The impact of reducing trading times of retailers selling alcohol for onsite consumption: Western Cape analysis

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EXECUTIVE SUMMARY

Introduction

The Western Cape is heavily burdened by harmful alcohol use. Alcohol misuse in the province, like in the rest of South Africa, has a detrimental impact on individuals, families, and communities. The Western Cape government (WCG) has therefore identified the harms caused by alcohol use as a priority issue for the province, and the Western Cape Provincial Cabinet has selected the reduction of alcohol-related harms as one of its "game changer" areas of focus. To this end, the province has developed an Alcohol Harms Reduction White Paper, which documents the provincial government's vision for reducing alcohol-related harms in the Western Cape.

One of the proposed policies in the White Paper is to restrict the trading hours of retailers selling alcohol for onsite consumption. The effectiveness of reducing trading hours in achieving a reduction in alcohol consumption and its associated harms is supported by international research. It is also endorsed by the World Health Organization as one of the 'best buy' policies that governments can enact to reduce alcohol consumption and its associated health and economic costs.

This report provides estimates of the health and economic impacts of implementing restrictions on the legally permissible trading hours of retailers selling alcohol for onsite consumption in the Western Cape.

Policy options and outcomes assessed

Currently, in the Western Cape, 25 different laws determine the permissible trading hours of retail liquor outlets, because each of the 24 local municipalities and one metropolitan municipality in the province have their own by-laws pertaining to liquor trading hours. In this report, we model the impact of three proposed closing time scenarios for retailers selling alcohol for onsite consumption in the Western Cape: midnight, 1am, and 2am.

We report the estimated impact of each of these proposed closing times on:

- alcohol consumption,
- the number of cases and the number of deaths associated with six alcohol-related conditions (road injury, intentional injury, liver cirrhosis, HIV, TB, and breast cancer) and the hospital costs associated with treating these conditions,
- individual alcohol expenditure, aggregate alcohol expenditure, excise tax, VAT, and retail revenue, and
- the costs of combatting alcohol-related crime.

Underpinning our model is the relationship between alcohol trading times and alcohol consumption, which is measured by the 'trading times elasticity'. This elasticity quantifies the percentage change in alcohol consumption expected to follow a one per cent change in alcohol trading times. We derive this elasticity based on an extensive international literature review and employ three elasticity scenarios in our modelling framework: a low-range elasticity estimate, a mid-range estimate, and an upper-bound estimate.

We provide nine sets of results for each of the policy outcomes of interest (three elasticity scenarios per proposed closing time). The trading times elasticities, both with respect to consumption and alcohol-related harms, are constant. In our model, a 10 per cent decrease in trading hours has the same proportional impact as a 5 per cent or a 2 per cent decrease in trading hours.

Impact on alcohol consumption

Each proposed closing time scenario corresponds to a reduction in alcohol consumption at **onsite drinking locations**. Depending on the elasticity applied, we estimate an average reduction in weekly alcohol consumption at onsite venues of between:

- 2.8 and 9.4 per cent at a midnight closing time,
- 1.5 and 5.1 per cent at a 1am closing time, and
- 0.2 and 0.8 per cent at a 2am closing time.

When considered in relation to alcohol consumption occurring at **both onsite and offsite drinking locations**, these estimated changes in average weekly onsite alcohol consumption translate to decreases in total alcohol consumption of between:

- 1.0 per cent and 3.3 per cent at a midnight closing time,
- 0.5 per cent and 1.8 per cent at a 1am closing time, and
- 0.1 per cent and 0.3 per cent at a 2am closing time.

Impact on alcohol-related harms

Alcohol-related deaths and disease are modelled based on a 20-year projection of the Western Cape population. This time-frame is chosen to allow for the full impact of the policy-induced reductions in alcohol consumption on the six modelled health conditions (road injury, intentional injury, liver cirrhosis, HIV, TB, and breast cancer) to manifest.

We provide two sets of estimates that quantify the impact of reductions in legally-permissible trading times at onsite drinking venues on alcohol-related harms: (a) conservative estimates and (b) estimates that account for the reality that the last hours of drinking are the most harmful in terms of a drinker's likelihood of experiencing an acute alcohol-related harm (e.g., a road injury or an intentional injury).

(a) Conservative health estimates

In the first instance, our estimates are derived through the use of relative risk equations and potential impact fractions that map the estimated reductions in total alcohol consumption under each proposed policy scenario onto changes in alcohol-related harms. This is done for each of the nine policy scenario simulations. This approach draws on the aforementioned (constant) trading times elasticities.

We predict that, over the next 20 years, the number of **alcohol-related deaths averted** due to the six conditions included in this study are between approximately:

- 570 and 1 500 for the midnight closing time scenario,

- 240 and 810 for the 1am closing time scenario, and
- 40 and 80 for the 2am closing time scenario.

In terms of **disease/injury prevalence**, we estimate that, over the next 20 years, the number of **cases averted** due to the six alcohol-related conditions included in this study are between approximately:

- 163 800 and 453 000 for the midnight closing time scenario,
- 88 700 and 220 300 for the 1am closing time scenario, and
- 12 600 and 28 300 for the 2am closing time scenario.

(b) Alternate model specification for acute alcohol-related harms

For the acute alcohol-related harms included in our model (road injury and intentional injury), the results that draw on the trading times elasticities provide conservative estimates of the likely changes in the number of alcohol-related deaths and injury cases associated with the changes in alcohol consumption.

Estimates for these injury conditions are conservative because in employing constant trading time elasticities, all drinking hours are weighted equally. Research shows that the last hours of drinking are the most harmful in terms of a drinker’s likelihood of experiencing an acute alcohol-related harm. The assumption that the trading time elasticities are constant (and that volume of alcohol consumed is therefore directly proportional to harms) thus underestimates the harms prevented from earlier closing times for the acute alcohol-related conditions included the model.

To address this, we draw on the international literature to derive a direct ‘harm elasticity’ for one of the acute conditions analysed in the model: intentional injury. Insufficient reporting in the majority of studies hindered our ability to appropriately derive a harm elasticity for road injury.

The range of harm elasticities derived for intentional injury quantify the percentage change in deaths/cases of intentional injury expected to follow a one per cent change in alcohol trading times. They account for the marginal impact of the last few alcoholic beverages that are more likely to cause people to fall victim to an acute alcohol-related death or injury. We derive a lower-bound and an upper-bound harm elasticity estimate for the **number of deaths** due to **intentional injury** from the international literature.

Using our **lower-bound harm elasticity estimate** for deaths, we estimate that, over 20 years, **deaths** due to **intentional injury averted** stand at approximately:

- 12 300 under a midnight closing time scenario,
- 6 600 under a 1am closing time scenario, and
- 1 000 under a 2am closing time scenario.

Under the **upper-bound harm elasticity estimate**, we estimate that, over 20 years, **deaths** due to **intentional injury averted** stand at approximately:

- 44 300 under a midnight closing time scenario,
- 23 800 under a 1am closing time scenario, and

- 3 600 under a 2am closing time scenario.

We derive one harm elasticity estimate that links changes in trading times to changes in the prevalence of intentional injury. Our model estimates that, over 20 years, the **cases of intentional injury averted** stand at approximately:

- 380 500 under a midnight closing time scenario,
- 204 300 under a 1am closing time scenario, and
- 31 000 under a 2am closing time scenario.

Hospital cost savings

We estimate the hospital cost savings associated with each proposed closing time over the next 20 years.

Our **conservative** model specification predicts that the cost to government of assisting drinkers presenting with the six alcohol-related conditions included in this study at hospitals is reduced under each proposed closing time scenario. The largest cost savings are for TB, followed by intentional injury. Depending on the elasticity applied, we estimate a total **hospital cost saving** of between:

- R326.8 million and R890.2 million under a midnight closing time scenario,
- R130.5 million and R381.2 million under a 1am closing time scenario, and
- R18.7 million and R46.0 million under a 2am closing time scenario.

The **alternate model specification** that draws on a direct harm elasticity for intentional injury indicates that the hospital cost savings over 20 years due **solely** to **cases of intentional injury averted** stand at approximately:

- R7 444 million at a midnight closing time,
- R3 998 million at a 1am closing time, and
- R607 million at a 2am closing time.

Cost of combatting alcohol-related crime

The cost of combatting alcohol-related crime in the Western Cape is reduced under each proposed closing time scenario. These estimates draw on the constant trading time elasticities. Depending on the elasticity applied, we estimate a **reduction in the costs of combatting alcohol-related crime** of between:

- R38.2 million (1.0 per cent) and R127.5 million (3.3 per cent) under a midnight closing time scenario,
- R20.5 million (0.5 per cent) and R68.5 million (1.8 per cent) under a 1am closing scenario, and
- R3.1 million (0.1 per cent) and R10.4 million (0.3 per cent) under a 2am closing time scenario.

Impact on tax and retail revenues

Each proposed closing time scenario is associated with a decrease in annual alcohol expenditure, tax revenue and retail revenue. The reductions in alcohol spend, VAT, excise tax and retail revenue are largest under a midnight closing time scenario and lowest under a 2am closing time scenario. These estimates draw on the constant trading time elasticities. Depending on the elasticity applied, aggregate annual expenditure on alcohol **decreases** by:

- between R428 million (1.0 per cent) and R1 426 million (3.3 per cent) under a midnight closing time scenario,
- between R230 million (0.5 per cent) and R766 million (1.8 per cent) under a 1am closing time scenario, and
- between R35 million (0.1 per cent) and R 116 million (0.3 per cent) under a 2am closing time scenario.

Changes in the excise tax under each policy scenario are calculated by multiplying the percentage change in volume of alcohol with baseline excise tax. This assumes a fixed ratio between volume of alcohol consumed and excise tax revenue. We calculate VAT by assuming that 13 per cent of retail expenditure is VAT. This reflects the effective VAT percentage, since the VAT rate of 15 per cent is levied on the net-of-VAT retail price, not the VAT-inclusive retail price.

Based on this, **tax revenue** (excise + VAT) collected in the Western Cape is expected to **decrease**, annually, by between:

- R100 million and R333 million under a midnight closing time scenario,
- R54 million and R179 million under a 1am closing time scenario, and
- R9 million and R27 million under a 2am closing time scenario.

These reductions in tax revenue (excise tax + VAT) translate to percentage reductions in excise taxes of between:

- 1.0 per cent and 3.3 per cent under a midnight closing time scenario,
- 0.5 per cent and 1.8 per cent under a 1am closing time scenario, and
- 0.1 per cent and 0.3 per cent under a 2am closing time scenario.

Identical percentage reductions are estimated for the amount of VAT collected under each proposed closing time scenario.

Depending on the elasticity applied, **retail revenue**, which is calculated as aggregate spend – excise tax – VAT, is **expected to decrease** by between:

- R 328 million (1 per cent) and R 1 093 million (3.3 per cent) under a midnight closing time scenario,
- R176 million (0.5 per cent) and R587 million (1.8 per cent) under a 1am closing time scenario, and
- R27 million (0.1 per cent) and R89 million (0.3 per cent) under a 2am closing time scenario.

Under the mid-range elasticity scenario, we estimate that a midnight closing time is associated with an annual decrease of R112 million in revenue from VAT; a R88 million decrease in annual revenue from excise tax; and alcohol retailers lose R656 million. These decreases reduce to annual losses in VAT and excise tax revenue of R60 million and R47 million in excise taxes, and retail revenue loses of R352 million at a 1am closing time; reducing further to estimated losses of R9 million in VAT revenue, R7 million in excise tax revenue and R53 million in retail revenue at a 2am closing time.

Conclusion and recommendations

Our estimates suggest that all closing time scenarios correspond to decreases in alcohol consumption, decreases in the number of deaths due to six alcohol-related conditions, decreases in the number of cases of these six conditions, decreases in the hospital costs of addressing these alcohol-related conditions, decreases in the cost of combatting alcohol-related crime, and decreases in the revenue accruing from alcohol sales and alcohol taxation.

The choice of which closing time to implement is a political decision that balances reductions in alcohol retailers' revenues and tax revenues with increased health benefits and the associated hospital cost savings, and reductions in the costs of combatting alcohol-related crime in the Western Cape. Our estimates suggest that a midnight closing time is the most pro-health policy option, while a 2am closing time is the most pro-industry. However, from a public health standpoint, the 2am closing time scenario still represents a modest improvement from the status quo.

It needs to be noted upfront that our analysis only includes a small subset of all the disease/injury conditions related to alcohol consumption. Because of this, the estimates provided in this report under-estimate the total health benefit and hospital cost savings that could arise from implementing trading time restrictions at onsite retailers in the Western Cape. We have also not estimated the reduction in harms to non-drinkers that arise from domestic violence and foetal alcohol spectrum disorders that would result from reduced alcohol consumption brought on by restricting onsite trading times. On the other hand, we have not estimated the impact of the proposed trading time restrictions on income taxes paid by retailers selling alcohol for onsite consumption. The estimated impact of each proposed closing time on tax revenue that we have provided may therefore be underestimated.

Consequently, while it may be tempting to use the estimates provided in this report as the basis of a cost-benefit analysis of implementing trading time restrictions for onsite retailers of alcohol, this would not be an appropriate interpretation of the results provided in this study. This because our model has not accounted for: (1) all the health conditions related to alcohol use, (2) the reduction in all harms to non-drinkers, (3) the productivity gains from fewer alcohol-related deaths and fewer instances of alcohol-related diseases and (4) the potential income tax losses that may result from the policy.

Outside of providing decision makers with estimates of the impact of restricting onsite alcohol trading times in the Western Cape to inform their decision-making, we offer five recommendations. These recommendations stem from the overarching finding of this study: that **trading time restrictions** will **reduce alcohol consumption and its associated harms and costs in the Western Cape**.

The **first recommendation** is that trading time restrictions at onsite retailers should be enacted alongside other targeted policy interventions geared toward reducing alcohol consumption and its associated harms. Our estimates suggest that, on its own, a policy that restricts the legally permissible trading times of onsite alcohol retailers will not be a total 'game changer' in terms of reducing alcohol-related harms. It will, however, contribute positively to achieving this outcome and amplify the impact of a more broad-based approach to reducing alcohol consumption and its related harms in the province.

To this end, we provide decision makers with a list of the World Health Organization's identified 'best buys' and other recommended interventions for reducing alcohol use. We also provide a description of what the World Health Organization describes as an enabling policy context for implementing polices geared toward reducing alcohol-related harms.

The **second recommendation** concerns the need for verified alcohol sales data to be reported to the Western Cape Liquor Authority as a condition of license for selling alcohol. Legislative provision should be made for an audit of these sales data. Relatedly, we offer as a **third recommendation** that the handover of these sales data include both historical and future alcohol sales.

The handover of historical sales data will have two benefits for WCG. The first is that it will assist government in obtaining a more accurate picture of the levels of alcohol consumption in the province. The second is that it will assist government in assessing the past tax compliance of alcohol retailers. Benefits to government that will be derived from the provision of all future alcohol sales data include monitoring trends in alcohol consumption, allowing the impact of any future policies that target alcohol consumption to be monitored and assessed, and increasing tax compliance among alcohol retailers.

Our **fourth recommendation** is that the handover of these sales data to a centralised agency should be accompanied by a research protocol that provides researchers with access to these data. To ensure the most useful application of these data, they should be made available to researchers in a manner that allows for their disaggregation at the municipal level, by day of the week, and hour of day.

Our recommendations on the need for verified alcohol sales data to be shared with researchers arises from the data adjustment processes we have had to employ to estimate alcohol consumption in the model baseline. The need for these adjustments stem from the absence of data on alcohol consumption that are specific to the Western Cape. While all these adjustments conform to scientifically sound standards, they reduce the precision of our estimates. The required data reweighting and adjustment can be avoided if alcohol sales data are made available.

Our need to rely on the international literature to estimate elasticities that quantify the association between alcohol trading times, alcohol consumption and its related harms also stems from the absence of a centralised system that collects data on alcohol sales in the Western Cape. Because there are several municipalities that have changed their legally permissible alcohol trading times historically, access to historical sales data will provide researchers an opportunity to produce local evidence on the impact that these changes in trading times have had on alcohol consumption, its related harms and costs, and industry revenue. While we were unable to access alcohol sales data from the Western Cape for this study, we will gladly re-run the model with these data as inputs to improve the precision of the estimates provided in this report.

Beyond the provision of access to historical alcohol sales data, continued access to these data will assist researchers in supporting government in its efforts to understand the likely impact of any future policies geared toward reducing alcohol-related harms in the province.

The **fifth and final recommendation** concerns the need for any legislative amendments to alcohol trading times to be implemented uniformly across the Western Cape. Our model results show that changes in alcohol trading times reduce alcohol-related harms. The enactment of trading times restrictions that vary by province will therefore not be conducive to WCG achieving its stated objective of reducing these harms across the province.

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We would also like to acknowledge the outstanding work of Dr Naomi Gibbs, whose transparent reporting in both her PhD thesis and subsequent publications that estimate the likely impact of implementing a minimum unit price in South Africa, informed our approach to developing the model. Dr Gibbs also provided invaluable support and input at various stages of the model development process.

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1. INTRODUCTION

Alcohol consumption contributes to more than 200 different diseases, injuries, and conditions and imposes significant health, economic and social costs on societies [1]. South Africa has the highest per capita alcohol consumption in Africa and ranks among those countries with the heaviest drinkers in the world [2]. The World Health Organization (WHO) has categorized South Africa as having a ‘poor pattern’ of drinking [2]. A poor pattern of drinking is characterized by people drinking large quantities of alcohol on each drinking occasion, festive drinking, people often getting drunk, and drinking in public places [2].

Developing policies that target reductions in alcohol consumption is particularly important for the country, since alcohol use has been identified as the sixth risk factor for disability adjusted life-years lost in South Africa, and the seventh risk factor for death [3]. A 2018 study found that 62 300 people died from alcohol-attributable causes in South Africa in 2015, just over 170 per day [4]. Research also suggests that hazardous rates of alcohol consumption in the country are on the rise [5].

In addition to the role that alcohol consumption plays as a risk factor for disease and injury, the harmful drinking patterns of South Africans places an additional burden on individuals. For example, the relative risk that a drinker faces of experiencing hypertension compared to an abstainer is 1.4 for infrequent drinkers, 2.0 for moderate drinkers, and 4.1 for heavy drinkers [6]. Additionally, South Africa has among the world’s highest reported prevalence rates of foetal alcohol spectrum disorders per 10 000 people [7].

Whilst alcohol consumption plays a leading role in poor health and the prevalence of injury, it also has a negative impact on social and economic outcomes. Harmful alcohol use affects both social and personal relationships and is a risk factor for gender-based violence [8]. According to local and international research, the negative social impacts of alcohol misuse result in long-term health issues, job insecurity, and deteriorating family relations [9, 10]. These adverse social outcomes are felt most severely amongst indigent families [9, 10]. Harmful use of alcohol also reduces job productivity, employment, and ultimately income levels [11]. The most recent estimate of the cost of harmful alcohol use to the South African economy stands at between 10 and 12 per cent of the country’s 2009 gross domestic product (GDP) [12].

The sporadic restrictions on alcohol sales during South Africa’s Covid-19 lockdown created greater awareness of the harmful quantities of alcohol consumed by many South Africans. Evidence from regional hospitals shows that whenever the sale of alcohol was banned, the number of trauma cases presenting at hospitals decreased, but increased again sharply when the sales bans were lifted [13-15]. A national-level analysis further shows that the number of unnatural deaths, especially over weekends, declined significantly whenever an alcohol sales ban was in place [16].

The WHO recommends a list of ‘best buy’ policies that governments can enact to reduce alcohol consumption and its associated harms [17]. These ‘best buy’ measures include: banning alcohol advertising, increasing alcohol prices through the adoption of a minimum unit price levied on the amount of pure alcohol in liquor products, reducing the legal limits for drinking and driving to a blood alcohol content of 0.02% or below, intensifying the availability of counselling and medically assisted treatment for persons struggling with alcohol dependence, and **restricting alcohol trading times** and the quantities in which alcohol may be sold [17].

