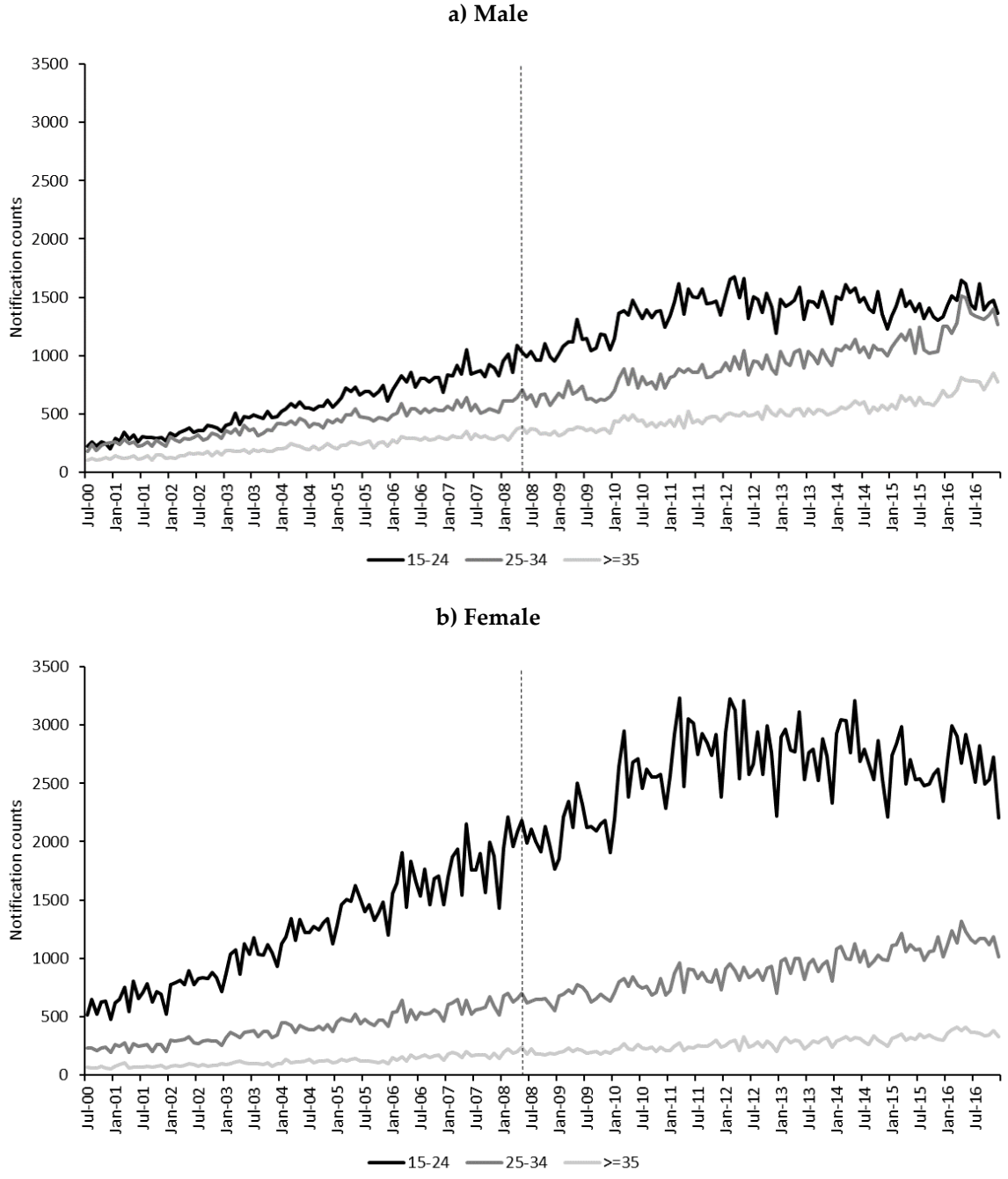

Figure S1. Monthly chlamydia notification counts by gender and age group, July 2000 to December 2016. Alcopops tax intervention point indicated by vertical dotted line at May 2008.