The Western Cape government (WCG) has identified harms caused by alcohol use as a priority issue for the province, and the Western Cape Provincial Cabinet has selected the reduction of alcohol-related harms as one of its ‘game changers’. To this end, the province developed an Alcohol Harms Reduction (AHR) White Paper, which documents the provincial government’s vision for reducing alcohol-related harms in the Western Cape [18]. The AHR White Paper draws heavily on the best-buy policies for reducing alcohol-related harms advocated by the WHO [2]. One of the policy measures that Western Cape government (WCG) plans to implement is restrictions on the permissible trading times of retailers selling alcohol for onsite consumption [18].[1]

The DG Murray Trust (DGMT), as part of its strategic mission to be a public innovator and to develop the potential of South Africa, aims to support government in its efforts to understand the likely impact of AHR policies in South Africa. DGMT commissioned research led by researchers based at the University of Cape Town to develop a model to estimate the health and economic impacts of reduced onsite alcohol trading times in the Western Cape. The outcome of this collaboration is documented in this report.

The work documented in this report forms part of a broader project. The objective of this project is to provide an evidence-base that will facilitate informed decision making on the selection and implementation of the WCG’s proposed trading times intervention. The project has been divided into two phases, of which this report covers the second:

Phase 1: Research into liquor retail trading days and hours restrictions to inform policy/legislative development in the Western Cape

Phase 2: Provide projections, using economic modelling and incorporating international research and experience, on how trading time regulations, of alcohol in the Western Cape with closing hour settings at midnight, 1am and 2am would impact over an identified period on:

- Consumption and reducing alcohol-related health and social harms (HIV, interpersonal violence, road injury, and others) and
- Costs (individual spend, excise tax and VAT, retail revenue, hospital and crime costs, and impact on the economy).

Phase 1 has shown that, in the Western Cape, 25 different laws determine the permissible trading hours of retail liquor outlets, because each of the 24 local municipalities and one metropolitan municipality in the province have their own by-laws pertaining to liquor trading

1 Onsite consumption refers to alcohol consumption at the point of sale (e.g., at bars, restaurants, or clubs). This is distinguished from ‘offsite consumption’, which refers to alcohol consumption away from the place of purchase (e.g., alcohol purchased at liquor stores, grocery stores, or convenience stores, and then drunk at home).

hours. The phase 1 deliverable takes the form of an online dashboard that allows users to estimate the impact of amending the legally permissible trading times governing the operations of liquor outlets in the Western Cape in terms of the number of liquor retail outlets affected, and the reduction in the number of legally permissible trading hours. The database can be accessed here. Phase 2 of the project uses this database as an input into understanding the role of reduced trading hours at onsite establishments on alcohol consumption and related harms and costs in the Western Cape.

A substantial body of international evidence shows that reductions in alcohol trading times reduce alcohol-related harms, while increases in alcohol trading times, increase alcohol-related harms [19-21]. The model developed in this project aims to provide WCG with estimates of the health and economic impacts of changes in trading times for onsite establishments across the Western Cape. The purpose of these estimates is to inform the decision-making process as WCG deliberates on appropriate implementation of the policies developed in the AHR White Paper.

The report is structured as follows: Section 2 provides an overview of alcohol use in the Western Cape and presents descriptive statistics of alcohol-related harms in the Western Cape. Section 3 discusses the data calibration process undertaken to estimate the model baseline, and outlines the methods employed. Section 4 provides the results, including sensitivity analyses. Section 5 documents the model limitations, and section 6 provides concluding remarks and recommendations.

2. EVIDENCE ON ALCOHOL CONSUMPTION AND ITS RELATED HARMS IN THE WESTERN CAPE

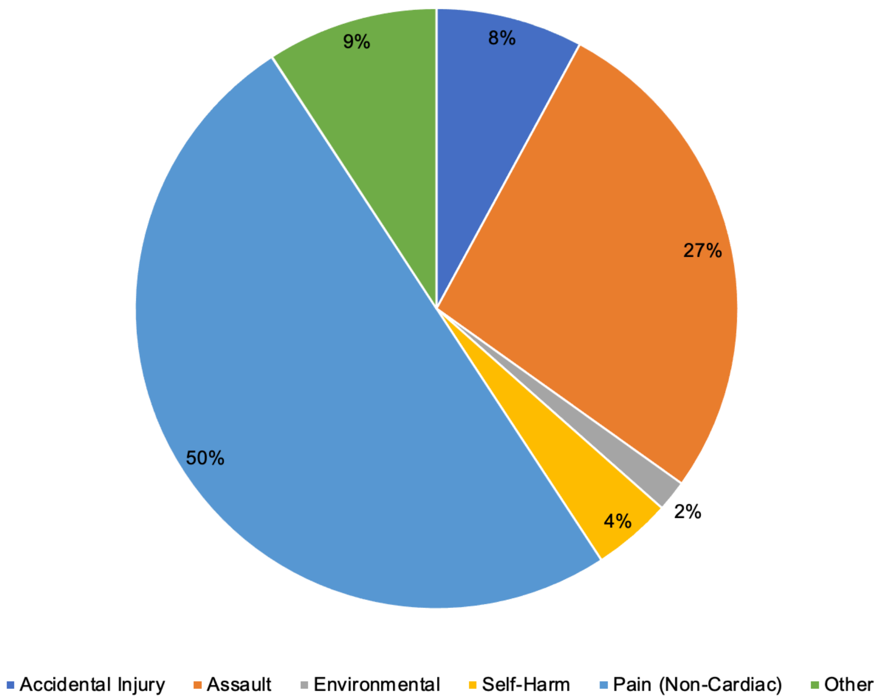
The Western Cape is heavily burdened by harmful alcohol use. In the Western Cape, the prevalence of alcohol use in the preceding seven days stands at 18.0 per cent, with 9.0 per cent of people reporting that they consumed five or more drinks on at least one occasion in the past 30 days [15]. Data from various waves of the National Income and Dynamics Study shows that, while the Western Cape is home to about 12 per cent of South Africa's adult population, its inhabitants account for between 14.2 per cent and 16.4 per cent of all alcohol consumed in the country [22].

One of the main factors contributing to high rates of heavy episodic drinking in the Western Cape is the legacy of the 'dop system', an institutional arrangement by which workers under the former apartheid regime were given alcohol as remuneration for work [23]. While the consequences of this system remain widespread, contributing significantly to the burden of disease in the Western Cape, the problem of harmful alcohol use became particularly visible as a result of the numerous alcohol sales bans that were implemented as part of the government's response to the Covid-19 pandemic.

The effects of the hard lockdown, and of subsequent restrictions on alcohol, were seen in the drastically reduced number of trauma cases in Western Cape hospitals. The mean total number of patients seen at Cape Town's Groote Schuur Hospital decreased by 53 per cent during the April and May 2020 hard lockdown [24]. Additionally, patients injured in road traffic accidents decreased by 74 per cent during the hard lockdown period and maintained a reduction of 32 per cent during the immediate post-lockdown period. The average total number of patients who visited the trauma unit returned to pre-lockdown levels in June 2020, when the ban on alcohol sales was lifted [24]. Similar trends were reported at other regional hospitals in Worcester and George [25]. Alcohol use has also been linked to 50 per cent of murders and intentional injuries in the Western Cape [26].

For the purpose of this project, we were granted access to incident data from the Western Cape Emergency Medical Services (EMS). Based on the categorisations in the data, we grouped these incidents into six broad categories: accidental injury, assault, environmental harm, self-harm, non-cardiac pain, and an 'other' category. The 'other' category includes bleeding, burns and corrosives, CPR in progress, electrocution, forensic pathology and near drowning. These categories, and the proportion of cases in each category in 2021, are shown in Figure 1. We provide a detailed breakdown of the annual counts for each of these six broad incident types in Appendix 1.

FIGURE 1. EMS DATA: INCIDENT TYPE CATEGORIES AND PROPORTION OF CASES IN EACH CATEGORY, 2021



There are no indicators of alcohol consumption or state of drunkenness in the EMS data. However, using data on alcohol consumption by day of the week and time of day from Mpumalanga [27], as well as our own estimates of peak alcohol consumption[2] based on our principal source of alcohol consumption used in the modelling process – the South African Demographic Health Survey (SADHS, 2016) [15] – we can use the distribution of incidents by day of week and time of day to make broad inferences about the link between alcohol consumption and these incidents.

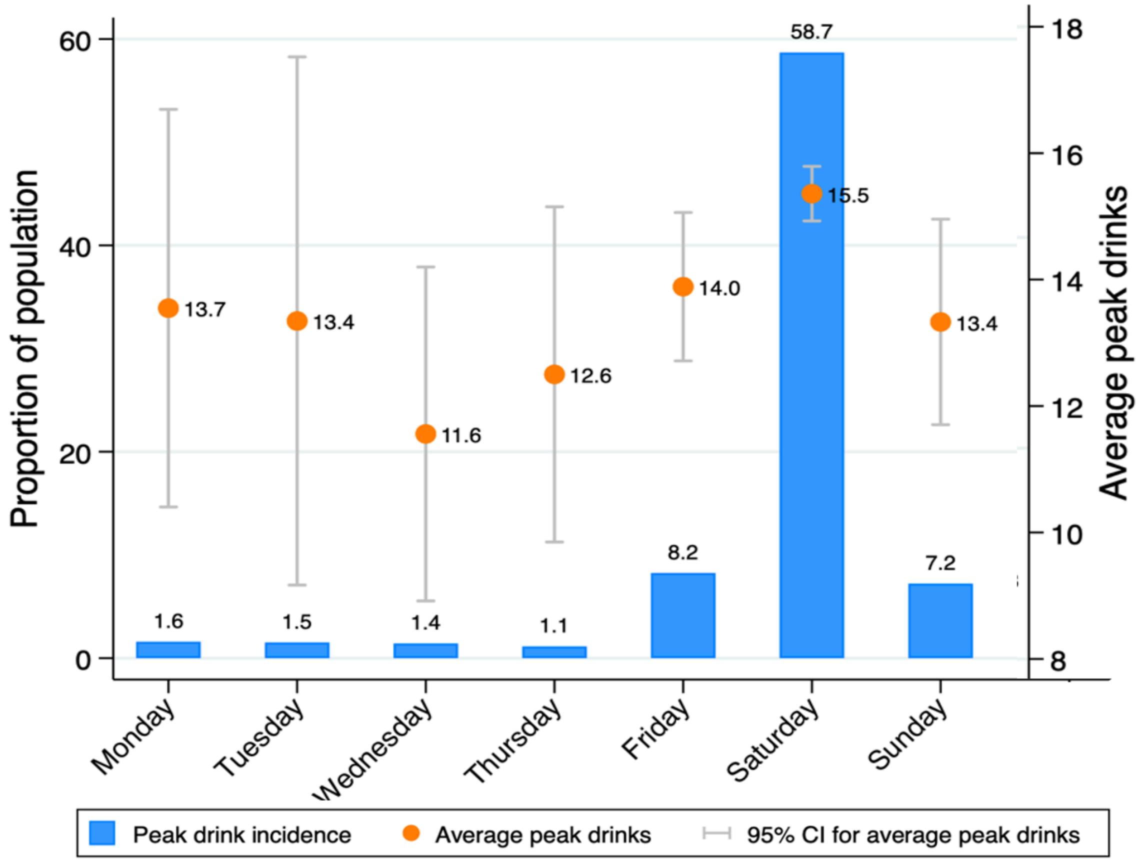
According to the research from Mpumalanga, which was based on a sample of 2 853 individuals from three districts within the province, the most common drinking day and time combination is on Saturday afternoon and Saturday evening [27]. The study shows that around 81 per cent of drinkers in the sample drink on Saturday evenings, and around 62 per cent drink on Saturday afternoons [27].

From the data presented by the authors, we can make some inferences about the most common days and times of drinking, though we are unable to calculate the exact percentage of drinkers in each category. The data presented suggests that the bulk of people reported drinking alcohol on Saturdays, followed by drinking on Fridays and Sundays [27]. The research further suggests that, on any given day of the week except a Wednesday, the proportion of people who report drinking in the evening is higher than the proportion reporting that they drink in the afternoon or morning. On a Saturday, for example, 15.7 per cent of the sample report drinking in the morning, 62.2 per cent report drinking in the afternoon, and 81.1 per cent report drinking in the evening [27].

[2] Peak consumption measures the highest number of drinks consumed on a single drinking occasion. It therefore relates to intoxication, which is epidemiologically associated with health harms such as interpersonal violence and road injury.

Our estimates of peak consumption using national-level SADHS (2016) data indicate that more than half of all drinkers report their peak alcohol consumption on Saturdays, and nearly three quarters (74.1 per cent) report peak consumption between Fridays and Sundays (Figure 2). Coupling this with the average number of drinks consumed, shown on the right-hand-side axis, it is clear that alcohol consumption increases on Saturdays to an average maximum consumption of 15.5 drinks per day, with average consumption on Fridays and Sundays only slightly lower at 14.0 and 13.4 drinks per day, respectively.

FIGURE 2. PEAK ALCOHOL CONSUMPTION PATTERNS BY DAY OF THE WEEK



Source: Own calculations from National Department of Health *et al.* (2019) [15] and StatsSA (2018) [28].
Notes: Homebrew alcohol consumption is excluded from this figure. Average peak drinks shows the average maximum daily number of drinks reported by individuals after a regression-based adjustment. We document this adjustment in section 3.2.4 of this report.

With this in mind, we plot the distribution of the grouped EMS incident data for 2021 by day of the week (Figure 3) and by time of day (Figure 4). We exclude non-cardiac pain from these Figures.

Figure 3 shows that incidents of assault, accidental injury, environmental harms, and self-harm peak on weekends. Over the course of 2021, the average number of assault incidents reported between Mondays and Thursdays was 5 945, which increased to 8 347 on Fridays, and averaged 22 547 on Saturdays and Sundays. The average number of accidental harm injuries reported between Mondays and Thursdays was 2 756, which increased to 3043 on Fridays and averaged 4235 on Saturdays and Sundays.

A similar clustering on weekends is observed for self-harm and environmental injuries (Figure 3). The average number of self-harm injuries reported between Mondays and Thursdays in 2021 was 1 501, which increased to 1 561 on Fridays and averaged 2 268 on Saturdays and Sundays. The average number of environmental harm injuries reported between Mondays and Thursdays was 532, which increased to 663 on Fridays and averaged 984 on Saturdays and Sundays.

FIGURE 3. INCIDENTS REPORTED TO WESTERN CAPE EMERGENCY MEDICAL SERVICES BY DAY OF THE WEEK, 2021

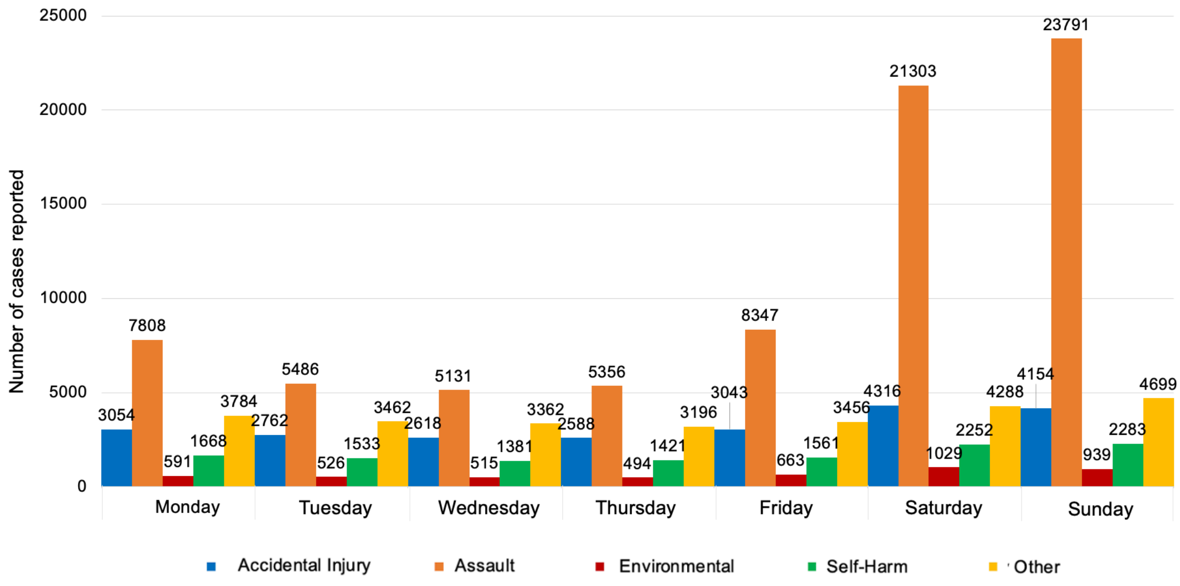
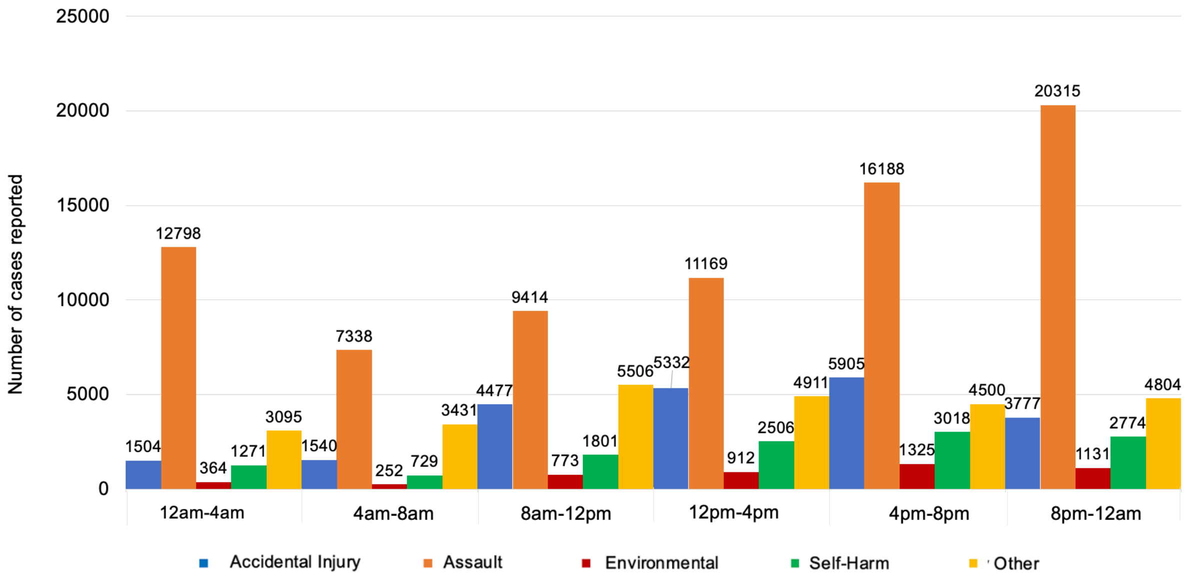


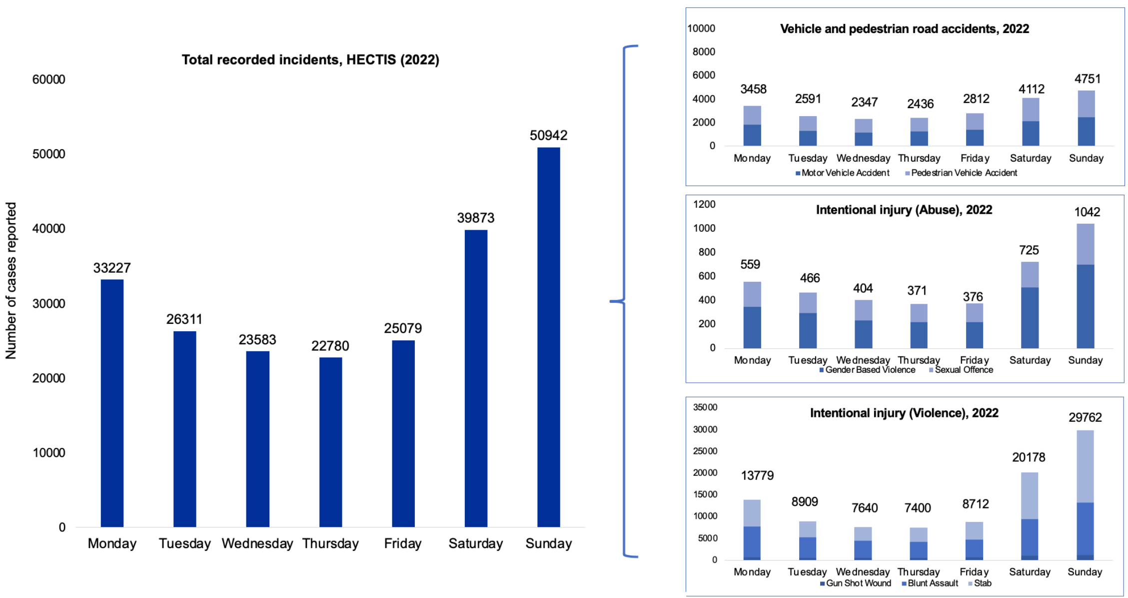
FIGURE 4. INCIDENTS REPORTED TO WESTERN CAPE EMERGENCY MEDICAL SERVICES BY TIME OF DAY, 2021



Incidents by time of day reported in Figure 4 are also suggestive of a link between alcohol consumption and harms since there is a persistent rise in incidents of assault between midday and midnight, which is when the existing research suggests that the bulk of drinking is likely to occur [27]. In 2021, the number of assault cases between 8pm and midnight was 2.2 times higher than the number of assault cases between 8am and midday. Incidents of environmental harms and incidents of self-harm only increase between midday and 8pm, though the number of cases reported between 8pm and midnight for each of these conditions is still higher than those observed between 8am and midday, when less drinking is likely to occur [27].