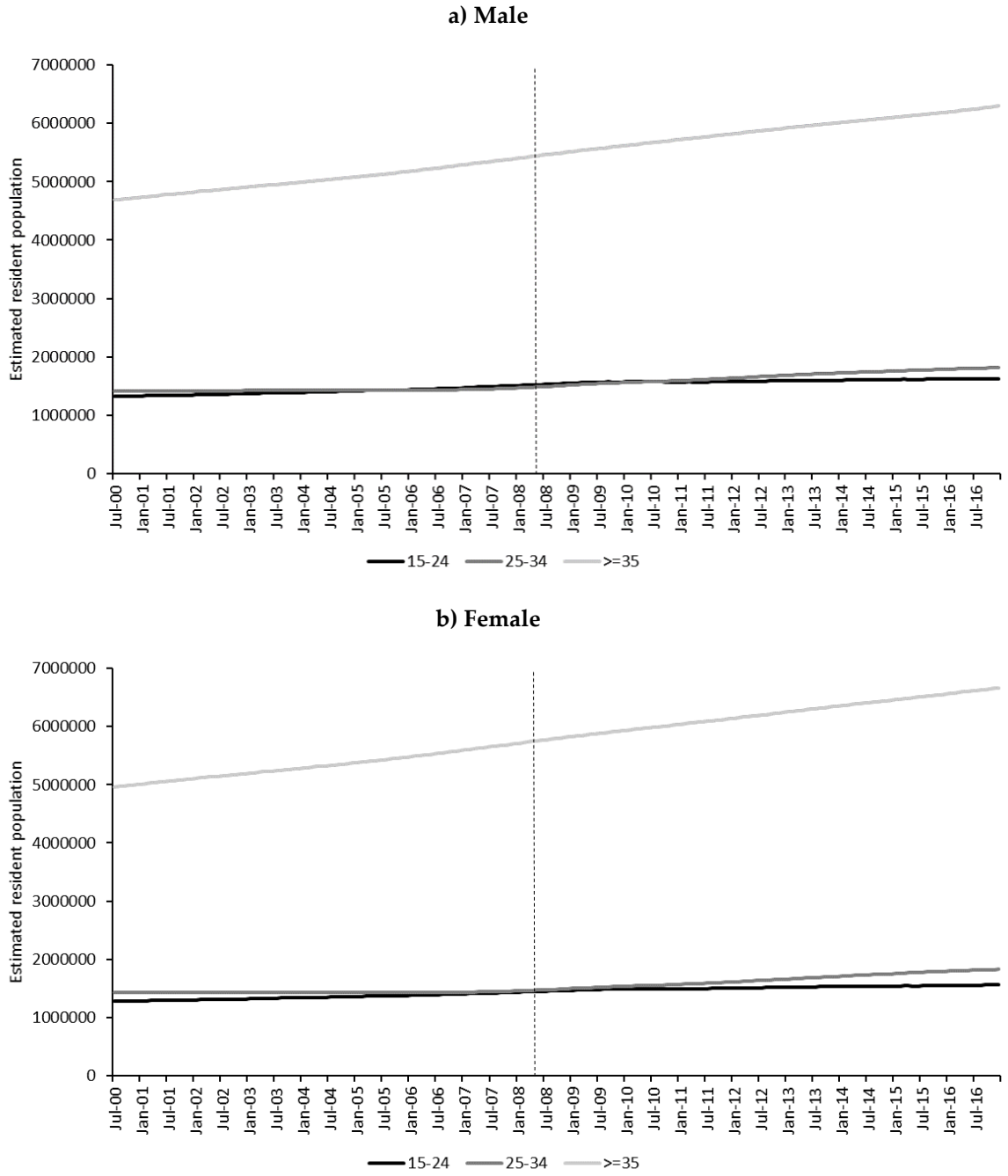

Figure S2. Monthly estimated resident population by gender and age group, July 2000 to December 2016. Alcopops tax intervention point indicated by vertical dotted line at May 2008. Quarterly estimated resident population was interpolated within age group and gender to achieve monthly data points.

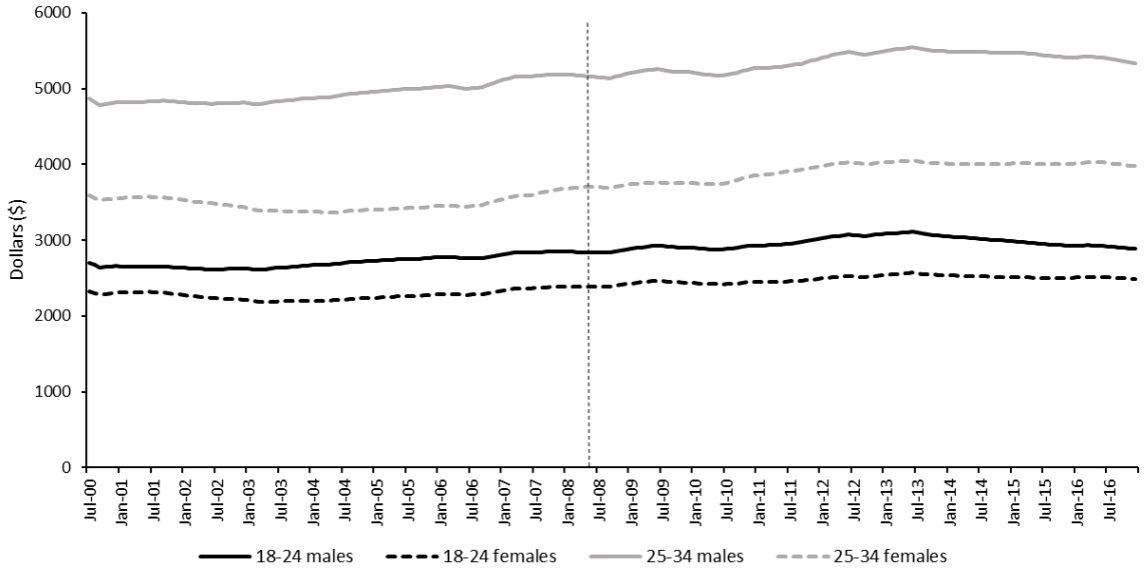

Figure S3. Monthly CPI-adjusted per capita total income ($) by age group and gender, July 2000 to Dec 2016. Alcopops tax intervention point indicated by vertical dotted line at May 2008.

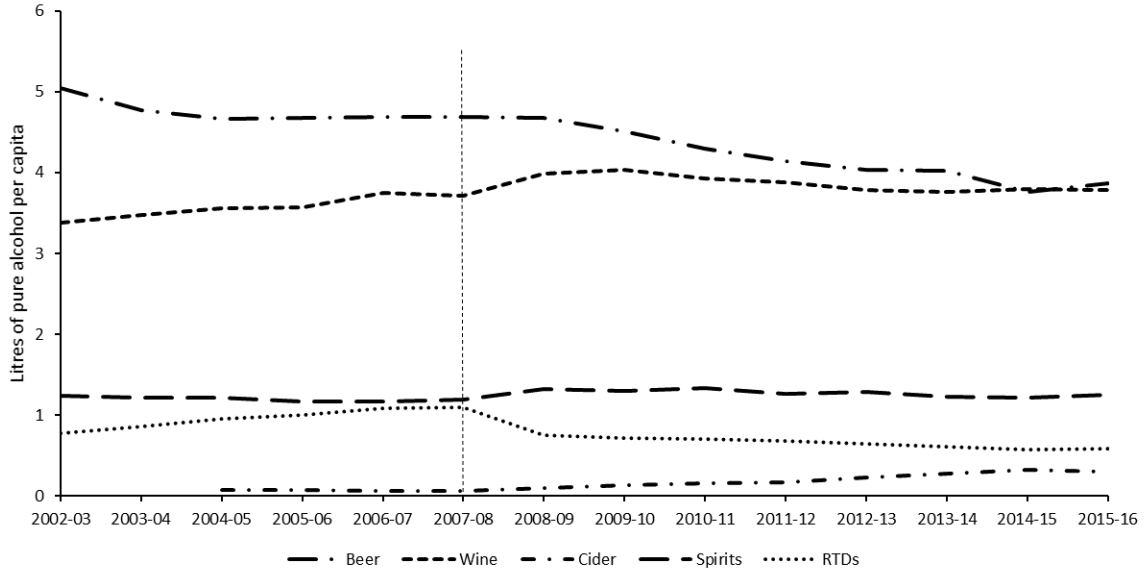

Figure S4. Annual litres of pure alcohol consumed per capita by beverage type, 2002-03 to 2015-16. Alcopops tax intervention point indicated by vertical dotted line at 2007-08.