For the purpose of this project, we were also granted access to data from the Hospital and Emergency Centre Tracking Information System (HECTIS). HECTIS reports on trauma cases presented to emergency centres across the Western Cape. Figure 5 shows the total number of recorded incidents reported in the HECTIS data in 2022, as well as a breakdown of these trauma cases by three broad categories: road accidents, intentional injuries (violence) and intentional injuries (abuse).The three categories shown in Figure 5 do not include all incident types reported in the HECTIS dataset.

FIGURE 5. TRAUMA INCIDENTS RECORDED BY THE HOSPITAL AND EMERGENCY CENTRE TRACKING INFORMATION SYSTEM BY DAY OF THE WEEK, 2022



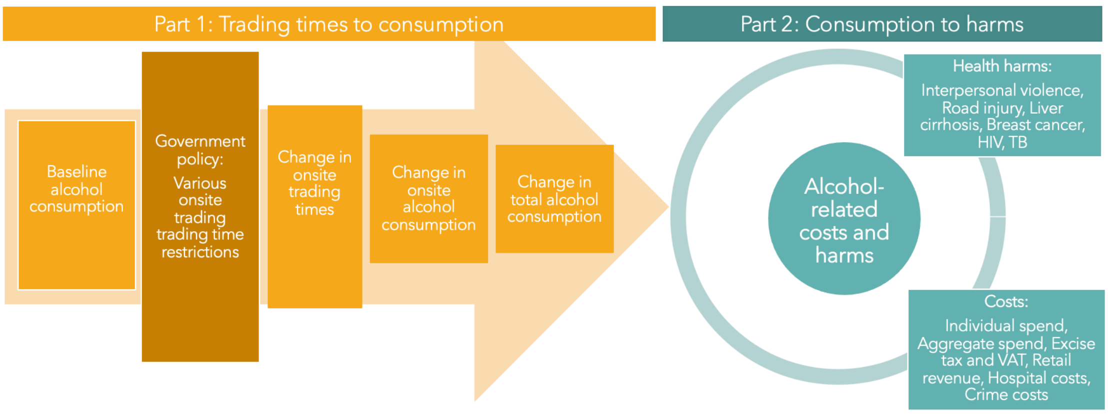
Consistent with the aforementioned research and data that shows that alcohol consumption peaks over weekends, the total number of trauma cases reported in the HECTIS data increases over weekends. These increases are driven by increases in road accidents, and intentional injuries experienced as a results of both violence and abuse (Figure 5). The link between alcohol consumption and harms is well-established in the peer-reviewed international literature [29]. The descriptive statistics provided in this chapter are indicative of this link existing at a local level. They thus lend credence to WCG's identification of targeting reductions in alcohol consumption in the province as a means to reducing alcohol-related harms.

3. DATA AND METHODS

3.1 Model overview

We simulate the impact of three different closing time scenarios at onsite alcohol trading locations (midnight, 1am, and 2am) in the Western Cape. We use an epidemiological model that relies on a comparative risk assessment approach with multistate life tables. This approach draws on the work done by Gibbs *et al*. (2021) to understand the likely impact of implementing a minimum unit price for alcohol at the national level in South Africa [30]. We also use the currently unpublished work of Van Walbeek and Gibbs (2021) who estimate the likely impact of implementing a minimum unit price in the Western Cape [31]. The modelling approach is shown in Figure 6 below. The baseline year of the model is 2018.

FIGURE 6. MODELLING APPROACH FOR ESTIMATING THE HEALTH AND ECONOMIC IMPACTS OF REDUCTIONS IN ONSITE TRADING TIMES FOR ESTABLISHMENTS SELLING ALCOHOL



Source: Adapted from Gibbs et al. (2021) [30]

The modelling framework is divided into two distinct sections. The first part of the model deals with the link between trading hours and alcohol consumption at onsite establishments. The responsiveness of alcohol consumption to changes in trading times is quantified by the trading times elasticity. The second part of the model quantifies the link between alcohol consumption at onsite venues and its associated health harms and economic costs. We conduct a sensitivity analysis of our two-part approach by replacing the trading times elasticity with a direct harms elasticity for the one of the acute conditions analysed in the model: intentional injuries.

There is no single dataset that can provide all the data required to calibrate the model. Instead, we combine survey datasets, market research data, and evidence from published literature. The variables we use, and the data sources we employed to operationalize each of these variables, are summarized in Table 1. A detailed description of each variable is provided in the remaining sub-sections of this chapter.

TABLE 1. DATA SUMMARY

What we want to measure	Variable	Data source	Data quality (score out of 7)[Ψ]
Baseline consumption	Per capita alcohol consumption	South African Demographic and Health Survey (2016)	6
		National Income Dynamic Study: Wave 4 (2014/2015)	6
		Euromonitor data on recorded per capita alcohol consumption (2018)	6
Policy intervention	Trading times	Phase 1 deliverable	6
	TT elasticity	International literature	N/A
Baseline Health	Number of deaths from HIV	Second National Burden of Disease Study (2016)	7
	Number of deaths from road injury	Second Injury Mortality Survey (2021)	6
	Number of deaths from intentional injury	Second Injury Mortality Survey (2021)	6
	Number of deaths from liver cirrhosis	Statistics South Africa Report on mortality and causes of death in South Africa (2017)	6
		Second National Burden of Disease Study (2016)	6
	Number of deaths from breast cancer	Statistics South Africa Report on mortality and causes of death in South Africa (2017)	6
		Second National Burden of Disease Study (2016)	6
	Number of deaths from TB	Second National Burden of Disease Study (2016)	6
	HIV prevalence	Western Cape Burden of Disease Review (2020)	6
	Road injury prevalence	Global Burden of Disease study Institute for Health Metrics Evaluation (2018)	4
	Intentional injury prevalence	Global Burden of Disease study Institute for Health Metrics Evaluation (2018)	4
	Liver cirrhosis prevalence	Global Burden of Disease study Institute for Health Metrics Evaluation (2018)	4
	Breast cancer prevalence	Global Burden of Disease study Institute for Health Metrics Evaluation (2018)	4
	TB prevalence	Western Cape Burden of Disease Review (2020)	6
	Socioeconomic gradient of ill-health	General Household Survey (2018)	5
	Relative risk of HIV	Probst *et al*. (2018)	N/A
	Relative risk of road injury	Shield *et al*. (2020)	N/A

	Relative risk of intentional injury	Shield *et al*. (2020)	N/A
	Relative risk of liver cirrhosis	Shield *et al*. (2020)	N/A
	Relative risk of breast cancer	Shield *et al*. (2020)	N/A
	Relative risk of TB	Shield *et al*. (2020)	N/A
	HIV multiplier	UNAIDS (2020)	6
	Intentional injury multiplier	Global Burden of Disease study Institute for Health Metrics Evaluation (2018)	6
		Matzopoulos *et al*. (2006)	5
	Road injury multiplier	Global Burden of Disease study Institute for Health Metrics Evaluation (2018)	6
		Matzopoulos *et al*. (2006)	5
	Liver cirrhosis multiplier	Ventoet et al. (2018)	5
	Breast cancer multiplier	Joffe *et al.* (2018)	5
	TB multiplier	Van Walbeek and Gibbs *et al.* (2021)	5
	Annual hospital costs associated with treating HIV	Meyer-Rath *et al*. (2019)	5
	Annual hospital costs associated with treating Road injury	Parkinson *et al*. (2014)	5
	Annual hospital costs associated with treating intentional injury	Bola *et al*. (2016)	5
	Annual hospital costs associated with treating liver cirrhosis	Health Systems Trust (2020)	6
	Annual hospital costs associated with treating breast cancer	Guzha *et al.* (2020)	5
Baseline Economics	Alcohol prices (required to calculate individual and aggregate spend)	International Alcohol Control Study (2014/2015)	4
	Excise revenue	Treasury's annual Budget Review (2020)	6
		National Income Dynamics Study: Wave 4 (2014/2015)	6
	VAT	Derived	N/A
	Retail revenue	Derived	N/A
	Crime costs	Matzopoulos *et al*. (2014)	6
		Statistics South Africa (2018)	6

Notes:
Ψ We assessed the quality of each of the data sources used against seven criteria. These criteria, and the scores allocated to each dataset are listed in Appendix 2.

3.2 Alcohol consumption

There are no surveys of alcohol consumption in the Western Cape. The discussion below thus pertains to the available national-level datasets on alcohol consumption and documents the methods we employ to recalibrate these national-level data to derive estimates of onsite alcohol consumption in the Western Cape.

The starting point of this process requires establishing a baseline for overall alcohol consumption in South Africa. Based on our reading of the literature, our model needs to incorporate both mean and peak alcohol consumption [30]. As noted by Gibbs *et al*. (2021), peak consumption measures the highest number of drinks consumed on a single drinking occasion and therefore relates to intoxication, which is epidemiologically associated with health harms such as interpersonal violence and road injury [30].

Surveys differ in the way they collect alcohol consumption data. Some use multiple choice questions that elicit responses about the typical quantity of alcohol consumed, or the typical frequency with which alcohol is consumed, while others ask respondents to recall their alcohol consumption during a specific time period such as the previous week, or each day of the previous week. As documented by Stockwell *et al*. (2004), quantity or frequency questions can underestimate a person's true alcohol consumption, whereas recall questions tend to lead to better coverage,[3] allow for a drinker's peak alcohol consumption to be estimated, and provide more accurate estimates of unrecorded consumption [32]. However, recall can miss irregular or lower-level drinking patterns if the individual does drink but happened to not drink anything in the previous week [32]. Ideally surveys that measure alcohol consumption should employ both recall and typical quantity/ frequency questions.

We studied the alcohol survey landscape in South Africa and found four surveys that asked questions relating to alcohol consumption. These are: the 2016 South African Demographic and Health Survey (SADHS) 2016 [15]; the 2014/2015 National Income Dynamic Study (NIDS) Wave 4 [33]; the 2015 All Media and Product Survey (AMPS) [34]; and the 2014/2015 International Alcohol Control (IAC) Study [35]. The questions used for eliciting alcohol consumption varied across these surveys (see Appendix 3).

SADHS uses a combination of recall and some quantity/frequency measures as well as asking about homebrewed alcohol consumption. Wave 4 of NIDS uses quantity/frequency questions only. AMPS uses seven-day recall and asks about the different brands of alcohol consumed. The IAC asks quantity/frequency questions and documents the nature of the respondents' drinking by asking questions on container size, drink type, and drinking locations.

Following a preliminary assessment of these data, and taking into consideration the approach adopted in previous modelling work done to estimate the impact of minimum unit pricing in South Africa [30] and the Western Cape [31], the 2016 SADHS was chosen as the main dataset used in our analysis. We modified the 2016 SADHS so that it would be representative of the Western Cape population. These adjustments follow the approach developed by Gibbs

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[3] 'Coverage' is defined as the proportion of all alcohol consumption (using administrative data sources) which is accounted for by the self-reported consumption of individuals in a survey.

et al. (2021) [30] and Van Walbeek and Gibbs (2021) [31]. We document these data adjustments below.

3.2.1 Overview of the SADHS data

The SADHS data is stored across a variety of different files. The datasets used for this analysis are specifically those that included any form of data on alcohol consumption. The questions included in the SADHS regarding alcohol consumption are reported in Table 2.

TABLE 2. QUESTIONS ON ALCOHOL CONSUMPTION IN THE SADHS, 2016

Questions	Answer options
Have you ever consumed a drink that contains alcohol such as beer, wine, ciders, spirits or sorghum beer? *Probe: Even one drink*	Yes No
Was this within the last 12 months	Yes No
In the last 12 months, how frequently have you had at least one drink? *Probe: Five or more days a week, 1-4 days a week, 1-3 days a month, or less often than once a month*	Five or more days a week 1-4 days a week 1-3 days a month Less often than once a month
During each of the last 7 days, how many standard drinks did you have? *Use showcard. Record total number of drinks consumed each day, starting with the day before the interview and proceeding backwards.*	Numeric. Answers coded from 0 to 30+ per day.
During the last 7 days, how many standard home-made beers or other homemade alcohol did you have?	Numeric. Answers coded from 0 to 30+.
In the past 30 days, have you consumed 5 or more standard drinks on at least one occasion?	Yes No

Source: National Department of Health *et al.* (2019) [15]

According to the SADHS metadata, these questions formed part of Section 12 of the Individual Questionnaire, which was administered to men and women according to different inclusion rules. By combining data from male and female individual questionnaire files, we obtained a final sample of 10 336 observations; 6 126 of which were female, and 4 210 of which were male.

3.2.2 SADHS population weights

Gibbs *et al*. (2021) discuss the application of population weights to the SADHS [30]. There are two types of weights available in the SADHS: a sampling weight (mv005 for men and v005 for women), and a sampling weight for the health questionnaire (smweight for men and sweight for women).[4]

[4] Neither weight allows an exact reproduction of the results presented in the supplementary material to Gibbs *et al*. (2021) [19]. Both get close to the figures presented, but neither seems exactly correct.

The sampling weights provided with the data (mv005 and v005) raise a number of concerns regarding the manner in which they will impact data analysis for this project. First. these weights are equal to zero for 1 933 females and 592 males. This is a problem since it effectively nullifies about 2500 observations in the sample: 384 of these individuals with zero weight are drinkers. Second, the gender split of the weighted observations is incorrect – we have 53.72 per cent female and 46.28 per cent male. We calibrate this appropriately later.

For this analysis, we opt to use the weight for the health questionnaire since this weight variable has no missing observations. The choice of this weight is not without problems, however. The gender split is further off (59.27 per cent female and 40.73 per cent male), but (as mentioned above) these are both issues that can be rectified with an appropriate recalibration of the weights.

In order to adjust the weights to account for the correct race/gender splits, a 'raking' calibration algorithm is implemented in Stata. Specifically, weights for any national calculations are calibrated according to the 2018 population totals, obtained from the Statistics South Africa 2018 mid-year population estimates [28]. These sex and race subtotals are reported in Table 3. This method rescales the population weights provided in the SADHS by a constant factor so that the population totals by race and gender accord with the figures presented in Table 3 below.

TABLE 3. 2018 MID-YEAR POPULATION ESTIMATES FOR POPULATION AGED 15+

	Male	Female	Total
African	15 468 387	16 565 291	32 033 678
White	1 823 663	1 967 506	3 791 170
Coloured	1 755 803	1 932 519	3 688 321
Indian/Asian	597 306	571 613	1 168 919
Total	19 645 159	21 036 929	40 682 088

Source: Own calculations based on Statistics South Africa (2018) mid-year population estimates [28]

3.2.3 Adjustment process for alcohol data

As a starting point for the adjustment process, we consider the number of individuals who reported having drunk alcohol in the past seven days (including homebrew alcohol). There are a total of 2 034 individuals (out of 10 336 in the sample) who report drinking alcohol in the past seven days (588 females and 1 446 males). However, when considering the frequency of alcohol consumption question (i.e., 'In the last 12 months, how frequently have you had at least one drink?'), a total of 3 311 individuals report having drunk alcohol in the past 12 months. As a result, the 7-day recall question is likely to have underestimated the number of drinkers in South Africa, especially if infrequent drinkers were interviewed in a period where they did not drunk in the past week. This would lead to an underestimate of alcohol consumption in South Africa. Following Gibbs et al. (2021) [30], we opt to utilise both the 7-day recall figures as well as the drinking frequency figures to impute drinking patterns for those who do not report a seven-day drinking pattern.

Table 4 presents the distribution of alcohol consumption frequency for those who reported drinking in the past seven days, and for those who did not report drinking in the past seven days. This table is a reproduction of that presented in Gibbs *et al*. (2021) [30]. Given that the figures exactly align with those in Gibbs *et al*. (2021), it suggests that all the correct data for alcohol consumption has been captured from the SADHS.

TABLE 4. ALCOHOL CONSUMPTION RESPONSES BY FREQUENCY AND 7-DAY RECALL PATTERN

Drinking frequency	Did not report drinks in last 7 days	Reported drinks in last 7 days	Total
5 or more days per week	27 (6 binge)	266 (22 binge)	293
1-4 days per week	103 (29 binge)	565 (71 binge)	668
1-3 days per month	364 (0 binge)	799 (83 binge)	1,163
Less often than once a month	783 (0 binge)	404 (42 binge)	1,187
Missing	7,025	0	7,025
Total	**8,302**	**2,034**	**10,336**

Source: Own calculations from National Department of Health *et al*. (2019) [15].

The next step is to normalise all alcohol consumption figures to a common unit of measurement. Consistent with Gibbs *et al*. (2021) [30], we opt to normalise consumption figures to annual alcohol consumption. To do this, we make use of a number of adjustment factors described in Gibbs *et al*. (2021) [30]. Specifically, we make the following adjustments:

For individuals who report drinking every week, and who report a 7-day drinking pattern – i.e., the blue cells – we can simply multiply the number of drinks consumed in the 7-day reference period by 52 to achieve the annual number of drinks consumed.

For individuals who report drinking less frequently than once a week, and who report a 7-day drinking pattern – i.e., the purple cells – we cannot simply multiply by 52 to get annual consumption, as this would be an overestimate of consumption. For those individuals who report drinking 1-3 days per month, we assume that the survey reference week was their one week of drinking per month, and so we multiply their reported monthly drinking volume by 12 to get an annual consumption figure. For those individuals who report drinking less often than once per month, we assume that the survey reference week captured their one week of drinking every 2 months, and so we multiply their consumption by 6 to get an annual consumption figure.

Now, we consider drinking patterns for those individuals who did not report a 7-day drinking pattern – i.e., those individuals who reported not having any drinks in the past 7 days. In total, this subset of respondents makes up 1 277 respondents. These individuals are distributed across the drink frequency distribution; however, unsurprisingly, there are more individuals who drink infrequently that report no drinks in the reference week.

For all individuals who do not report drinking in the 7-day reference period – i.e., all those in the yellow and green cells – we impute consumption as the average number of drinks consumed by those of the same sex and in the same drinking frequency category, but who did report a 7-day drinking pattern. In the case of the yellow cells, we further split the analysis into those who binge drink and those who do not. A binge-drinker is someone who consumes five or more drinks on one occasion [30]. Average consumption figures are calculated for binge-drinkers and non-binge-drinkers within each drink frequency category and the relevant average is assigned to an individual without a 7-day drinking pattern.