Table S1. ARIMA model results of the association between introduction of the alcopops tax and monthly chlamydia test positivity rates (secondary outcome) by age group and gender with a two-month re-alignment of test to notification month, July 2000 to December 2016.

							Immediate			**3 Month Lag**			**6 Month Lag**		
Age	Gender	Model	SR^2	Q	df	*p*	Est	SE	*p*	Est	SE	*p*	Est	SE	*p*
15–24	Male	$(0,0,0)\ (1,0,0)_{12}$	0.64	33.40*	17	0.01	-1.221	0.618	0.05	-1.159	0.617	0.06	-1.311*	0.614	0.03
	Female	$(3,0,0)\ (1,0,0)_{12}$	0.80	22.64	16	0.12	-0.300	0.447	0.50	-0.145	0.458	0.75	-0.147	0.467	0.75
25–34	Male	(0,0,3)	0.79	22.49	17	0.17	-0.796*	0.313	0.01	-1.017*	0.305	<0.01	-1.157*	0.301	<0.001
	Female	$(3,0,1)\ (1,0,0)_{12}$	0.89	12.78	14	0.54	-0.199	0.180	0.27	-0.118	0.180	0.51	-0.204	0.180	0.26

*p<0.05. ARIMA models controlled for gender-specific chlamydia rates for the 35 and older age group and age- and gender-specific total income. Notification data were aligned with test data that were processed two months later. Stationary R^2 for immediate effect models. Ljung-Box test (Q) based on first 18 autocorrelation lags of the pre alcopops tax model residuals.

Table S2. ARIMA model results of the association between introduction of the alcopops tax and monthly chlamydia test counts by age group and gender, July 2000 to December 2016.

							Immediate			**3 Month Lag**			**6 Month Lag**		
Age	Gender	Model	SR^2	Q	df	*p*	Est	SE	*p*	Est	SE	*p*	Est	SE	*p*
15–24	Male	$(0,1,1)\ (1,0,0)_{12}$	0.54	21.16	16	0.17	0.003	0.005	0.55	0.002	0.006	0.77	0.000	0.006	0.97
	Female	$(0,1,1)\ (1,0,1)_{12}$	0.60	21.92	15	0.11	0.002	0.003	0.49	0.002	0.003	0.56	0.001	0.003	0.72
25–34	Male	$(0,1,1)\ (1,0,0)_{12}$	0.56	13.64	16	0.63	0.005	0.004	0.17	0.005	0.004	0.19	0.005	0.004	0.27
	Female	$(0,1,1)\ (0,1,1)_{12}$	0.72	19.41	16	0.25	-0.002	0.002	0.29	-0.001	0.002	0.46	-0.001	0.001	0.58

*p<0.05. ARIMA models controlled for gender-specific test counts for the 35 and older age group. Natural logarithm applied to age- and gender-specific test counts. Test counts shifted back by 1 month to represent date of service better (rather than date processed). Stationary R^2 for immediate effect models. Ljung-Box test (Q) based on first 18 autocorrelation lags of the pre alcopops tax model residuals.

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Publications 2, 3, 4

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Appendix F: Other publications authored during enrolment, 2016-2022 (A relevant selection)

Alcohol policy and availability

Journal articles

Lam, T., Fischer, J., Salom, C., L., Ogeil, R., Wilson, J., C., Lubman, D., Burns, L., Lenton, S., **Gilmore, W.**, Chikritzhs, T., N., Aiken, A. and Allsop, S. (2021). Safety first: beliefs of older peers supplying alcohol to underage friends. *Health Promotion Journal of Australia*, 32, pp. 407–415.

Lam, T., Ogeil, R., Fischer, J., Midford, R., Lubman, D., **Gilmore, W.**, Chikritzhs, T., N., Liang, W., Lenton, S., Aiken, A. and Allsop, S. (2020). Alcohol supply as a favour for a friend: Scenarios of alcohol supply to younger friends and siblings. *Health Promotion Journal of Australia*, 31, (1), pp. 112-120.

Hydes, T., **Gilmore, W.***, Sheron, N. and Gilmore, I. (2019). Treating alcohol-related liver disease from a public health perspective. *Journal of Hepatology*, 70, pp. 223-236. (*Joint first author)

Sherk, A., **Gilmore, W.**, Churchill, S., Lensvelt, E., Stockwell, T., R. and Chikritzhs, T., N. (2019). Implications of cardioprotective assumptions for national drinking guidelines and alcohol monitoring systems. *International Journal of Environmental Research and Public Health*, 16, (24), pp. 4956.

Aiken, A., Lam, T., **Gilmore, W.**, Burns, L., Chikritzhs, T., N., Lenton, S., Lloyd, B., Lubman, D., Ogeil, R. and Allsop, S. (2018). Youth perceptions of alcohol advertising: Are current advertising regulations working? *Australian and New Zealand Journal of Public Health*, 42, (3), pp. 234-239.

Lensvelt, E., Liang, W., **Gilmore, W.**, Gordon, E., Hobday, M. and Chikritzhs, T., N. (2016). Effect of the Australian 'alcopops tax' on alcohol-related emergency department presentations for injury in two states. *Journal of Studies on Alcohol and Drugs*, 77, (5), pp. 730-739.

Liang, W., **Gilmore, W.** and Chikritzhs, T., N. (2016). The effect of short-term alcohol restriction on risk of alcohol-related injury: A state wide population-based study. *International Journal of Drug Policy*, 28, pp. 55-59.

Hobday, M., Meuleners, L., Liang, W., **Gilmore, W.** and Chikritzhs, T., N. (2016). Associations between alcohol outlets and emergency department injury presentations: Effects of distance from the central business district. *Australian and New Zealand Journal of Public Health*, 40, (1), pp. 43-48.

Gilmore, W., Liang, W. and Chikritzhs, T., N. (2016). The Wild West: Associations between mining and violence in Western Australia. *Australian Journal of Rural Health*, 24, (2), pp. 136-143.

Chapters

Gilmore, W., Brown, K. and Gilmore, I. (2018). Prevention approaches to alcohol-related harm. In Bhugra, D., Bhui, K., Wong, S. and Gilman, S. (eds.) *Oxford Textbook of Public Mental Health*. Oxford University Press, Oxford.

Reports

Gordon, E., Liang, W., **Gilmore, W.**, Lensvelt, E. and Chikritzhs, T., N. (2017). *Modelling the public health and safety impacts of liquor licensing changes on communities: enhancing evidence-based liquor licensing decisions, Stage 2 Report.* National Drug Research Institute, Curtin University, Perth, Western Australia.

Lam, T., Lenton, S., Chikritzhs, T., N., **Gilmore, W.**, Burns, L., Aiken, A., Ogeil, R., Lloyd, B., Lubman, D., Mattick, R. and Allsop, S. (2016). *Designed to protect: impact of alcohol policy measures on young risky drinkers*. National Drug Research Institute, Curtin University, Perth, Western Australia.

Alcohol use and related harms

Journal articles

Gilmore, W. and Gilmore, I. (2022) Has the pandemic exacerbated alcohol harm? *Trends in Urology & Men's Health*, 13, (4), pp. 2-3.

Lam, T., Laslett, A., L., Fischer, J., Salom, C., L., Ogeil, R., Lubman, D., Aiken, A., Mattick, R., **Gilmore, W.** and Allsop, S. (2022). Disclosures of harming others during their most recent drinking session: Findings from a large national study of heavy-drinking adolescents. *Drug and Alcohol Review*, 41, (1), pp. 197-207.

Lam, T., Laslett, A., L., Ogeil, R., Lubman, D., Liang, W., Chikritzhs, T., N., **Gilmore, W.**, Lenton, S., Fischer, J., Aiken, A., Mattick, R., Burns, L., Midford, R. and Allsop, S. (2019). From eye rolls to punches: experience of harm from others' drinking amongst risky drinking adolescents across Australia. *Public Health Research & Practice*, 29, (4), pp. e2941927.