As an example, a female who drinks five or more days a week, but has not drunk in the past seven days, and does not report binge drinking, would have an imputed number of drinks assigned to them. In other words, imagine Respondent X who does not report a 7-day drinking pattern with the following characteristics: a female drinker who does not report binge drinking, but who drinks five or more days per week. To estimate the number of drinks consumed by Respondent X, we calculate the average number of drinks consumed by individuals who match Respondent X's characteristics – i.e., female drinkers, who do not report binge drinking, and who drink five or more days per week. Empirically, such individuals consume an average of 641.77 drinks per year. We then assign this number of drinks (641.77) to Respondent X as their annual alcohol consumption.

We then further adjust these figures to compute annual litres of alcohol consumed. Note that the SADHS reports alcohol consumption as 'number of standard drinks'. A standard drink in South Africa is considered to be 15ml or 12 grams of pure ethanol. In order to compute the annual number of litres of alcohol consumed, we use the following conversion:

$$Litres\ of\ alcohol = Number\ of\ drinks \times 0.015$$

Assuming that each drink reported in the SADHS is a standard drink containing 15ml of ethanol, this conversion estimates the total amount of alcohol consumed in South Africa per year.

Table 5 presents a summary of drinking prevalence and alcohol consumption from purely the 7-day recall data, as well as the frequency-adjusted data that takes into account the imputed number of drinks for individuals who did not report a 7-day drinking pattern. The inclusion of the imputations increases drinking prevalence for both sexes. Male drinking prevalence is substantially higher than female drinking prevalence – a result that is consistent with the findings presented in Gibbs *et al*. (2021) [30]. The prevalence figures of 19.6 per cent for women and 54.1 per cent for men are also broadly consistent with the figures reported by Gibbs *et al*. (2021), at 18 per cent and 54 per cent for women and men, respectively. The average consumption figures are also generally higher for men than women – another expected result.

Average litres of alcohol consumed per year, however, are slightly different to the figures reported by Gibbs *et al*. (2021). Where Gibbs *et al*. (2021) report an adjusted average consumption of 1.65 litres per capita (or 5.0 litres per drinker), we find that consumption differs slightly, although not too drastically. Specifically, we find that consumption per capita is approximately 2 litres per person, while consumption per drinker is approximately 4.6 litres. In both cases, the 95% confidence intervals for our estimates do not include the estimate reported by Gibbs *et al*. (2021); however, the general pattern of consumption is consistent. We note that Gibbs *et al*. (2021) exclude homebrew consumption in their initial baseline consumption estimate, whereas we include homebrew consumption in our estimates. This does increase drinking prevalence in our estimates, which could explain why our per capita figures are higher while our per drinker figures are lower.

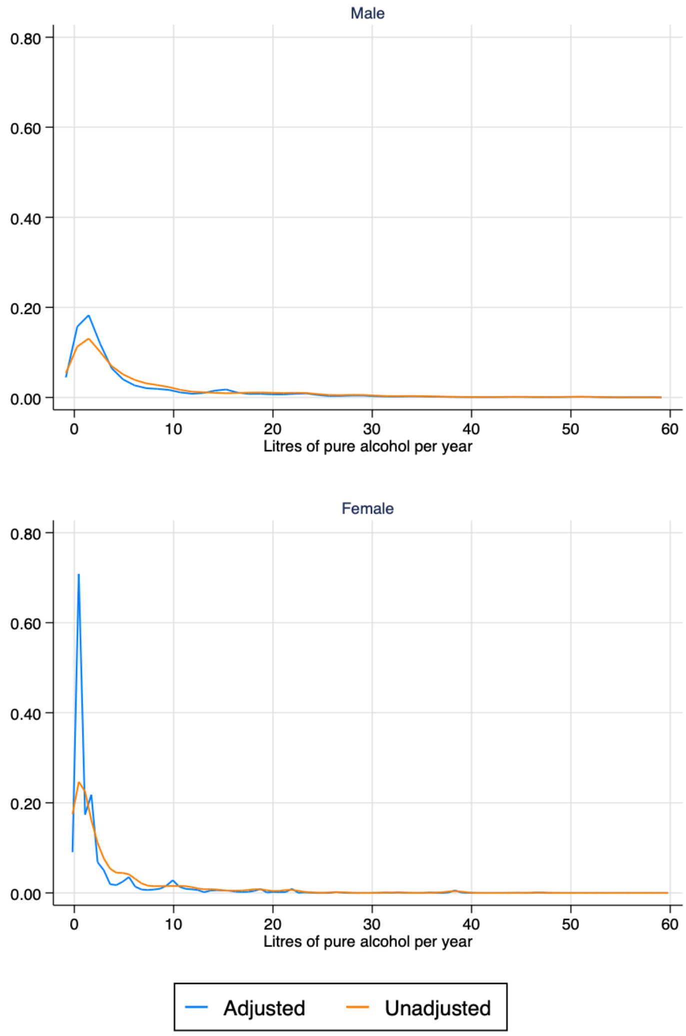
TABLE 5. DRINKING PREVALENCE AND CONSUMPTION IN SADHS BEFORE AND AFTER FREQUENCY ADJUSTMENT

	Prevalence of drinking			Sample size: drinkers			Annual litres of alcohol (per capita)			Annual litres of alcohol (per drinker)		
	Total	Female	Male	Total	Female	Male	Total	Female	Male	Total	Female	Male
SADHS 7 day recall only	23.7% [22.4;25.0]	10.9% [9.8;12.0]	37.4% [35.2;39.7]	2034	588	1446	1.70 [1.5;1.9]	0.43 [0.3;0.5]	3.06 [2.6;3.5]	5.97 [5.3;6.7]	4.02 [3.0;5.0]	8.20 [7.2;9.2]
SADHS 7 day recall and frequency data	36.3% [34.9;37.7]	19.6% [18.2;21.0]	54.1% [51.8;56.5]	3311	1125	2186	2.01 [1.8;2.2]	0.55 [0.4;0.7]	3.58 [3.2;4.0]	4.58 [4.1;5.0]	2.77 [2.2;3.3]	6.59 [5.9;7.3]

Source: Own calculations from National Department of Health et al. (2019) [15].
Note: Figures in square parentheses are 95% confidence intervals.

To get a better idea of alcohol consumption behaviour and how the adjustments have influenced consumption figures and patterns, we plot the annual alcohol consumption for men and women as density plots below in Figure 7. In both cases, the orange lines represent the unadjusted, unimputed, 7-day recall data, while the blue lines indicate the data after imputations and adjustments have been made. It is clear that for both men and women, the adjustment increases the number of drinkers who consume low levels of alcohol. This is not surprising, since the majority of individuals who did not report 7-day drinking patterns were less frequent drinkers. As a result, it makes sense that there is greater density for low-consumption drinkers in the imputed data. The pattern of distributional shifts mimics those presented in Gibbs *et al*. (2021) closely, including the shape of the distributions.

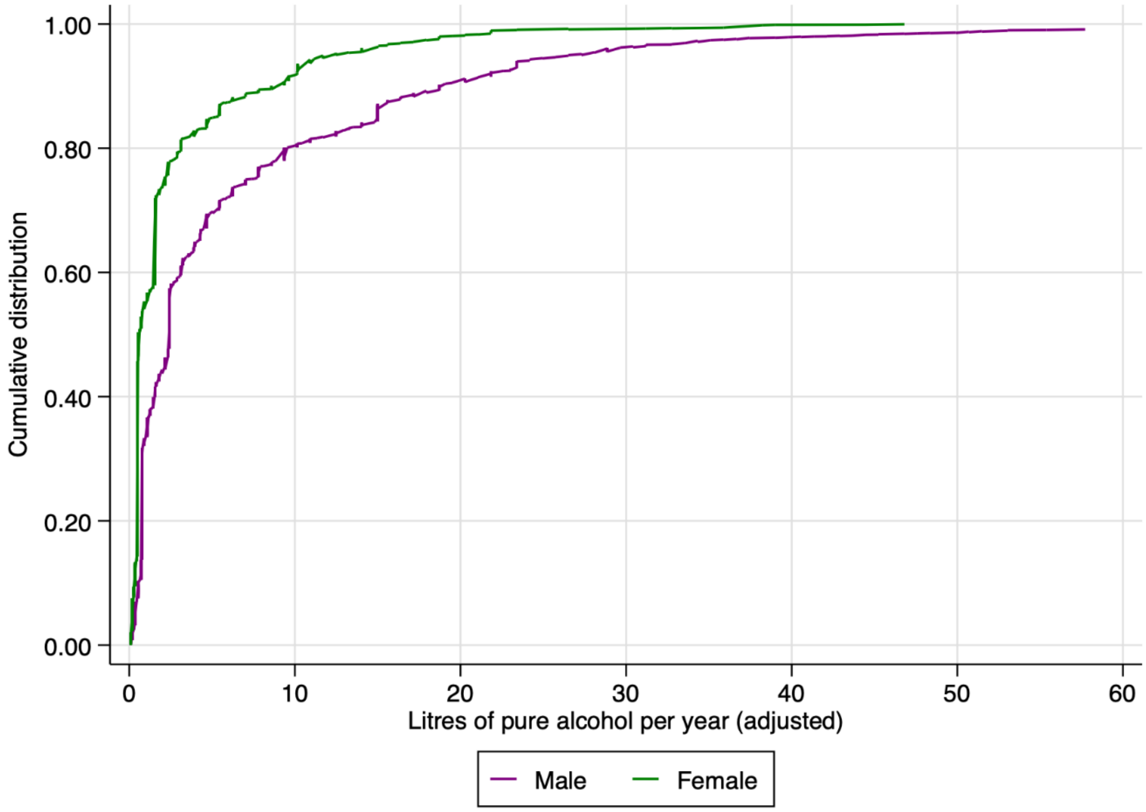
FIGURE 7. SADHS ALCOHOL CONSUMPTION DENSITY PLOTS, BY SEX, WITH AND WITHOUT FREQUENCY ADJUSTMENT



Source: Own calculations from National Department of Health *et al.* (2019) [15]

Figure 8 plots the cumulative distribution of the frequency-adjusted annual alcohol consumption by sex. Males tend to be heavier drinkers than females, with the cumulative density function of alcohol consumption by males always lying to the right of alcohol consumption by females. About 80 per cent of males, while closer to 90 per cent of females drink 10 litres of alcohol or less per year. Males are more likely to be heavy drinkers than females, with almost no females drinking above 22 litres of alcohol per year, while approximately 10 per cent of males drink above 22 litres of alcohol per year.

FIGURE 8. CUMULATIVE DISTRIBUTION OF FREQUENCY-ADJUSTED ANNUAL ALCOHOL CONSUMPTION, BY SEX



Source: Own calculations from National Department of Health et al. (2019) [15].
Notes: Cumulative density functions weighted according to recalibrated population weights.

The results in Table 5, and Figure 7 and Figure 8 appear correct, however, the average alcohol consumption per year is far too low. It is well-known that individuals under-report their alcohol consumption relative to what administrative sources suggest true alcohol consumption to be [36]. This is a global phenomenon. South African alcohol consumption has been estimated at between 9.3 and 11.5 litres per capita for the period 2010 to 2017 [37, 38], and alcohol sales figures provided by Euromonitor suggest that approximately 7.2 litres of pure alcohol were sold per capita in South Africa in 2018 [39]. As a result, it is clear that the alcohol consumption figures in the SADHS need to be uplifted to ensure that consumption is accurately captured.

In order to adjust the alcohol consumption figures, we follow the method put forward by Gibbs *et al*. (2021) [30]. This method requires alcohol consumption in the SADHS to be compared to alcohol sales data that has been adjusted for storage, stockpiling and tourist consumption to calculate the coverage of the survey. Using the coverage of the survey, we are able to estimate a shifted mean and standard deviation of a theoretical gamma distribution that we believe our consumption figures should fit. Finally, we can use this theoretical distribution to determine the factor by which we need to inflate consumption figures along the entirety of the alcohol consumption distribution. It is worth noting that our adjustment to the alcohol consumption figures in the SADHS only impact those individuals who actually report consuming alcohol. In other words, if individuals falsely report that they do not drink anything, then this will lead to an underestimate of drinking prevalence overall. As a result, for our adjustment below, we assume that all those people who drink (however infrequently) do in fact report that they drink.

We begin by estimating the coverage of the survey relative to reported alcohol sales data for South Africa. The calculations for the survey coverage are presented in Table 6. Table 6 presents two calculations of the coverage figure: one for uncapped consumption and another for capped consumption. Gibbs *et al*. (2021) [30], based on Gmel *et al*. (2013) [40], apply a cap of 68 litres of alcohol per person per year to consumption, since this is the maximum possible consumption that can be maintained in the long-run. We thus make use of the capped consumption adjustment, however, we present both calculations in Table 6 to show that there is not much difference between the two methods.

TABLE 6. CALCULATING SADHS COVERAGE RELATIVE TO EUROMONITOR PER CAPITA ALCOHOL SALES DATA

	Uncapped consumption	**Capped (i.e., max 68 litres p.a.)**
SADHS total annual consumption figure (litres) (A)	81 828 959	80 563 716
SADHS per capita consumption figure (B)	2.01	1.98
Euromonitor annual sales	**295 758 193**	**295 758 193**
Adjusted Euromonitor figure (80% of original value to account for spillage, stockpiling, etc.)	236 606 554	236 606 554
Litres of homebrew alcohol per year (SADHS)	*3 001 496*	*3 001 496*
Percentage home brew consumption	*3.67%*	*3.73%*
Upscaled Euromonitor figure to account for homebrew (C)	245 615 770	245 762 733
Expected per capita consumption (Euromonitor) (D)	6.04	6.04
Coverage (A/C or B/D)	***33.32%***	***32.78%***
Multiplier (1/Coverage)	***3.002***	***3.051***

Source: Own calculations from National Department of Health et al. (2019) [15], Statistics South Africa (2018) and Euromonitor International (2022) [39].

The method for calculating coverage is as follows: Using the figure of 295.76 million litres of alcohol sales in South Africa per annum – sourced from Euromonitor International (2022) – we adjust this figure down by 20 per cent to account for spillage, stockpiling, and tourist consumption. We then calculate the proportion of consumption that is attributable to homebrew consumption, and which is thus not captured in Euromonitor sales data. Similarly to Gibbs *et al*. (2021) [30], who report homebrew consumption of approximately 4%, we find that homebrew accounts for approximately 3.7 per cent of consumption in South Africa (based on the SADHS survey data). We then upscale the Euromonitor sales figure to account for this homebrew consumption to arrive at a total alcohol sales figure of approximately 246 million litres of alcohol sold annually in South Africa. We then calculate what percentage of this figure our SADHS per capita consumption figure accounts for – this is known as the coverage of the survey. In both cases (uncapped and capped consumption), coverage is approximately one third. The inverse of the coverage is used as a multiplier to inflate the average alcohol consumption figure for men and women separately. This inflation procedure is conducted according to the following formula:

$$\hat{\mu}_{shifted} = \frac{1}{Coverage} \times \hat{\mu}_{SADHS}$$

At this point, we can use this shifted mean of consumption to estimate the standard deviation of the distribution for men and women, using a relationship put forward by Rehm *et al.* (2010) [41]. This relationship relates the standard deviation of the distribution of alcohol consumption to the coverage-shifted mean and sex according to the following relationship:

$$\hat{\sigma}_{shifted} = 1.174 \times \hat{\mu}_{shifted} + 1.003 \times female$$

where $female$ is a binary indicator variable, which is equal to 1 when we calculate the shifted standard deviation for the female distribution, and 0 when we calculate it for men.

Once we have calculated the shifted mean and standard deviation of the male and female consumption distribution, we are able to relate this to a theoretical gamma distribution with shape parameter α and rate parameter β. These parameters relate to the mean and standard deviation as follows:

$$\alpha = \left(\frac{\hat{\mu}_{shifted}}{\hat{\sigma}_{shifted}}\right)^2$$

$$\beta = \frac{\hat{\mu}_{shifted}}{\left(\hat{\sigma}_{shifted}\right)^2}$$

Using the shape and rate parameters calculated using the relationships above, we are able to produce a gamma distribution that models the theoretical distribution of alcohol consumption for men and women, respectively. This theoretical distribution serves as a yardstick against which we can measure our observed alcohol consumption distribution. As a result, we can fit a gamma distribution to our existing data and estimate the $\hat{\alpha}$ and $\hat{\beta}$ that best describe our existing data. This estimation procedure makes use of Maximum Likelihood Estimation (MLE))techniques.

Hereafter, we make use of a simulation to compare the two distributions: the theoretical distribution $\gamma \sim (\alpha, \beta)$ and the observed distribution $\hat{\gamma} \sim (\hat{\alpha}, \hat{\beta})$. By using a random draw of 100 000 observations, we generate synthetic observations describing alcohol consumption patterns that fit each of our two gamma distributions. Hereafter, we calculate the percentiles of each distribution and compare them to determine how much the observed data should be inflated by to better represent the theoretical distribution of alcohol consumption we expect to see. We note that our observed data requires inflating by a factor of between 1 and 11, with larger inflations required at the bottom of the distribution. By way of a summary, Table 7 shows the mean, minimum, and maximum of alcohol consumption by sex for the original SADHS data as well as the gamma-shifted data following the above procedure.

TABLE 7. COMPARISON OF ALCOHOL CONSUMPTION BEFORE AND AFTER GAMMA SHIFT, BY SEX

	Mean	Min	Max
Female			
SADHS (frequency adjusted and capped)	2.72	0.09	68
Gamma-adjusted estimates	12.21	1	68
Male			
SADHS (frequency adjusted and capped)	6.45	0.09	68
Gamma-adjusted estimates	21.55	1	68
Both			
SADHS (frequency adjusted and capped)	4.52	0.09	68
Gamma-adjusted estimates	16.77	1	68

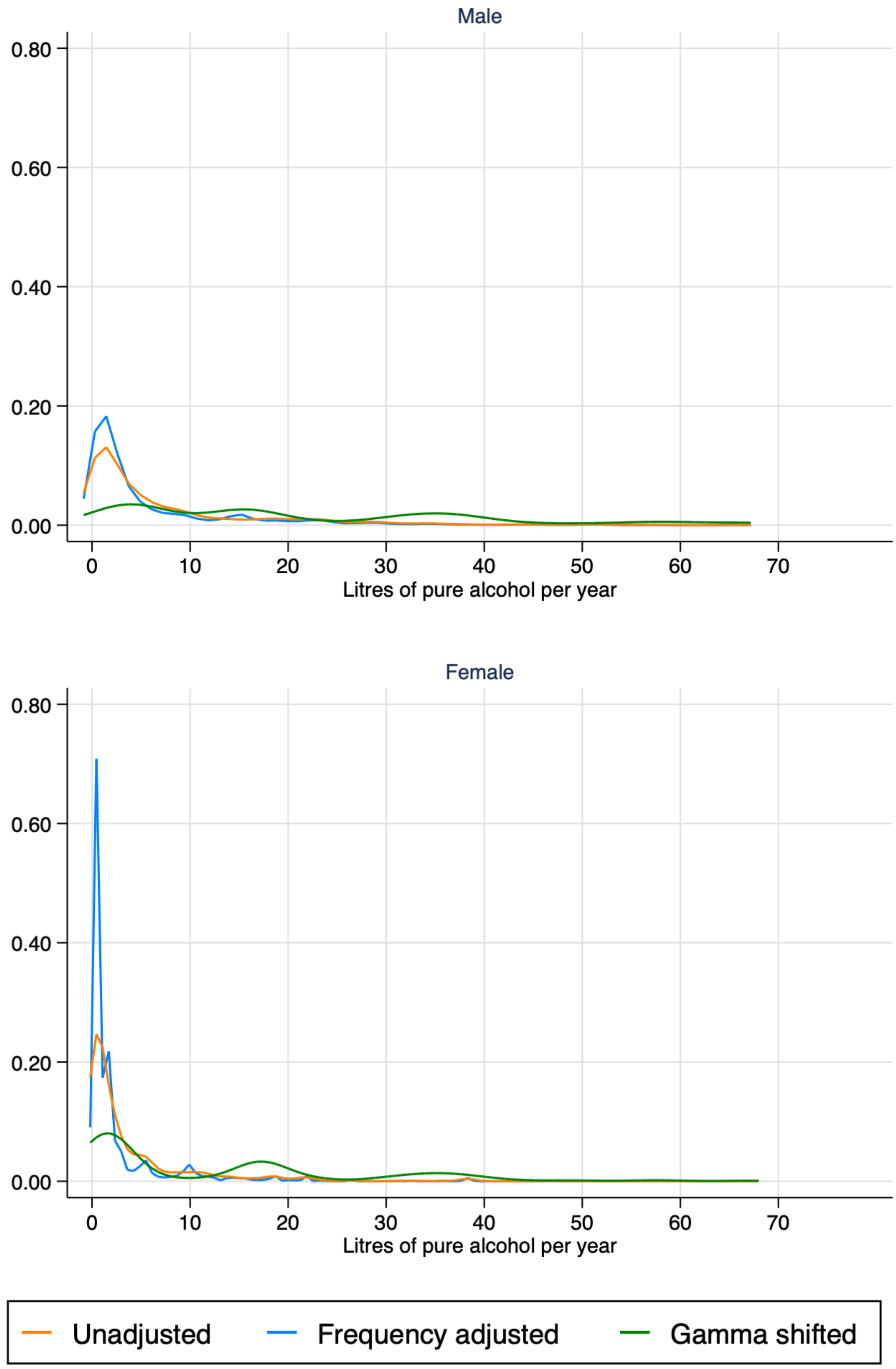
Source: Own calculations from National Department of Health et al. (2019) [15]

Notes: Figures for the SADHS estimates do not exactly match estimates in Table 5 due to the implementation of the cap at 68 litres per person per year.