Lam, T., Lenton, S., Ogeil, R., Burns, L., Aiken, A., Chikritzhs, T., N., **Gilmore, W.**, Lloyd, B., Wilson, J., C., Lubman, D., Mattick, R. and Allsop, S. (2017). Most recent risky drinking session with Australian teenagers. *Australian and New Zealand Journal of Public Health*, 41, (1), pp. 105–110.

Ogeil, R., Lloyd, B., Lam, T., Lenton, S., Burns, L., Aiken, A., **Gilmore, W.**, Chikritzhs, T., N., Mattick, R., Allsop, S. and Lubman, D. (2016). Pre-drinking behaviour of young heavy drinkers: Differences based on demographics and location. *Substance Use and Misuse*, 51, (10), pp. 1297-1306.

Chapters

Gilmore, W. and Gilmore, I. (2021). Alcohol and men's health. In Kirby, R., Carson, C., White, A. and Kirby, M. (eds.) *Men's Health (4th ed)*. CRC Press (Taylor & Francis Group), London.

Gilmore, I. and **Gilmore, W.** (2018). Dietary, lifestyle, and environmental factors affecting health: Alcohol. In Davey, P. and Sprigings, D. (eds.) *Diagnosis and Treatment in Internal Medicine.* Oxford University Press, Oxford.

Reports

Reedy, C., **Gilmore, W.** and Chikritzhs, T., N. (2022). *Estimated alcohol-attributable deaths and hospitalisations in Australia, 2010 to 2017*. National Alcohol Indicators, Bulletin 17. National Drug Research Institute, Curtin University, Perth.

Whetton, S., Tait, R., J., **Gilmore, W.**, Dey, T., Agramunt, S., Abdul Halim, S., McEntee, A., Mukhtar, A., Roche, A., Allsop, S. and Chikritzhs, T., N. (2021). *Examining the Social and Economic Costs of Alcohol Use in Australia: 2017/18.* In Tait, R., J. and Allsop, S. (eds.). National Drug Research Institute, Curtin University, Perth, Western Australia.

Lensvelt, E., **Gilmore, W.**, Liang, W., Sherk, A. and Chikritzhs, T., N. (2018). *Estimated alcohol-attributable deaths and hospitalisations in Australia, 2004 to 2015.* National Alcohol Indicators Project, Bulletin No. 16. National Drug Research Institute, Curtin University, Perth, Western Australia.

Lam, T., Lenton, S., Chikritzhs, T., N., **Gilmore, W.**, Liang, W., Pandzic, I., Ogeil, R., Faulkner, A., Lloyd, B., Lubman, D., Aiken, A., Burns, L., Mattick, R., ACT Health, A., Olsen, A., Bruno, R., deAngelis, O., Roche, A., Fischer, J., Trifonoff, A., Midford, R., Salom, C., L., Alati, R. and Allsop, S. (2017). *Young Australians' Alcohol Reporting System (YAARS): National Report 2016/17.* National Drug Research Institute, Curtin University, Perth, Western Australia.

Lensvelt, E., **Gilmore, W.**, Gordon, E., Liang, W. and Chikritzhs, T., N. (2016). *Trends in estimated alcohol-attributable assault hospitalisations in Australia 2003/04 to 2012/13.* National Alcohol Indicators Project, Bulletin No. 15. National Drug Research Institute, Curtin University, Perth, Western Australia.

Loxley, W., **Gilmore, W.**, Catalano, P. and Chikritzhs, T., N. (2016). *National Alcohol Sales Data Project (NASDP) Stage Five Report, 2016.* National Drug Research Institute, Curtin University, Perth, Western Australia.

Loxley, W., **Gilmore, W.**, Catalano, P. and Chikritzhs, T., N. (2016). *National Alcohol Sales Data Project (NASDP) Stage Four Bulletin.* National Drug Research Institute, Curtin University, Perth, Western Australia.

Lensvelt, E., **Gilmore, W.**, Gordon, E., Liang, W. and Chikritzhs, T., N. (2016). *Trends in estimated alcohol-attributable assault hospitalisations in Australia 2003/04 to 2012/13.* National Alcohol Indicators Project, Bulletin No. 15. National Drug Research Institute, Curtin University, Perth, Western Australia.

Interactive webtool

Gilmore, W., Lensvelt, E., Jones, P., Dorocicz, J., Sherk, A., Churchill, S., Stockwell, T., Chikritzhs, T. (2021). *Australian alcohol-attributable harm visualisation tool.* National Drug Research Institute, Curtin University and Canadian Institute for Substance Use Research, University of Victoria. http://www.alcoholharmtool.info/

Nightlife studies

Journal articles

Coomber, K., Chikritzhs, T., N., Morgan, A., Lam, T., Droste, N., Mayshak, R., Curtis, A., Guadagno, B., Hyder, S., **Gilmore, W.**, Peacock, A., Bruno, R., Taylor, N. and Miller, P., G. (2018). Targeting at-risk samples through brief face-to-face interviews in night-time entertainment precincts. *Journal of Substance Use*, 23, (4), pp. 353-357.

Droste, N., Miller, P., G., Kaestle, C., Curtis, A., Hyder, S., Coomber, K., Pennay, A., Chikritzhs, T., N., Lam, T. and **Gilmore, W.** (2018). Comparing levels of blood alcohol concentration and indicators of impairment in nightlife patrons. *Drug and Alcohol Review*, 37, pp. S348-S356.

Hyder, S., Coomber, K., Pennay, A., Droste, N., Curtis, A., Mayshak, R., Lam, T., **Gilmore, W.**, Chikritzhs, T., N. and Miller, P., G. (2018). Correlates of verbal and physical aggression among patrons of licensed venues in Australia. *Drug and Alcohol Review*. 37, pp. 6-13.

Wilson, J., C., Ogeil, R., Lam, T., Lenton, S., Lloyd, B., Burns, L., Aiken, A., **Gilmore, W.**, Chikritzhs, T., N., Mattick, R., Lubman, D. and Allsop, S. (2018). Re-thinking pre-drinking: Implications from a sample of teenagers who drink in private settings. *International Journal of Drug Policy*, 52, pp. 20-24.

Coomber, K., Mayshak, R., Hyder, S., Droste, N., Curtis, A., Pennay, A., **Gilmore, W.**, Lam, T., Chikritzhs, T., N. and Miller, P., G. (2017). Demographic and substance use factors associated with non-violent alcohol-related injuries among patrons of Australian night-time entertainment districts. *International Journal of Environmental Research and Public Health*, 14, (1), pp. 75.

Curtis, A., Coomber, K., Droste, N., Hyder, S., Mayshak, R., Lam, T., **Gilmore, W.**, Chikritzhs, T., N. and Miller, P., G. (2017). Consumption plans for the rest of the night among Australian nightlife patrons. *International Journal of Alcohol and Drug Research*, 6, (1), pp. 19-25.

Submissions to government consultations

Rechichi, V., **Gilmore, W.**, Chikritzhs, T., N. and Allsop, S. (2019). *Submission to NSW Joint Select Committee on Sydney's night time economy.* National Drug Research Institute, Curtin University, Perth, Western Australia.

Rechichi, V., **Gilmore, W.**, Chikritzhs, T., Lenton, S. (2017). *Submission to Energy Labelling of Alcoholic Beverages Targeted Stakeholder Consultation*. National Drug Research Institute, Curtin University, Perth, Western Australia.

Chikritzhs, T., N., **Gilmore, W.**, Rechichi, V. and Allsop, S. (2016). Submission to the Independent Review of the Impact of Liquor Law Reforms in NSW. National Drug Research Institute, Curtin University, Perth, Western Australia.

Chikritzhs, T., N., Allsop, S., **Gilmore, W.** and Rechichi, V. (2016). Submission to the Senate Legal and Constitutional Affairs Committee Inquiry into the need for a nationally-consistent approach to alcohol-fuelled violence. National Drug Research Institute, Curtin University, Perth, Western Australia.