The results in Table 7 indicate that the gamma shift of consumption resulted in a large increase in the average consumption of alcohol for both men and women. Although the average consumption figure has increased significantly, the maximum consumption remains at 68 litres per person per year due to the fact that this is the maximum sustainable consumption of alcohol for an individual.

In Figure 9 we present a comparison of the overall distributions of alcohol consumption for males and females. We plot the original consumption distribution before any adjustments, as well as the frequency-adjusted and gamma-adjusted distributions. It is clear that for both men and women, the gamma-adjusted consumption figures have shifted consumption considerably to the right, and have also led to a flattening of the peak in consumption at the far left of the distribution.

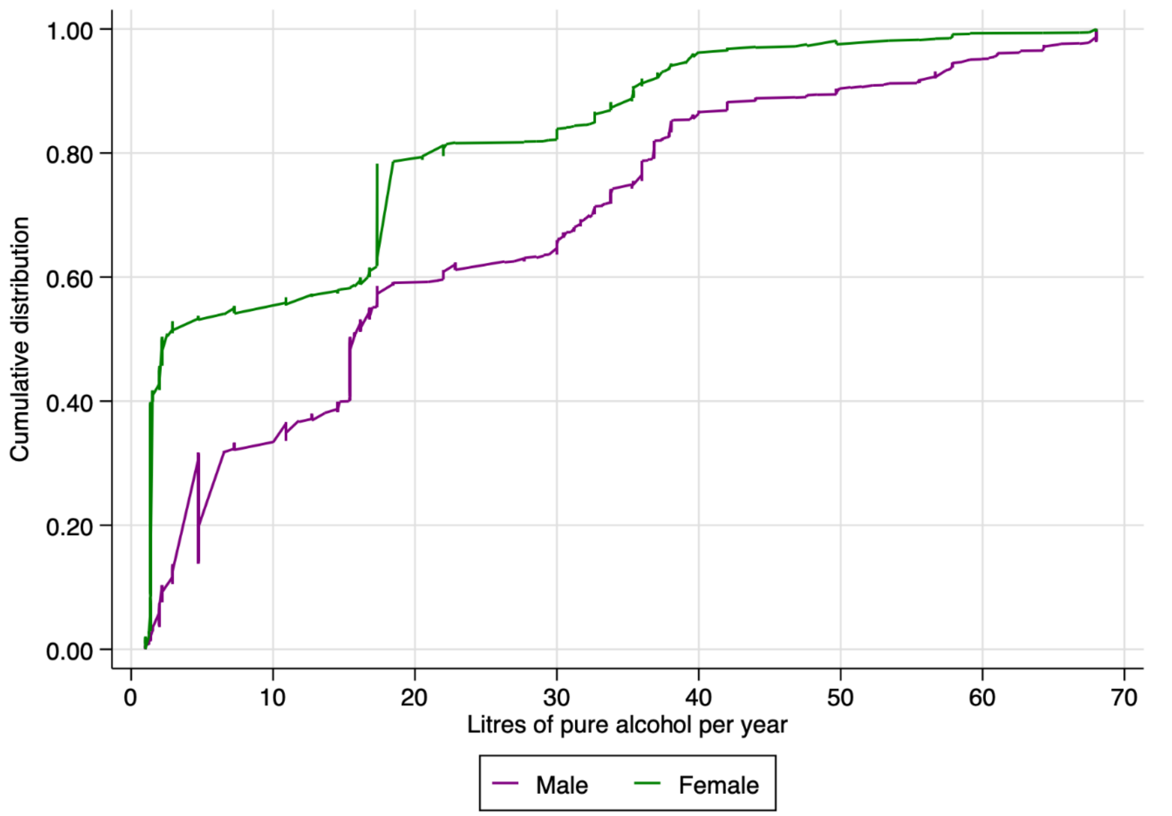
FIGURE 9. SADHS ALCOHOL CONSUMPTION DENSITY PLOTS, BY SEX, FREQUENCY ADJUSTED AND GAMMA-SHIFTED



Source: Own calculations from National Department of Health et al. (2019) [15]

Figure 10 shows that the general pattern of males being heavier drinkers than females has remained unchanged after the gamma shift adjustment. However, consumption of alcohol has increased. Before, almost no females were consuming in excess of 22 litres of alcohol per year, now, just under 20 per cent of females are consuming more than 22 litres of alcohol per year. Similarly, the upper limit of male alcohol consumption has shifted up. In Figure 8, we observed that almost no males drank more than 50 litres of alcohol per year whereas in Figure 10, we see that approximately 10 per cent of males drink above 50 litres per year.

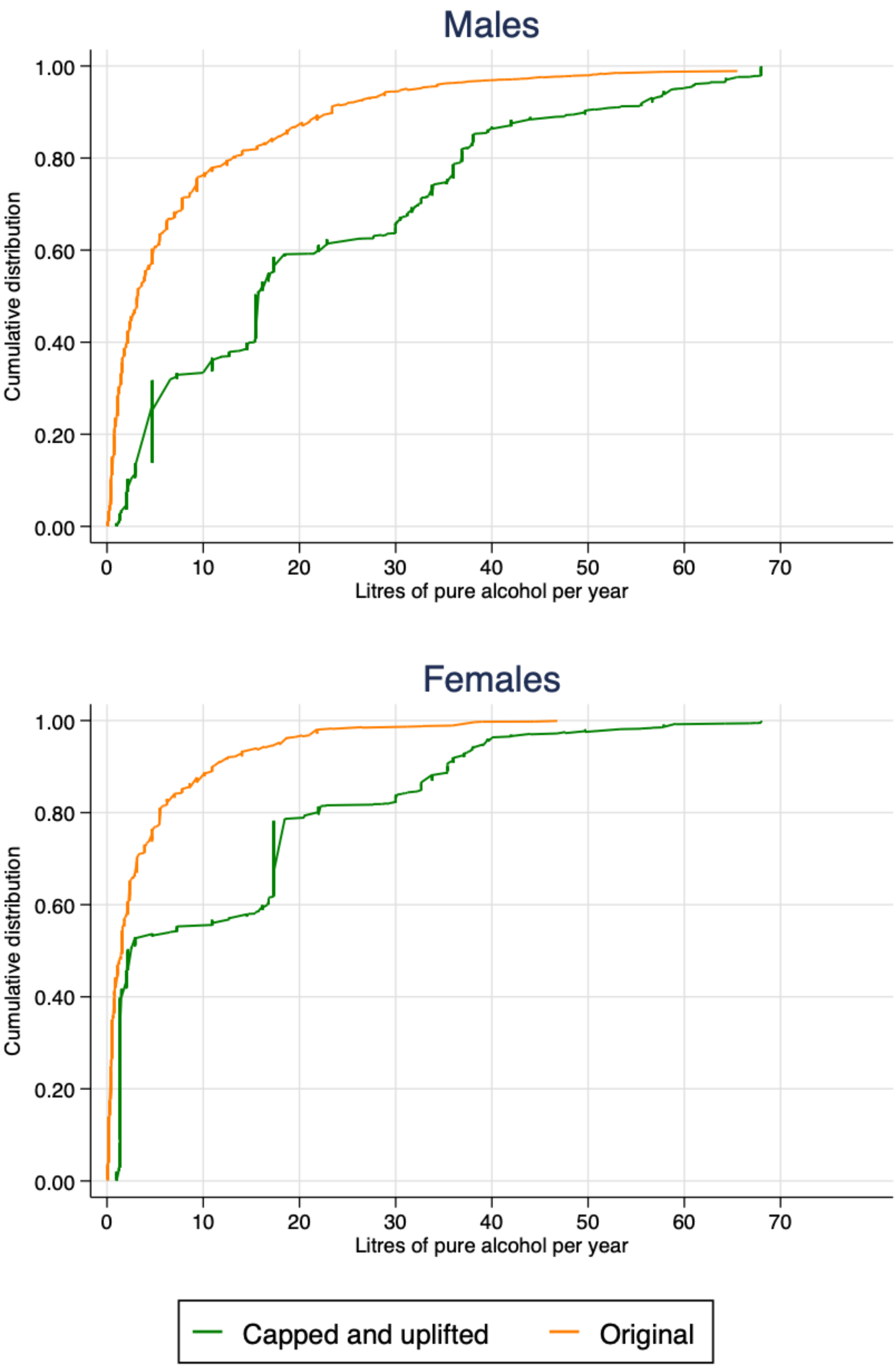
FIGURE 10. CUMULATIVE DISTRIBUTION OF CAPPED AND GAMMA-SHIFTED ANNUAL ALCOHOL CONSUMPTION, BY SEX



Source: Own calculations from National Department of Health et al. (2019) [15].
Notes: Cumulative density functions weighted according to recalibrated population weights.

To illustrate the overall impact of the adjustment of the consumption figures, we plot the cumulative density functions of the original, unadjusted litres of alcohol consumed against the capped and uplifted figures. This comparison, by sex, is presented in
Figure 11. The first point to note is that the adjustment process, unsurprisingly, has increased consumption substantially for both males and females from the original unadjusted figures. Furthermore, the adjustment process seems to have inflated male alcohol consumption rather more than female consumption. The vertical spike in the male cumulative density function for capped and uplifted consumption in the top panel of
Figure 11 also suggests that the cap of 68 litres of alcohol per annum particularly impacted the data for male consumption rather than female consumption.

FIGURE 11. CUMULATIVE DENSITY COMPARISON OF ORIGINAL AND 'CAPPED AND UPLIFTED' ALCOHOL CONSUMPTION, BY SEX



Source: Own calculations from National Department of Health *et al.* (2019) [15].
Notes: Cumulative density functions weighted according to recalibrated population weights.

3.2.4 Adjusting peak consumption

In the previous subsection, the discussion focussed mainly on adjusting average consumption. However, for the purposes of our model, we also require information on peak consumption patterns. This subsection details how we adjust peak consumption estimates to ensure that these figures account for the issues mentioned above, such as underreporting.

Due to the nature of peak consumption being a maximum consumption, the underlying distribution of the data is unlikely to be the same as that of mean consumption. Indeed, Gibbs *et al.* (2021) follow a very different approach to adjust peak consumption than that which they use to adjust mean consumption [30].

Firstly, we define peak consumption. In the SADHS, the recall-based questions asked individuals how many standard drinks they had consumed on each of the past 7 days. As a result, we were able to make use of this to determine, over the past week, what the maximum number of drinks a person consumed in one day was. This maximum consumption figure is then specified as peak consumption.

This peak consumption figure is adjusted upwards using a regression-based technique, which is based on the method put forward by the Sheffield Alcohol Policy Model described by Brennan *et al.* (2015)[42]. In short, this model requires the fitting of two linear regression models, both of the same functional form, but to slightly different data. The functional form of the regression relates peak consumption to mean consumption, age group, and sex:

$$peak\ drinks_i(SADHS) = \beta_0 + \beta_1 consumption_i + \beta_2 age\ group_i + \beta_3 sex_i + \varepsilon_i$$

In this model, $consumption_i$ is the unshifted measure of alcohol consumption from the SADHS, $age\ group_i$ is a categorical variable describing the individual's age group (in 5-year bands), and sex_i is the sex of the individual. As Gibbs *et al.* (2021) note, this relationship between peak and mean consumption is linear, but is allowed to vary by age group and sex.

This model is run twice: once for the sample of all individuals (including those with zero consumption and zero peak drinks), and once for the sample of drinkers (those with non-zero consumption and peak drinks). The fitted values from these regressions are predicted and all those who originally were abstainers had their fitted values coded to remain abstainers. Then, the adjusted peak drinks were calculated as follows:

$$peak_i(shifted) = peak_i(SADHS) \times \left(\frac{E\left(peak_{i,drinkers}\right)}{E\left(peak_{i,all}\right)}\right)$$

This adjustment is only appropriate insofar as individuals underreport their mean and peak consumption in a consistent way – i.e., the magnitude by which mean and peak consumption are underreported is the same. It is unclear whether this is likely to be the case, however, we make this assumption to adjust peak consumption figures.

Finally, we also ensure that peak consumption figures are never below mean consumption (as it would not make sense for an individual to be consuming more on average per day than their maximum daily alcohol consumption). As a result, we overwrite all those with peak consumption below their average consumption and assign them their mean daily consumption as peak consumption instead. This affects a total of 229 individuals in our sample of 3 311 (6.9 per cent).

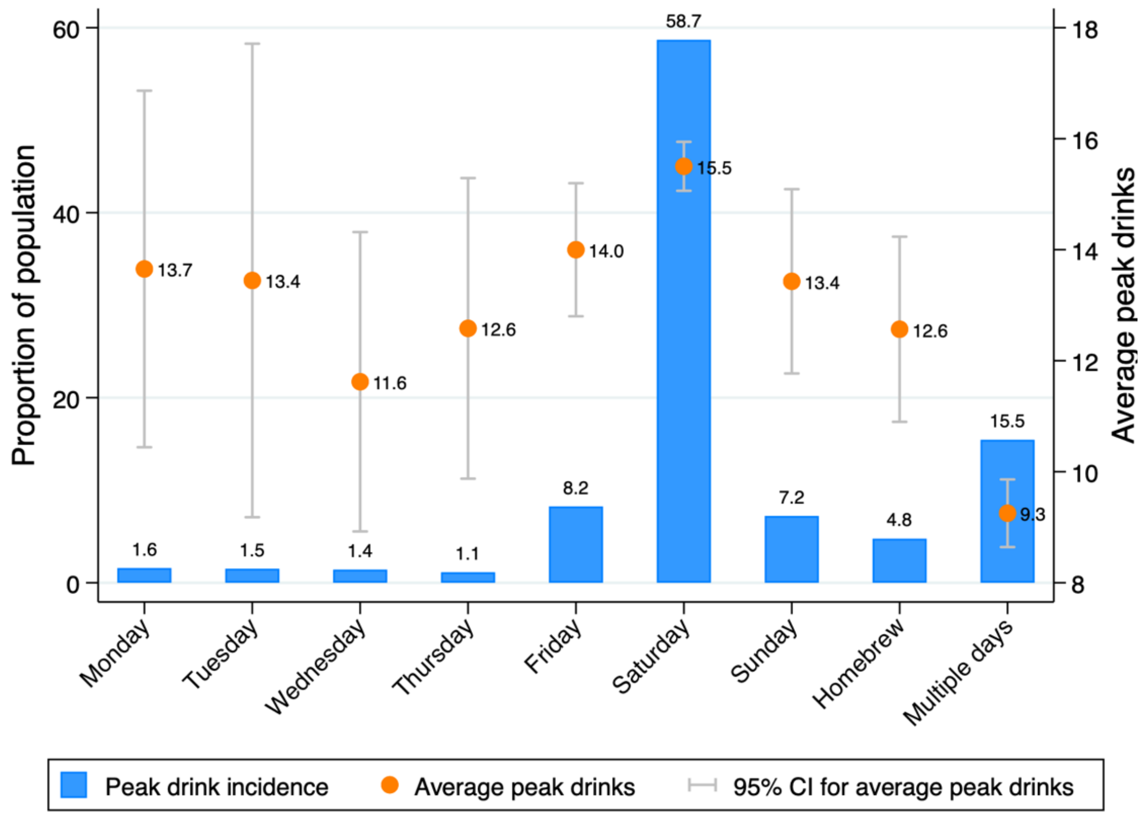
Given that peak consumption is derived from a variable that asks individuals to specify their consumption on each day of the week, we can analyse patterns in peak consumption over the week. We derive a variable that indicates the day of the week that corresponds to peak alcohol consumption for each individual, however, in so doing, we make a few assumptions. Firstly, we assume that for those individuals for whom we had to impute alcohol consumption due to there being no 7-day drinking pattern, that their peak consumption day can be modelled by the modal peak consumption day for their relevant sex, drinking frequency, and binge-drinking group. In other words, if a female who drinks 5 or more times per week, but is not a binge-drinker, does not have a 7-day drinking pattern, then we consider when the group of female non-binge-drinkers who drink 5 or more times per week most commonly exhibit peak alcohol consumption. Assume that the group with 7-day drinking patterns drink their peak consumption on a Friday. In this case, we would assign Friday as the peak consumption day to the aforementioned female without a 7-day drinking pattern.

Secondly, there are some individuals whose peak consumption is actually captured by homebrew alcohol consumption. Homebrew consumption is not separated by day of the week, and so as a result, we separate these individuals into a group called ‘Homebrew’, indicating that their peak consumption pattern is due to homebrew consumption.

Thirdly, some individuals report their peak consumption figure across multiple days of the week. For example, someone may have a peak consumption of 3 drinks per day, but they drank 3 drinks per day on both Friday and Saturday in the reference week. Rather than trying to assign these individuals to a specific day, we opt to categorise them as having ‘Multiple day’ peak consumption.

After making these adjustments, we can calculate the average peak number of drinks for groups of individuals according to the day on which they consume the most alcohol. The results of this are plotted in Figure 12. The most striking result from this figure is that more than half of individuals report their peak consumption of alcohol on Saturday, and nearly three quarters (74.1%) report peak consumption between Friday and Sunday each week. Coupling this with the average number of drinks consumed, it is clear that consumption increases on Saturdays to an average maximum consumption of 15.5 drinks per day, with average consumption on Fridays and Sundays only slightly lower at 14.0 and 13.4 drinks per day, respectively. Furthermore, although those individuals who report peak consumption across multiple days make up the second-largest proportion of the population, their average maximum consumption is substantially lower than any other category of individuals – at only 9.3 drinks per day. This is consistent with the notion that individuals who were flagged as having multiple peak consumption days during the week are more likely to be more moderate drinkers.

FIGURE 12. PEAK ALCOHOL CONSUMPTION PATTERNS BY DAY OF THE WEEK



Source: Own calculations from National Department of Health *et al.* (2019) [15] and StatsSA (2018) [28].
Notes: Average peak drinks shows the average maximum daily number of drinks reported by individuals after the regression-based adjustment described above.

3.2.5 From national data to Western Cape data

One of the advantages of using the SADHS for alcohol consumption data is that the questions on alcohol consumption provide fairly detailed information on the consumption patterns of South Africans. However, since the data are calibrated to the national level, and our research here is specifically focussed on the Western Cape, we need to find a way to make the SADHS usable for a Western Cape-specific model. Given the fairly small sample size of the SADHS (only 754 individuals report living in the Western Cape), it is impossible to simply restrict the sample to those who reside in the Western Cape.