Appendix G: Oral presentations given during enrolment, 2016-2022 (A relevant selection)

*Presenting author

Gilmore, W. Associations between government regulation of alcohol availability, alcohol use and health in Australia. National Drug Research Institute, Perth, 7th Sep 2022. (PhD Milestone 3)

Allsop, S.*, **Gilmore, W.***, Tait, R.J.* and Chikritzhs, T.N.* The $67 billion cost of one of our favourite drugs. National Drug Research Institute Public Webinar Series. Online, April 2022.

Gilmore, W.*, Chikritzhs, T.N., McManus, H., Kaldor, J., Guy, R. Association between the Australian alcopops tax and national chlamydia rates among young people. Working Together: Community Collaboration in Drug Policy and Practice Research. National Drug Research Institute Symposium. Perth, 6th October 2021.

Gilmore, W.*, Chikritzhs, T.N. Australian alcohol-attributable harm visualisation tool – an introduction. Centre of Research Excellence in Indigenous Health and Alcohol, University of Sydney. Online, 15th July 2021. (Invited)

Gilmore, W.*, Chikritzhs, T.N. Australian alcohol-attributable harm visualisation tool – an introduction. National Drug Research Institute. Perth, 1st July 2021.

Gilmore, W. Associations between Community Alcohol Availability and Alcohol-Related Disorders and Diseases in Australia. National Drug Research Institute, Perth, 5th April 2019. (PhD Milestone 2)

Gilmore, W. Western Australian trends in alcohol use and related harm. Local Drug Action Groups and Aboriginal Alcohol and other Drug Worker Conference: Working Together, Creating Change. Perth, 16th August 2019. (Invited)

Gilmore, W. Alcohol: a population-level approach. Guest lectures. Curtin University Medical School, Perth. March 2018 and March 2019. (Invited)

Gilmore, W.*, Chikritzhs, T.N. Developments in alcohol policy research at the National Drug Research Institute. Council of Capital City Lord Mayors' National Local Government Drug and Alcohol Advisory Committee, Perth. Perth, 9th November 2017. (Invited)

Gilmore, W. Associations between Community Alcohol Availability and Alcohol-Related Disorders and Diseases in Australia. National Drug Research Institute. Perth, 10th April 2017. (PhD Milestone 1)

Lam, T.*, Laslett, A-M., Pandzic, I., Chikritzhs, T., **Gilmore, W.**, Lenton, S., Ogeil, R., Aiken, A., Burns, L., Lloyd, B., Lubman, D., Roche, A., Fischer, J., Alati, R., Salom, C., Midford, R., Allsop, S. Experience of harm from others' drinking amongst risky drinking adolescents across Australia. The Australasian Professional Society on Alcohol and other Drugs (APSAD) conference, Sydney, NSW. 12-15 Nov 2017.

Lam, T.*, Laslett, A-M., Pandzic, I., Chikritzhs, T., **Gilmore, W.**, Lenton, S., Ogeil, R., Aiken, A., Burns, L., Lloyd, B., Lubman, D., Roche, A., Fischer, J., Alati, R., Salom, C., Midford, R., Allsop, S. 'Eye-rolls to punches: adolescent experience of harms attributed to others' drinking' Global Alcohol Policy Conference (GAPC), Melbourne, Australia, 4-6 Oct 2017.

Lam, T.*, Laslett, A-M., Pandzic, I., Chikritzhs, T., **Gilmore, W.**, Lenton, S., Ogeil, R., Aiken, A., Burns, L., Lloyd, B., Lubman, D., Roche, A., Fischer, J., Alati, R., Salom, C., Midford, R., Allsop, S. Eye-rolls to punches: adolescent experience of harms attributed to others' drinking. Presented at the 15th World Congress on Public Health, Melbourne, Australia, 3rd-7th April 2017.

Lensvelt, E.*, **Gilmore, W.**, Gordon, E., Liang, W., Chikritzhs, T. National Alcohol Indicators Project - Bulletin 15. Trends in estimated alcohol-attributable assault hospitalisations in Australia 2003/04 to 2012/13. Australasian Professional Society on Alcohol and other Drugs Conference 2016. Sydney, 31st Oct 2016.