In order to overcome this challenge, we make use of a reweighting procedure that allows us to recalibrate the SADHS national population estimates to be representative of the Western Cape. Following the method proposed by Van Walbeek and Gibbs (2021), we opt to use the National Income Dynamics Study (NIDS) as a baseline against which to calibrate the SADHS estimates [31]. The NIDS panel began as a nationally representative panel study in 2008 that has been used in a wide body of research to examine a range of socio-economic issues [43]. The fourth wave of the NIDS, which will be used here, was run in 2014–2015, and included a total of 4 543 individuals living in 1 115 households in the Western Cape. While the NIDS is not designed to be provincially representative, it is the best source of data available for us to obtain a demographic breakdown of the Western Cape that includes drinking prevalence patterns. As a result, we make use of the NIDS and assume the results to be representative of the Western Cape, even though this is not specifically part of the survey design.

Data on alcohol consumption in the NIDS is captured by two questions in the adult questionnaire. Specifically, these questions are ‘How often do you drink alcohol?’ and ‘On a day that you have an alcoholic drink, how many standard drinks do you usually have?’. The first question has options ‘I have never drunk alcohol’, ‘I no longer drink alcohol’, ‘I drink very rarely’, ‘less than once a week’, ‘on 1 or 2 days a week’, ‘on 3 or 4 days a week’, ‘on 5 or 6 days a week’, and ‘every day’. The second question has options ‘13 or more’, ‘9 to 12’, ‘7 to 8’, ‘5 to 6’, ‘3 or 4’, and ‘1 or 2’ standard drinks.[5]

As a comparison point to the SADHS data, we translate responses to these questions into annual number of drinks consumed. Since individuals tend to under-report their consumption, we choose the maximum number of drinks from each category in the questions – e.g., if an individual reported drinking ‘1 or 2 standard drinks’, we assume they drink 2 standard drinks on a given day; if they report drinking ‘on 3 or 4 days per week’, we assume they drink on 4 days per week. This is consistent with the approach taken by Van Walbeek and Gibbs (2021) [31].

We then scaled this number of drinks by the frequency with which an individual drinks. For those individuals who report drinking every week – i.e., ‘on 1 or 2 days per week’, ‘on 3 or 4 days per week’, ‘on 5 or 6 days per week’, or ‘every day’ – we multiplied their number of drinks per day by the number of days per week they drink, and then multiplied this figure by 52 to get an annual number of drinks. So, as an example, if an individual drank 1 or 2 drinks 3 to 4 times per week, they would be assigned a total of 2 drinks per day $\times$ 4 days per week $\times$ 52 weeks per year $=$ 416 drinks per year.

For those individuals who drink less than once a week, we assumed that they drank every two weeks, and thus, instead of multiplying their consumption pattern by 52 to get annual consumption, we multiplied it by 26. Those individuals who drink very rarely were assumed to drink once a month, and so their consumption figure was multiplied by 12 to get an annual number of drinks.

By making use of the NIDS data, we are further able to calculate certain key demographic characteristics of the population and recalibrate the SADHS to match these characteristics. In so doing, we can ‘reweight’ the SADHS as a whole to be representative of the Western Cape, and thus use the full SADHS as the basis of the epidemiological model for the Western Cape. Van Walbeek and Gibbs (2021) [31] do exactly this, calibrating the SADHS to the NIDS according to sex, race, and drinking prevalence. A summary of the results under the various weighting procedures is presented in Table 8.

Table 8 is divided into two panels. The first panel presents estimates from the NIDS, while in the second panel presents estimates from the SADHS. The first column in the NIDS panel presents estimates of certain summary statistics for the country as a whole using the post-stratification survey weights that are released with the NIDS. The second column presents

[5] A standard drink in the NIDS is defined as a small glass of wine, a 330ml can of regular beer, a tot of spirits, or a mixed drink.

these same descriptive statistics from the NIDS, but only for the Western Cape. Moving across to the SADHS panel, the first column presents comparable descriptive statistics where possible at the national level. The statistics are weighted using the original, unraked survey weights provided in the SADHS data. The second column in the SADHS panel presents the raked/adjusted estimates where the SADHS weights have been recalibrated according to sex, race, and drinking behaviour found in the NIDS Wave 4 data. A summary of the figures used for the raking calibration of the SADHS weights is presented in Table 9.

TABLE 8. SUMMARY DATA FOR REWEIGHTING OF SADHS TO NIDS WAVE 4 PROPORTIONS

		National Income Dynamics Study (NIDS)		**South African Demographic and Health Survey (SADHS)**	
		National proportions (weighted)	Western Cape proportions (weighted)	National proportions (original weights)	New proportions following reweighting (representative of Western Cape)
Sex	Female	0.47	0.46	0.59	0.46
	(Count)	13284	1475	6126	6126
	Male	0.53	0.54	0.41	0.54
	(Count)	9456	1147	4210	4210
Province	Western Cape	0.12		0.11	
	Eastern Cape	0.12		0.12	
	Northern Cape	0.02		0.02	
	Free State	0.05		0.05	
	KwaZulu-Natal	0.19		0.18	
	North West	0.07		0.07	
	Gauteng	0.25		0.27	
	Mpumalanga	0.08		0.08	
	Limpopo	0.10		0.10	
Geographical Setting	*NIDS*				
	Traditional	0.32			
	Urban	0.63	0.94		
	Farms	0.05	0.06		
	SADHS				
	Urban			0.66	0.85
	Rural			0.34	0.15
Population Group	Black African	0.79	0.30	0.84	0.30
	Coloured	0.09	0.46	0.08	0.46
	Indian/Asian	0.03	0.01	0.02	0.01
	White	0.09	0.23	0.06	0.23
	Other			0.00	0.00
Drinker	Yes	0.33	0.45	0.33	0.45
	No	0.67	0.55	0.67	0.55
Drinker (men only)	Yes	0.48	0.54	0.54	0.57
	No	0.52	0.46	0.46	0.43
Drinker (women only)	Yes	0.20	0.37	0.18	0.31
	No	0.80	0.63	0.82	0.69
Wealth groups	Q1			0.19	0.08
	Q2			0.19	0.08
	Q3			0.21	0.15
	Q4			0.20	0.26
	Q5			0.21	0.43
Monthly household income [R]	Mean	10 078	12 109		
	Standard Deviation	988	1 522		
	Median	4 700	7 000		
Standard Drinks per year	Min	24	24	67	67
	Max	5 475	5 475	4533	4533
	Mean	370.4	347.6	1245.6	1344.4
	Standard Deviation	19.5	53.3	37.6	54.0
	Median	96	96	1029	1029
Age	Mean	37.1	39.9	38.9	42.9
	Median	34.0	37.0	35.0	35.0

Source: Own calculations from Southern Africa Labour and Development Research Unit (2018) and National Department of Health *et al.* (2019) [15].

Table 9 presents the totals that are used to recalibrate the SADHS weights so as to ensure that the SADHS data are representative of the Western Cape rather than of South Africa. This is necessary given that the Western Cape is substantially different from the broader country in a number of observable ways: for example, compared to South Africa as a whole, the Western Cape has substantially more urban dwellers, the average household is wealthier, and there are substantially more White and Coloured individuals and much fewer Black African individuals.

The proportions in the first column of Table 9 are pulled from the second column of the NIDS panel in Table 8. These proportions provide the expected division of the population according to sex, race, and drinking behaviour that we want to apply to the SADHS data. In order to calculate the totals for the population, Statistics South Africa's mid-year provincial population estimates for 2018 are used. Since the SADHS only focusses on individuals aged 15+, the Western Cape population aged 15+ is used to scale all the proportions found from the NIDS.

TABLE 9. POPULATION TOTALS FOR WEIGHT RAKING CALIBRATION: CALIBRATING SADHS TO NIDS WAVE 4

	Proportion (NIDS W4)	Population
Western Cape Population (total)		6,721,215
Western Cape Population (15+)		5,038,359
Sex division		
Male	0.54	2,722,803
Female	0.46	2,315,557
Race division		
Black African	0.30	1,526,899
Coloured	0.46	2,309,687
Indian/Asian	0.01	36,512
White	0.23	1,165,262
Other	0.00	-
Drinking prevalence		
Non-drinker	0.55	2,782,795
Drinker	0.45	2,255,564

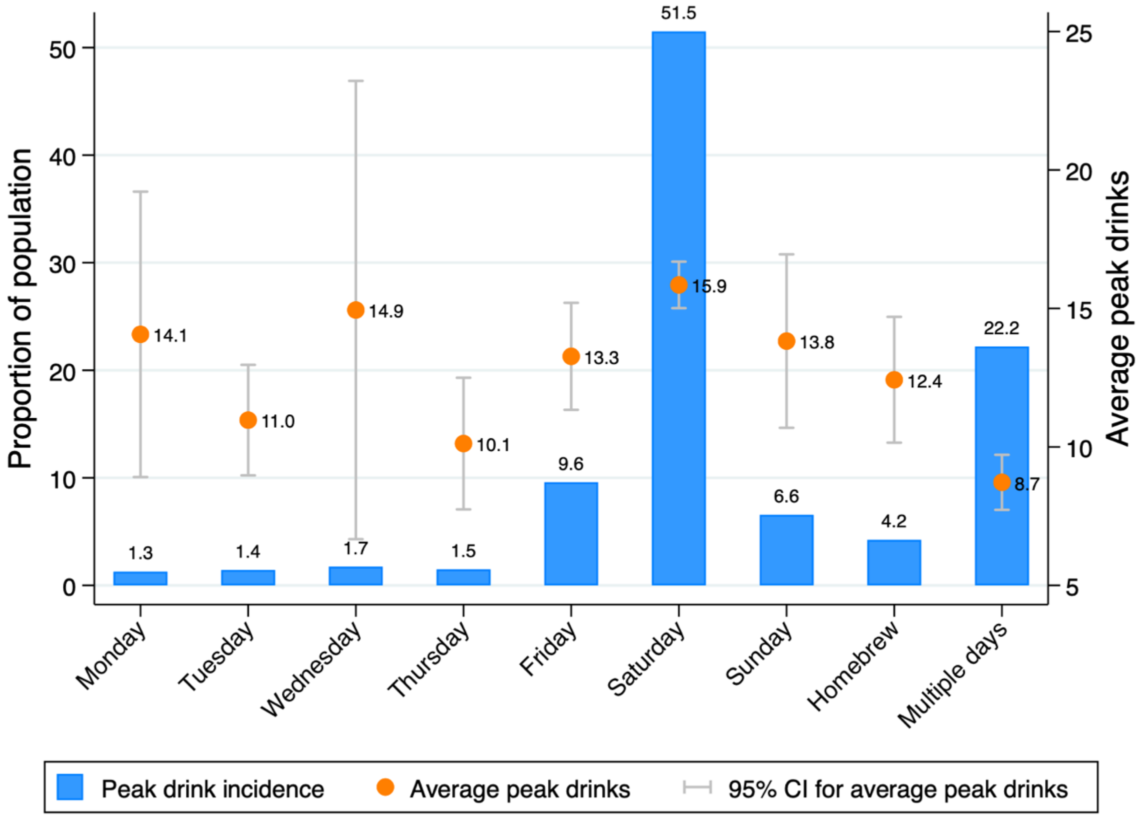
Source: Own calculations from Southern Africa Labour and Development Research Unit (2018) [43] and StatsSA (2018) [28]

Overall, the raking adjustment of the SADHS performs fairly well, with the adjusted SADHS estimates in the final column of Table 9 being generally very similar to the estimates in the second column of the NIDS panel (i.e., the two shaded columns in Table 8).

Since the aim of this project is to investigate the impact of changes in alcohol trading times in the Western Cape, it is helpful to understand if drinking patterns in the Western Cape are similar to those at the national level. To this extent, we plot the peak drink consumption pattern across the days of the week for the Western Cape-adjusted data in Figure 13 below. This figure presents a very similar picture to the national one: alcohol consumption peaks on

Saturdays, however now only two thirds (67.7 per cent) of individuals indicate peak consumption between Friday and Sunday. We have a much larger proportion of individuals reporting multiple peak days, and again, the average peak consumption for these individuals is substantially lower than weekend peak consumption figures. An interesting finding from the Western Cape data is that peak consumption during the week seems slightly higher than it is for the national data, however, the small sample size suggests a large margin of error for these estimates, meaning that there is a large degree of uncertainty surrounding the weekday consumption figures.

FIGURE 13. PEAK ALCOHOL CONSUMPTION PATTERNS BY DAY OF THE WEEK, WESTERN CAPE ONLY



Source: Own calculations from National Department of Health *et al.* (2019) [15] and StatsSA (2018) [28].
Notes: Average peak drinks shows the average maximum daily number of drinks reported by individuals after the regression-based adjustment described above. Estimates calibrated according to the raking procedure to make the data representative of the Western Cape.

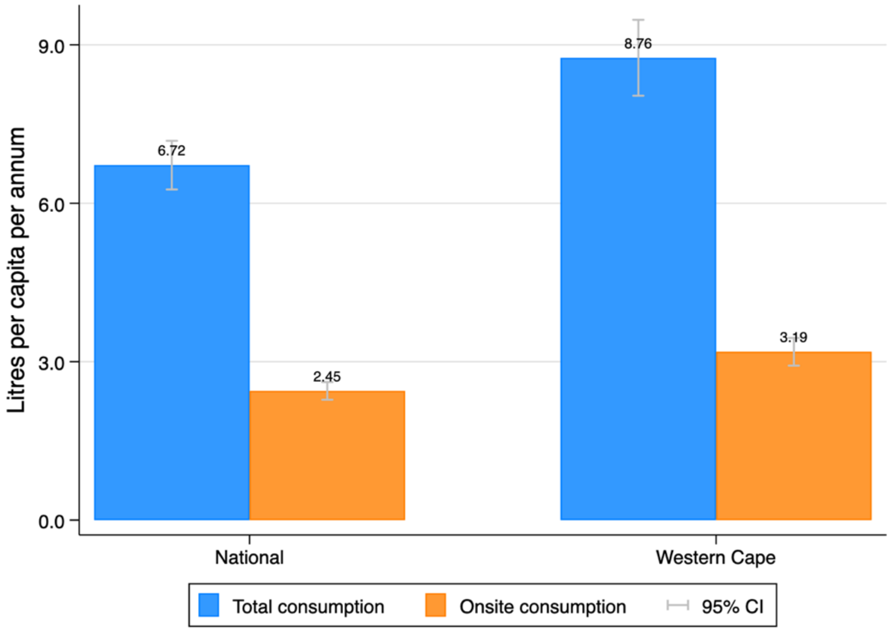
3.2.6 Onsite vs offsite consumption adjustment

This project aims to investigate the impact of policies that restrict onsite alcohol trading, and as a result, our estimates of alcohol consumption need to take into account the volume of alcohol consumed at onsite liquor-serving establishments only. Using data from Euromonitor International (2022), we note that 36.4 per cent of alcohol was captured as 'On-Trade Volume' in 2018 [39]. As a result, we assume that only 36.4 per cent of alcohol consumption actually takes place onsite. It should be noted that the proportion of onsite alcohol consumption reported by Euromonitor (2022) is basically identical to the proportion of onsite trade recorded in the International Alcohol Control Study (2014), which sampled 982 adults aged 18-65 years in the City of Tshwane [44]. As was indicated in the data summary provided in Table 1, we use the IAC data to obtain estimates of individual alcohol expenditure in the baseline.

To adjust annual litres of alcohol consumed to only reflect onsite consumption, we multiply our calculated litres of alcohol variable by 0.364. This assumes that every individual consumed 36.4% of their alcohol onsite, and the remaining 63.6 per cenent of alcohol is consumed elsewhere. We further note that homebrew alcohol is not likely to be consumed at a liquor-serving establishment, and, as a result, we further scale individual consumption down according to the proportion of alcohol consumed that is homebrew. For example, if an individual consuming 50 litres of alcohol per year indicated that 10 per cent of their consumption was homebrew, then they would have a new onsite consumption figure of 50 litres per year × 36.4% onsite consumption × 90% standard non-homebrew drinks = 16.34 litres of onsite alcohol consumption per year.

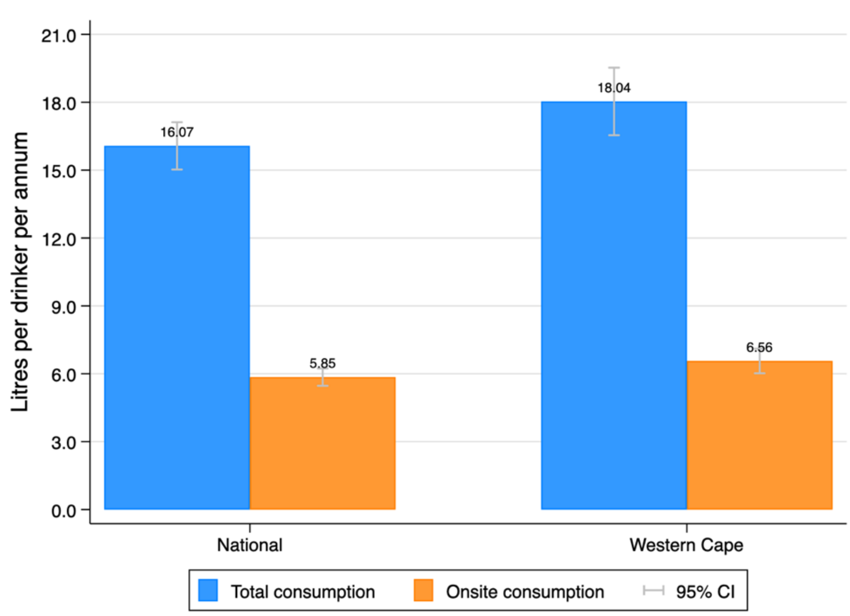
Figure 14 presents estimates of both total and onsite consumption at the national level, as well as after using the raking adjustment to make the SADHS representative of the Western Cape only. As would be expected, onsite consumption is substantially lower than total alcohol consumption in South Africa, and Western Cape estimates are slightly higher (and statistically insignificantly different from) the national estimates of alcohol consumption.

FIGURE 14. AVERAGE TOTAL AND ONSITE ALCOHOL CONSUMPTION PER CAPITA, NATIONAL VS WESTERN CAPE



Source: Own calculations from National Department of Health *et al.* (2019) [15] and Euromonitor International (2022) [39]

FIGURE 15. AVERAGE TOTAL AND ONSITE ALCOHOL CONSUMPTION PER DRINKER, NATIONAL VS WESTERN CAPE



Source: Own calculations from National Department of Health *et al.* (2019) [15] and Euromonitor International (2022) [39]

Following this adjustment process, which was based on the procedure followed by Gibbs *et al*. (2021) [30], and by making use of the raking recalibration to make the SADHS data representative of the Western Cape, following the method employed by Van Walbeek and Gibbs (2021) [31], we have produced a dataset that can form the basis of an epidemiological model for alcohol consumption in the Western Cape.

3.2.7 Classifying drinkers into categories

Consistent with the approach taken by Gibbs *et al.* (2021) [30], we subdivide the drinking population according to the frequency and volume of alcohol consumption. The definitions used by Gibbs *et al.* (2021), and those adopted in this report are as follows:

- **Heavy drinkers** are those individuals who drink more than 15 drinks per week.
- **Occasional binge-drinkers** are those individuals who drink fewer than 15 drinks per week, but who also report binge drinking.
- **Moderate drinkers** are those individuals who drink fewer than 15 drinks per week and do not binge drink.

As a logical consequence of the adjustments performed to calibrate and increase alcohol consumption figures in the SADHS, the final distribution of drinker classifications will depend on when the classification takes place. In Table 10 we present the distribution of drinkers according to this definition, but show how the outcome varies depending on the stage at which the classification was applied. In the first case, we show the distribution of drinkers after only the frequency adjustment was made to account for those individuals with no 7-day drinking pattern. In other words, the first distribution (pre-adjustment) refers to a distribution of drinkers before alcohol consumption was inflated using coverage or gamma-adjustments. The second case (post-adjustment) shows the distribution of drinkers if they were classified according to their post-gamma adjustment consumption.

TABLE 10. DISTRIBUTION OF DRINKER TYPES DEPENDING ON CLASSIFICATION TIME, BY SEX

	Male		Female		Total	
	Pre-adjustment	Post-adjustment	Pre-adjustment	Post-adjustment	Pre-adjustment	Post-adjustment
Abstainers	43.3%	43.3%	69.2%	69.2%	55.2%	55.2%
Moderate Drinker	38.5%	15.7%	25.5%	13.8%	32.5%	14.9%
Occasional binge-drinker	5.4%	1.8%	2.3%	1.2%	4.0%	1.5%
Heavy drinker	12.8%	39.2%	3.0%	15.8%	8.3%	28.4%

Source: Own calculations from National Department of Health et al. (2019) [15] and StatsSA (2018) [28]
Notes: All estimates calibrated to be representative of the Western Cape using raking adjustment.

As expected, the post-adjustment figures for all categories of individuals are more heavily-skewed towards heavy drinkers than the pre-adjustment figures. This pattern remains when the table is constructed for South Africa as a whole, and is consistent with the results presented by Gibbs *et al.* (2021) [30]. Given that consumption was capped at 68 litres of pure alcohol per year, this upward-shift of individuals' consumption implies that there will have been a shift of high-consumption moderate and occasional binge drinkers into the heavy drinker category. The final result is that all categories of drinkers are likely to be right-skewed – i.e., over-represent low-consumption drinkers in their categories. This has an impact for estimates of consumption across each category: specifically, it will tend to provide estimates that look somewhat lower than seems feasible (for example, occasional binge-drinkers average approximately 5.14 drinks per week, which is nonsensical given that a binge-drinker by definition has to have consumed at least 5 drinks in one sitting to be classified as such).

On the other hand, classifying individuals according to their pre-adjustment drinking category does not necessarily solve the problem. Although the figures here are higher and make mathematical sense (for example, occasional binge-drinkers now average approximately 22.9 drinks per week), these figures are inconsistent with the definitions used to classify drinkers, since occasional binge-drinkers, by definition, drink fewer than 15 drinks per week.

It is not immediately clear which of these is the correct approach to use, as both approaches have limitations. One option would be to adjust the definitions of our drinker classes, however, this then leads to a lack of comparability between this study and other existing studies [30, 31]. To this end, we opt to highlight the shortcomings of our classifications, and use the post-adjustment classification process for our future estimations.

3.3 Trading times elasticity

Our model hinges on the link between onsite trading times and alcohol consumption, which will henceforth be referred to as the 'trading times elasticity'. This trading times elasticity can be thought of as a measure of the responsiveness of per capita alcohol consumption to a percentage change in onsite trading times. It can be calculated as:

$$Trading\ times\ elasticity = \frac{\%\ change\ in\ alcohol\ consumption/sales\ at\ onsite\ locations}{\%\ change\ in\ trading\ hours\ at\ onsite\ locations}$$

At present, there are no studies that have estimated this elasticity in the South African context. Estimating a trading times elasticity for the Western Cape requires access to a panel dataset on alcohol consumption or alcohol sales at onsite locations in as many of the province's municipalities as possible (alcohol sales are a good proxy for alcohol consumption). With these data, we can use our knowledge of those municipalities in which onsite liquor trading times have changed historically to measure the change in alcohol consumption at onsite locations. In this exercise, those municipalities with no changes in onsite trading times would serve as control areas. Unfortunately, however, we do not have access to data on onsite (or overall) alcohol sales or consumption at the municipal level. This eliminates the possibility of estimating a trading times elasticity for the Western Cape.

In the absence of these data, we need to rely on the international literature that has examined the relationship between changes in alcohol trading times and alcohol consumption. As will be shown below, only one study [13] in this body of literature directly reports a trading times elasticity estimate. For all other studies, we need to calculate the elasticity implied by the data used in the analysis. In these studies, the percentage change in alcohol consumption due to trading time restrictions or extensions (the numerator of the elasticity formula) is reported and requires no adjustment; however, none of these studies report on the percentage change in trading hours that led to the observed change in alcohol consumption. We therefore use the data on trading times before and after the policy change reported on in each study to calculate the percentage change in trading times. As will be shown below, a consistent trend in the trading hours reported in these studies is that they rely on legislated as opposed to actual trading times.

While legally permissible trading hours institute a maximum number of hours during which liquor may be sold, the actual hours during which establishments selling alcohol may trade can be less than the maximum hours permitted by law. For any given percentage change in alcohol consumption, an estimate of the percentage change in trading hours that uses their maximum trading hours as stipulated in legislation will produce a higher elasticity estimate than would be the case if the actual trading hours were shorter than those allowed by the legislation. The drawback of this is that the elasticities derived from these international studies are likely to overstate the responsiveness of alcohol consumption to changes in trading times. Consider a hypothetical example. If the legal hours of sale decrease from 20 hours to 18 hours, this represents a 10 per cent decrease in legislated trading times. If the actual trading hours decrease from 15 hours to 13 hours, this represents a 13.3 per cent decrease. If consumption decreases by 8 per cent, the legal elasticity is 8/10= 0.8, while the actual trading time elasticity is 8/13.3 = 0.6. The legal times elasticity thus overstates the responsiveness of consumption relative to that which relies on the change in actual trading times. We return to this discussion on actual versus legislated trading times again at the end of this section when we discuss our use of the Phase 1 inputs to estimate the number of hours of alcohol sales lost at each of three simulated closing times.

Our initial literature search for international trading times elasticity estimates uncovered three systematic reviews [19-21] that have summarized the literature on the association between outlet trading times and alcohol-related harms. The 24 studies that appear in the most recent review [20], as presented in Matzopoulos *et al*. 2020 [45], are summarized in Table 11 below. Nineteen of these studies analyse the effects of trading time extensions, while five analyse the impact of trading time restrictions.

TABLE 11. EFFECTS OF CHANGES IN CHANGES IN OUTLET TRADING TIMES ON ALCOHOL-RELATED HARMS

Author, publication year, place of the study	Policy description; Direction of change in trading time (↑ inc / ↓ dec)		Outcome (source); harm direction (↑ inc / ↓ dec / - insignificant)	
Chikritzhs et al, 2002 Perth, Australia	Extended: trading permits (1 hr).	↑	Violent assaults (police records).	↑
Chikritzhs et al, 2006 Perth, Australia	Extended: trading permits (1 hr).	↑	Impaired driver road crashes (police records).	↑
Duailibi et al, 2007 Diadema,Brazil	Restricted: all bars have to close at 23:00 (before remained open until midnight).	↓	Violence against women (police records).	-
Duailibi et al, 2007 Diadema, Brazil	Restricted: all bars have to close at 23:00 (before remained open until midnight).	↓	Homicides (police records).	↓
Green et al, 2014 UK	Extended: trading permits (max 6 hrs).	↑	Traffic accidents (Department of the Environment, Transport and the Regions database)	↓ a
Gronqvist et al, 2011 Sweden	Extended: allowed alcohol outlets to open on Saturdays.	↑	Crime (Swedish conviction register kept by National Council for Crime Prevention (BRA)).	↑
Han et al, 2016 Pennsylvania, USA	Extended: lifted ban on Sunday package alcohol sales.	↑	Violent crime (police records).	-
Han et al, 2016 Pennsylvania, USA	Extended: lifted ban on Sunday package alcohol sales.	↑	Total crime and property crime (police records).	↑
Humphreys et al, 2013 Manchester, England	Extended: removed fixed closing times in favour of staggered closing times for alcohol outlets.	↑	Violent incidents (police records).	↑ b
Humphreys et al, 2014 Manchester, England	Extended: removed fixed closing times in favour of staggered closing times for alcohol outlets.	↑	Violent incidents (police records).	-
Kypri et al, 2010 Newcastle, Australia	Restricted: reduce pub closing times (1.5–2 hrs).	↓	Assaults (police records).	↓
Kypri et al, 2014 Newcastle, Australia	Restricted: reduce pub closing times (1.5 hrs).	↓	Assaults (police records).	↓
Maloney et al, 2009 New Mexico, USA	Extended: lifted ban on Sunday package alcohol sales.	↑	Motor vehicle accidents and fatalities (accident-level analysis files maintained by the University of New Mexico Division of Government Research).	-
McMillan et al, 2006 New Mexico, USA	Extended: lifted ban on Sunday package alcohol sales.	↑	Motor vehicle accidents and fatalities (accident-level analysis files maintained by the University of New Mexico Division of Government Research).	↑
McMillan et al, 2007 New Mexico, USA	Extended: lifted ban on Sunday package alcohol sales.	↑	Motor vehicle accidents and fatalities (accident-level analysis files maintained by the University of New Mexico Division of Government Research).	-

Author, publication year, place of the study	Policy description; Direction of change in trading time (↑ inc / ↓ dec)	Outcome (source); harm direction (↑ inc / ↓ dec / - insignificant)
Newton et al, 2007 London, UK	Extended: removed fixed closing times in favour of staggered closing times for alcohol outlets. ↑	Alcohol-related assault attendances to the emergency department (ED) (hospital and patient records). ↑
Norstrom et al, 2005 Sweden	Extended: Saturday opening of alcohol retail shops. ↑	Assault (Swedish National Council for Crime Prevention database). =
Rossow et al, 2011 Norway	Extended: Flexible, extended or restricted closing hrs (<2 hrs). ↑	Violence (police records). ↑
Sanchez et al, 2011 Cali, Colombia	Restricted sales and consumption of alcohol (6–8 hrs). ↓	Homicides (The Cali Crime Observatory's fatal injury surveillance system). ↓
Stehr et al, 2010 USA	Extended: lifted ban on Sunday package alcohol sales. ↑	Crash fatalities (The Fatality Analysis Reporting System (FARS) database) ↑c
Vingilis et al, 2005 Ontario, Canada; New York and Michigan, USA	Extended the hrs of alcohol sales (1 hr). ↑	Motor vehicle fatalities (The Traffic Injury Research Foundation (TIRF) and the US Fatal Analysis FARS databases). =
Vingilis et al, 2006 Windsor, Ontario, Canada; Detroit, Michigan, USA	Extended the hrs of alcohol sales (1 hr). ↑	Alcohol-related motor vehicle casualties (Ministry of Transportation of Ontario (MTO) databases and the FARS). ↑ d
Vingilis et al, 2007 Ontario, Canada	Extended the hrs of alcohol sales (1 hr). ↑	Motor vehicle crash injury (The Ontario Trauma Registry). -
Vingilis et al, 2008 London and Windsor, Ontario	Extended: alcohol sales (1 hr). ↑	Assault charges (police records). -

a – The authors provide this explanation: "These controversial results were explained by the fact that fixed closing times can lead people, especially younger drivers (18–25 years), drinking to beat the clock to a massive mobilisation at closing time. In contrast, flexible closing time allows customers to remain in the bar and spread out their drinking leading to a larger apparent decline in traffic accidents."; b - Night only. Overall unchanged; c – New Mexico only; d - Increase in intervention area (Windsor) and decrease in neighbouring control area (Detroit).

Source: Adapted from Sanchez-Ramirez & Voaklander (2017) [20] by Matzopoulos *et al*. 2020 [45], which is the source from which we have taken this table.

The studies listed above show that the effects of changes in alcohol trading times are either in the expected direction, or the effect is not significant. Specifically, they show that extended trading hours are associated with increases in alcohol-related harms, while decreases in trading hours are linked to decreases in alcohol-related harms. Barring six studies [14, 46-50], the studies summarized in Table 11 do not include measures of alcohol consumption in their analyses. Instead, the studies directly estimate the relationship between changes in trading hours and alcohol-related harms. This limits their relevance for the present study since our modelling framework relies on the link between changes in trading times and changes in alcohol consumption to estimate the impact of changes in trading times on alcohol-related harms.

The six studies listed in Table 11 that consider alcohol consumption do so in different ways, some of which are not useful for the purposes of this study. For example, the research by Chikritzhs and Stockwell (2002) sought to examine the impact of later trading hours for licensed pubs in Perth (Australia) on levels of violent assault on or near these premises for the period 1991–1997 [46]. In Western Australia, where Perth is located, the Liquor Licensing

Act of 1988 stipulates closing times for licensed premises, but allows pubs to make applications to trade for an additional hour beyond the permissible midnight closing time [51].

The model estimated by Chikritzhs and Stockwell (2002) has assaults occurring at or near bars that had applied for an extended trading permit as the dependent variable. To ascertain whether changes in alcohol consumption had a mediating effect on the relationship between extended trading hours and assaults near these venues, the authors included average wholesale alcohol purchases of high- and low-alcohol content beverages as independent variables in their regressions [46]. With the inclusion of these sales data, the authors find that the increased levels of violence associated with later bar trading in Perth were, in large part, due to higher levels of wholesale purchases of high-strength alcohol made by these bars [46]. However, they do not report on the changes to wholesale alcohol sales data that occurred as a result of the extended trading hours (i.e., wholesale alcohol sales data are never used as a dependent variable in their models). We therefore cannot use the results of this study to arrive at a trading times elasticity.

A later study by Chikritzhs and Stockwell (2006) sought to analyse the impact of later trading hours for pubs in Perth on levels of impaired driver road crashes and driver breath alcohol levels between 1990 and 1997 [47]. The authors' include wholesale alcohol purchases by pubs as a control in their regressions. As in their earlier study [46], this is done to ascertain whether changes in alcohol consumption, measured by wholesale alcohol sales, had a mediating effect on the relationship between extended trading hours and their outcome measures of interest [47]. Results show that the association between crashes and both high- and low-alcohol content beverage purchases at the wholesale level was positive and significant ($p<.01$), but this was not the case for blood alcohol levels, for which the authors report a statistically insignificant result [47]. Again, because alcohol sales data are not treated as the dependent variable in this study (i.e., changes in alcohol sales are not linked to changes in trading times), we cannot derive an elasticity estimate from this study.

More useful for our purposes are the four studies listed in Table 11 that estimate alcohol consumption as 'intermediate outcomes' in their analyses focusing on the impact of changes in trading times on alcohol-related harms [14, 48-50]. Three of these studies draw their samples from Sweden [14, 48, 49], while the fourth study was conducted in Ontario (Canada) [50]. We discuss the results of each of these studies below, beginning with the Canadian analysis by Vingilis *et al*. (2005) [50].

In May 1996, Ontario amended its Liquor Licence Act to extend the hours of alcohol sale and service in licensed establishments from 01:00 to 02:00. Vingilis *et al*. (2005) sought to analyse the road safety impact of these extended drinking hours in Ontario [50]. As an intermediate outcome, the authors also indicate that data on yearly alcohol sales to licensees, as well as sales to retail for domestic and imported wines, beers and spirits for the period 1 April 1989 to 31 March 1999, were used to assess the impact of the trading times extension on alcohol sales.

Unfortunately, however, the results of this analysis are described in a single paragraph that does not provide any sales figures. No tables or figures accompany this paragraph either. The authors only inform the reader that '…the volume of sales in thousands of litres for beer, wine and spirits and per capita 15 years and over for Ontario between 1989 and 1999 were subjected to time series analyses. The trends indicate that the consumption of beer has decreased between 1994 and 1998, while the consumption of wine and spirits decreased in the early 1990s and increased in the late 1990s'. Because the change in alcohol sales is not reported, this study cannot be used to yield any insight on trading time elasticities at the international level.

A Swedish study by Norström and Skog (2005) [48] is more useful for our purposes. This study serves as an extension of earlier work by the same authors, published in 2003 [49]. In 1955, the Swedish government established an alcohol monopoly, called the Systembolaget, which holds exclusive rights to the offsite retail sale of beverages with an alcohol content greater than a stipulated percentage [52].[6] By law, these alcohol retailers were not permitted to trade on Saturdays and Sundays. In February 2000, the government of Sweden began a trial of allowing alcohol retail shops to open on Saturdays in certain parts of Sweden, and in July 2001, Saturday opening was extended to the whole country [48].

Using monthly alcohol sales data provided by the Systembolaget for the period January 1995–July 2002, and controlling for cross-border shopping in Sweden by residents from Norway, Norström and Skog (2005) estimate how alcohol sales evolved in their experimental area compared to their control areas because of the policy using the auto-regressive integrated moving-average (ARIMA) time-series technique [48].

The authors found that alcohol sales increased by 3.5% relative to the pre-2000 period in which Saturday sales were not permitted [48]. This provides us with the numerator required in the trading times elasticity formula. However, the authors do not specify the total number of trading hours before and after the policy change, which we require to obtain the denominator of the elasticity formula. Additional desktop research indicates that the legally permissible trading hours of the Systembolaget are 10:00–18:00 on Monday to Wednesday and on Friday, 10:00–19:00 on Thursday and, following the policy change, 10:00–15:00 on Saturday [53]. On Sundays, Systembolaget stores are closed [53]. Using this information, we calculate the total number of legally permissible trading hours per week before the policy change and after the policy change in Table 12.

[6] The exact strength of alcohol appears to have changed over time. A 2010 study reports that the monopoly on off-premise retail sale of all alcoholic beverages held by the Systembolaget applied to beverages with more than 2.25% of alcoholic content. Another study, which discusses the history of the Systembolaget, stipulates that that percentage of alcohol content stood at 3.5% when the Systembolaget was established in 1955.

TABLE 12. PERCENTAGE CHANGE IN WEEKLY LEGAL PERMISSIBLE TRADING HOURS IN SWEDEN

Before the policy change			After the policy change	
Day	Hours during which alcohol be sold	Number of hours during which alcohol may be sold	Hours during which alcohol be sold	Number of hours during which alcohol may be sold
Monday	10:00–18:00	8	10:00–18:00	8
Tuesday	10:00–18:00	8	10:00–18:00	8
Wednesday	10:00–18:00	8	10:00–18:00	8
Thursday	10:00–19:00	9	10:00–19:00	9
Friday	10:00–18:00	8	10:00–18:00	8
Saturday	Not allowed	Not allowed	10:00-15:00	5
Sunday	Not allowed	Not allowed	Not allowed	Not allowed
Number of permissible trading hours per week		41.00		46.00
Percentage change in number of permissible trading hours		12.20%		
Percentage change in alcohol sales reported in the study		3.5%		
Trading times elasticity		0.29		

Results show that the total number of permissible trading hours in Sweden increased by five following the policy change that permitted alcohol retail outlets to sell liquor on a Saturday (Table 12). Given that 41 hours of offsite alcohol sale were permitted each week before the policy change, the percentage change in hours post-policy is 12.2% (=5/41). Combining this percentage change in permissible trading hours with the 3.5% reported increase in alcohol sales yields a trading times elasticity estimate of 0.29.

A later study by Gronqvist *et al*. (2014), the results of which we discuss shortly, also assesses the impact of the Saturday trading extension in Sweden. In this study, the authors note that the new law 'required all alcohol retail stores in selected areas to stay open on Saturdays' [14]. Given that a state monopoly on alcohol retail exists in Sweden, the statement by Gronqvist *et al*. (2014) [14] suggests that the nationally legislated trading times are probably the actual trading times people experience in Sweden, which is not the case in most other countries. This gives us more confidence in the accuracy of the elasticity estimate derived from the analysis conducted by Norström and Skog (2005) [48].

As mentioned, Gronqvist *et al*. (2014) also analyse the effects of legislated Saturday opening of the Systembolaget in Sweden [14]. One question posed by Gronqvist *et al*. (2014) is whether the new law truly increased alcohol consumption in the country. The authors critique the work of Norström and Skog (2005), arguing that their analysis fails to account for the fact that, during the 1990s and early 2000s, the illicit trade in alcohol in Sweden rose substantially, and the number of licensed bars and restaurants in the country also increased. Because the analysis of Norström and Skog (2005) does not account for these underlying trends, Gronqvist *et al*. (2014) postulate that their results may be subject to omitted variable bias [14].

The authors indicate that they adopt two approaches to address these concerns. First, they use survey data on self-reported alcohol consumption from the Swedish Living Conditions Survey, disaggregated by day of the week, to contrast alcohol consumption on Saturdays versus other days of the week before and after the policy change [14]. Questions about alcohol consumption were included in the 1996/1997 and 2004/2005 rounds of the survey. Second, they use the similar alcohol sales data as Norström and Skog (2005), but instead adopt a differences-in-differences approach to estimating the impact of the policy on these sales. The authors argue that this approach provides a more convincing way to control for the influence of unobserved factors [14].

The analysis based on self-reported consumption data conducted by Gronqvist *et al*. (2014) is purely descriptive [14]. The authors present their results of this analysis in a paragraph, with no corresponding figures or tables. Findings indicate that average consumption of alcohol on Saturdays, measured in terms of 100% alcohol per person aged 20 and older, rose from 26.1 millilitres (reported by the authors 2.61 centilitres) in 1996/1997 to 29.2 millilitres (reported by the authors 2.92 centilitres) in 2004/2005. They further report that weekday alcohol consumption remained more or less unchanged, rising slightly from 18.4 ml (reported as 1.84 centilitres) in the pre-policy period to 18.8 ml (reported as 1.88 centilitres) in the post-policy period. Taken together, these figures suggest that the policy led to a 10.3% increase in alcohol use on Saturdays.[7]

However, as noted by Gronqvist *et al*. (2014), because the surveys were conducted several years before and after the policy change, they only provide a crude estimate of the impact of the policy on alcohol consumption. We therefore do not use this reported increase in alcohol consumption on Saturdays to try and infer a trading times elasticity, and opt to instead use the results obtained by Gronqvist *et al*. (2014) in their difference-in-difference analysis of the policy's impact on total alcohol sales.

Like Norström and Skog (2005), Gronqvist *et al*. (2014) obtain monthly alcohol sales data from the Systembolaget, but include a shorter time period of these data in their analysis (January, 1998 and June, 2001) than Norström and Skog (2005), who analyse the period from January 1995 to July 2002.

Like Norström and Skog (2005), the authors exclude counties neighbouring Norway from their analysis to reduce any biases that may emanate from cross-border shopping. However, different to Norström and Skog (2005), the model estimated by Gronqvist *et al*. (2014) accounts for persistent unobserved regional characteristics that are potentially correlated with the introduction of the policy (this is done through their use of a panel regressions) and they

7 The authors calculate this as ([0.31 − 0.04]/2.61)%, where 0.31 is the change in average alcohol consumption on Saturdays before and after the policy; 0.04 is the difference (in centilitres) in weekday alcohol consumption on weekdays and 2.61 is average consumption of alcohol on Saturdays before the policy change.

include time-fixed effects in the regressions, which further removes countrywide trends in alcohol sales. Three different regression specifications report a coefficient on the policy's impact on (the log of alcohol sales). The coefficients reported are 0.040 (baseline), 0.045 (model including linear time trends), and 0.043 (model controlling for border counties). All these coefficients are significant at the five percent level.

Taking the model that includes border counties as the preferred model specification, the policy resulted in a 4.3% increase in alcohol sales at offsite retailers. Using the change in trading hours estimated in Table 12 the trading times elasticity implied by the study conducted by Gronqvist *et al*. (2014) is 0.35 [14], which is very close to the trading times elasticity of 0.29 which we derived from the work of Norström and Skog (2005) [48].

In addition to analysing each of the studies listed in Table 11 to ascertain whether the link between alcohol trading times and alcohol consumption was estimated as an intermediate outcome, we conducted an independent literature search for studies that directly estimate the link between alcohol trading times and alcohol consumption. The studies found through this process are summarized in Table 13.

As can be seen, this body of literature is less extensive than that examining the relationship between trading times and alcohol-related harms (as shown in Table 11). However, like the literature on the link between alcohol trading times and alcohol-related harms, this body of literature is dominated by studies analysing trading time extensions, rather than restrictions. A further drawback of this body of literature is that, with the exception of one study which analysed the effect of changes in trading times on alcohol consumption in Russia [54], the analyses are exclusively confined to high-income countries. According to the World Bank (2022), like South Africa, Russia is also an upper-middle income country [55].

Before explaining how we derived the implied elasticities reported in the table, a couple of the its features warrant explanation. First, five of the ten studies listed do not have a corresponding elasticity estimate in the final column. The first of these studies is that by Chikritzhs *et al*. (1997), who draw their sample from Perth, Australia [56]. The Western Australian Liquor Licensing Act of 1988 allowed pubs to make applications to trade for an additional hour over and above the permissible midnight closing time on weekdays and Saturdays and 21:00 on Sundays [56]. According to the authors, between 1989 and 1996, 69 pubs were granted trading permits to remain open for an additional hour on each permissible day of trade, with the majority of licenses being granted in 1993. Limiting their sample to the Perth city area, Chikritzhs *et al*. (1997) report the mean percentage change in wholesale liquor purchases by pubs that had been granted an extended trading licence (N=17) as well as the mean percentage change in wholesale liquor purchases in pubs that had not (N=24), between 1991 and 1994 [56].

They calculated that the average percentage change in liquor purchases for pubs with an extended trading permit increased by 53 per cent between 1991 and 1994, whereas the mean percentage increase for those without an extended trading permit was significantly lower, at 19.6 per cent ($t = 2.49$, $p = 0.017$) [56]. Obtaining an elasticity estimate based on this crude assessment would be misleading, for the following reason. The authors did not estimate a model that linked the changed trading times of pubs with extended trading permits to the changes in wholesale alcohol purchases. Without estimating the association using statistical techniques that adequately control for other confounding factors, any inference on the link between the extended trading hours and increases in wholesale alcohol purchases would be speculative.

The study by Carpenter and Eisenberg (2009) [57], which assesses the impact of allowing Sunday sales of alcohol in Ontario (Canada) on self-reported alcohol consumption, has no elasticity estimate because the study finds that the impact to be statistically insignificant. The authors do find, however, that the allowance of Sunday alcohol sales alters the within-week distribution of drinking, particularly from drinking on Saturdays to drinking on Sundays [57].

An elasticity estimate is also not provided for the study by Knight and Wilson (1980), which examined the impact of extended evening trading hours on weekdays by one hour as well as the provision for special licenses to allow pubs to open regularly on Sundays in Scotland. This is because we learned of the study and its broad findings through a systematic review on the effectiveness of policies restricting the permissible days on which alcohol may be sold by Middleton *et al*. (2010) [58], but were unable to access to the study. According to the reference list given in Middleton et al. (2010)[8], the study was conducted for His Majesty's Stationery Office.

For the same reason of not being able to access the study, the work by Nordlund (1985)[9] on the effects of closing wine and spirit shops in Norway on Saturdays also does not have an implied trading times elasticity in the table. According to what we can find online, the research was presented at the 31st International Institute on the Prevention and Treatment of Alcoholism, which took place in June in Italy in 1985.

Another systematic review, conducted by Popova *et al*. (2009), considers studies examining the density of alcohol outlets and alcohol trading times on alcohol consumption and damage [19]. This review alerted us to a study by Hough and Hunter (2008) [59], who evaluate the 2003 Licensing Act's impact on crime and disorder in the United Kingdom. The law was enacted in 2005 and abolished set licensing hours for pubs and clubs, allowing trading hours to be set locally through the conditions of individual licences [59]. According to Popova *et al*. (2009), Hunter and Hough (2008) observe a fall in alcohol consumption in the UK [19]. Review of the original work by Hunter and Hough (2008) reveals that the decrease in consumption reported on by Popova *et al*. (2009) is based on qualitative interviews with 105 business owners. It is not making possible to estimate a trading times elasticity from these data.

A final point worth mentioning regarding Table 13 is that only one study presented explicitly reports a trading time elasticity [13]. However, in all other cases, enough information was provided for us to calculate the elasticity implied by the data by supplementing the research findings with information contained in the relevant country's legislation regarding legally permissible trading times. We discuss the results of each of these studies and how we use their findings to arrive at elasticity estimates below. The results of each of these studies are discussed in the order that they appear in Table 13, which itself is listed in alphabetical order

8 The reference provided for the study by Knight and Wilson (1980) is listed in Middleton et al. (2010) as follows: Knight I, Wilson P. Scottish licensing laws. London: Office of Population Censuses and Surveys, Social Survey Division; 1980.

9 The reference provided for the study by Norlund (1985) is listed in Middleton et al. (2010) as follows: Nordlund S. Effects of Saturday closing of wine and spirits shops in Norway. Oslo, Norway: Statens institutt for alkoholforskning; 1985. A google search for this study will take the reader to the following page, where it is indicated that the study is "not available digitally".

by ‘place of study’. The elasticities derived above based on the work of Norström and Skog (2005) [48] and Gronqvist *et al*. (2014) [14] are included in this table, but the derivation of the elasticities are not revisited below, because it has been discussed previously.

TABLE 13. STUDIES EXAMINING THE RELATIONSHIP BETWEEN CHANGES IN ALCOHOL TRADING TIMES AND ALCOHOL CONSUMPTION

Author (publication year)	Place of study	Onsite vs Offsite	Changes in hours of sale vs days of sale	Extension or restriction of hours/days of sale	Description of policy	Measure of alcohol consumption (years of data)	Implied trading times elasticity
Chikritzhs *et al*. (1997) [56]	Australia	Onsite	Hours of sale	Extension	The Liquor Licensing Act of 1988 allowed pubs to make applications to trade for an additional hour over and above the permissible midnight closing time on weekdays and Saturdays and 21:00 on Sundays.	Wholesale alcohol purchases of each licensed premise in Western Australia (1991-1994)	Not possible to estimate
Carpenter and Eisenberg (2009) [57]	Canada	Offsite	Days of sale	Extension	Ontario allowed the sale of alcohol on Sundays in 1997.	Self-reported alcohol consumption (1994-1999)	Not possible to estimate
Norlund (1985)	Norway	Offsite	Days of sale	Extension	In 1983, shops selling alcohol in some Norwegian villages were allowed to re-open on Saturdays in contrast to the newly implemented ban on Saturday sales of liquor in the rest of the country.	–	Not possible to estimate
Kolosnitsyna *et al.* (2017) [54]	Russia	Offsite	Hours of sale	Restrictions	A law passed in 2006 permitted each region in Russia to implement time restrictions on alcohol sales.	Self-reported individual consumption of alcohol, excluding beer and homebrew, grams of pure alcohol per month (2009–2010).	0.61

Knight (1980)	Scotland	Onsite	Hours and days of sale	Extension	In 1973, Scottish Licensing Law changed to allow the extension of evening hours on weekdays to 23:00 (previously 22:00) and the provision for special licenses to allow pubs to open regularly on Sundays.	-	Not possible to estimate
Bassols and Castello (2018) [60]	Spain	Onsite	Hours of sale	Restrictions	Reduction of bar closing hours from 6am to 2–3.30am, depending on the region.	Annual household expenditure at bars	0.97
Gronqvist *et al*. (2011) [14]	Sweden	Offsite	Days of sale	Extension	Prior to February 2000, all Systembolaget outlets were closed on Saturdays. From July 2001, across all of Sweden, the Systembolaget outlets were allowed to open on Saturdays between 10:00 and 15:00.	Monthly total alcohol retail sales (1998-2001)	0.35
Norström and Skog (2005) [48]	Sweden	Offsite	Days of sale	Extension	Same as above	Monthly total alcohol retail sales (1995– 2002)	0.29
Avdic and von Hinke (2021) [13]*	Sweden	Offsite	Hours of sale	Extension	This study does not analyse a policy change per se, but rather estimates the impact of an observed trend of increases in Systembolaget operating hours over the study period	Alcohol sales per person aged 20 and above, measured in liters of 100% alcohol (2008-2015)	0.481 for the specification that controls for the nearest neighbouring county and 0.267 for the model that controls for the second-nearest neighbouring county

Hough and Hunter (2008) [59]	United Kingdom	Onsite	Hours of sale	Extension	The Licensing Act 2003, introduced in November 2005, replaced statutory trading hours with trading hours set locally through the conditions of individual trading licences.	–	Not possible to be estimated

Notes: * indicates that the study directly estimated a trading times elasticity.

As mentioned, a study by Kolosnitsyna *et al*. (2017), which estimates the impact of night time alcohol trade restrictions on the consumption of alcoholic beverages in Russia [54], provides the only opportunity for us to gain insight into this association in a middle-income country setting. In 2006, regional authorities in Russia were granted the authority to impose restrictions on the times at which alcohol for offsite consumption could be sold at night, with the exception of beer which, at that time, was not considered an alcoholic beverage in the country [54].

According to the authors, while few regional authorities had exercised this right in 2006, by 2010, most regions had established their own closing time restrictions on outlets selling alcoholic beverages [54]. Using data on self-reported alcohol consumption in grams of pure alcohol per month from the Russian Longitudinal Monitoring Survey for 2009–2010, the authors make use of the natural experiment arising from the fact that in some regions of Russia had implemented trading time restrictions, while others had not, to assess the impact of different closing times on alcohol consumption [54]. The authors estimate that every additional sales hour during the night increases alcohol consumption by 4.2%. This result is statistically significant at the 5% level [54].

The authors also provide a table which shows the time restrictions imposed on the sales of alcohol for offsite consumption in each of Russia's 83 regions. This information is shown in the second column of Table 14 below. Using the information contained in column 2, we calculate the total number of hours during which alcohol was not allowed to be sold in each region (column 3), and the total hours during which alcohol was permitted to be sold (column 4). The latter was determined by subtracting the total number of hours in which alcohol was not permitted to be sold (column 3) from 24, which is the total number of hours in a day. We were initially alarmed that the permissible trading times reported by Kolosnitsyna *et al.* (2017) for the Chechen Republic amounts to 2 hours. However, additional desktop research revealed that the vast majority of people living in the Chechen Republic are Muslim, which may explain the stringent alcohol trading times [61]. The simple average of the total permissible alcohol trading hours shown in column 4 is 15.3 hours.

TABLE 14. TIME RESTRICTIONS ON THE SALES OF ALCOHOL (EXCLUDING BEER) IN REGIONS OF THE RUSSIAN FEDERATION, 2010

Region	Hours during which alcohol may not be sold	Number of hours during which alcohol may not be sold	Total number of hours during which alcohol may be sold
Chechen Republic	10 am to 8 am	22	2
Republic of Ingushetia	6 pm to 10 am	16	8
Chukotka autonomous Okrug	8 pm to 12 pm	16	8
Nenets autonomous Okrug	8 pm to 11 am	15	9
Moscow Oblast	9 pm to 11 am	14	10
Murmansk Oblast	9 pm to 11 am	14	10
Republic of North Ossetia-Alania	9 pm to 11 am	14	10
Tver Oblast	9 pm to 10 am	13	11
Jewish autonomous Oblast	10 pm to 11 am	13	11
Kamchatka Krai	10 pm to 11 am	13	11
Krasnodar Krai	10 pm to 11 am	13	11
Ulyanovsk oblast	8 pm to 8 am	12	12
Ivanovo oblast	7 pm to 9 am	14	10
Kabardino-Balkar Republic	10 pm to 10 am	12	12
Orenburg oblast	10 pm to 10 am	12	12
Republic of Dagestan	10 pm to 10 am	12	12
Republic of Tatarstan	10 pm to 10 am	12	12
Moscow	10 pm to 10 am	12	12
Magadan oblast	11 pm to 11 am	12	12
Kemerovo oblast	10 pm to 9 am	11	13
Novosibirsk oblast	10 pm to 9 am	11	13
Primorskii krai	10 pm to 9 am	11	13
Stavropol krai	10 pm to 9 am	11	13
Republic of Tyva	11 pm to 10 am	11	13
Bryansk oblast	10 pm to 8 am	10	14
Irkutsk oblast	10 pm to 8 am	10	14
Nizhniy Novgorod oblast	10 pm to 8 am	10	14
Mari El Republic	10 pm to 8 am	10	14
Republic of Sakha (Yakutia)	10 pm to 8 am	10	14
Ryazan oblast	10 pm to 8 am	10	14
Belgorod oblast	11 pm to 9 am	10	14
Republic of Adygea	11 pm to 9 am	10	14
Amur oblast	11 pm to 8 am	9	15
Astrakhan oblast	11 pm to 8 am	9	15
Kaluga oblast	11 pm to 8 am	9	15
Kursk oblast	11 pm to 8 am	9	15
Lipetsk oblast	11 pm to 8 am	9	15
Novgorod oblast	11 pm to 8 am	9	15
Orel oblast	11 pm to 8 am	9	15
Perm krai	11 pm to 8 am	9	15
Republic of Bashkortostan	11 pm to 8 am	9	15
Komi Republic	11 pm to 8 am	9	15
Tambov oblast	11 pm to 8 am	9	15
Tomsk oblast	11 pm to 8 am	9	15
Volgograd oblast	11 pm to 8 am	9	15

Vologda oblast	11 pm to 8 am	9	15
Yaroslavl' oblast	11 pm to 8 am	9	15
Sakhalin oblast	12 am to 9 am	9	15
Chelyabinsk oblast	11 pm to 7 am	8	16
Chuvash Republic	11 pm to 7 am	8	16
Kirovskaya oblast	11 pm to 7 am	8	16
Leningrad oblast	11 pm to 7 am	8	16
Pskov oblast	11 pm to 7 am	8	16
Republic of Buryatia	11 pm to 7 am	8	16
Republic of Karelia	11 pm to 7 am	8	16
Rostov oblast	11 pm to 7 am	8	16
St. Petersburg	11 pm to 7 am	8	16
Tula oblast	11 pm to 7 am	8	16
Tyumen oblast	11 pm to 7 am	8	16
Udmurt Republic	11 pm to 7 am	8	16
Vladimir oblast	11 pm to 7 am	8	16
Voronezh oblast	11 pm to 7 am	8	16
Yamalo-Nenets autonomous okrug	11 pm to 7 am	8	16
Astrakhan oblast	12 am to 8 am	8	16
Transbaikal krai	12 am to 8 am	8	16
Penza oblast	11 pm to 6 am	7	17
Republic of Kalmykia	11 pm to 6 am	7	17
Republic of Mordovia	11 pm to 6 am	7	17
Republic of Altai	12 am to 7 am	7	17
Sverdlovsk oblast	12 am to 7 am	7	17
Saratov oblast	12 am to 6 am	6	18
Republic of Khakassia	2 am to 7 am	5	19
Altai Krai	No restrictions	0	24
Kaliningrad oblast	No restrictions	0	24
Karachai–Cherkessia Republic	No restrictions	0	24
Khabarovsk krai	No restrictions	0	24
Khanty-Mansiysk autonomous okrug-Yugra	No restrictions	0	24
Kostroma oblast	No restrictions	0	24
Krasnoyarsk oblast	No restrictions	0	24
Kurgan oblast	No restrictions	0	24
Omsk oblast	No restrictions	0	24
Samara oblast	No restrictions	0	24
Smolensk oblast	No restrictions	0	24

Source: Adapted from Kolosnitsyna et al. (2017). Includes author's own calculations.

By way of a footnote, one learns that the Russian Longitudinal Monitoring Survey for 2009–2010 only represents 32 of the 83 Russian regions presented in Table 14. The authors do not specify the names of these 32 regions. We therefore downloaded the Russian Longitudinal Monitoring Survey dataset and analyzed the ‘region’ variable to ascertain which regions were included in the survey. A few issues arising in this process need to be noted.

First, a region called ‘Kaluzhskaya Oblast: Kuibyshev Rajon’ is listed in the raw data of the Russian Longitudinal Monitoring Survey, but we could not find any corresponding region in the Table presented in Kolosnitsyna *et al*. (2017), which is replicated in columns 1 and 2 of Table 14. A google search for the term ‘Kaluzhskaya Oblast: Kuibyshev Rajon’ returned results for ‘Kaluga Oblast’, which is included in Table 14. We thus assume that Kaluga Oblast represents ‘Kaluzhskaya Oblast: Kuibyshev Rajon’ and it is therefore included in the refined sample shown in Table 15.

The second issue is that a region called ‘Altaiskij Kraj: Biisk CR’ is listed in the raw data of the Russian Longitudinal Monitoring Survey, but we could not find any corresponding region in the table of alcohol trading time restrictions presented in Kolosnitsyna *et al*. (2017). A search within the table for the root word ‘Alta’ showed two potential regions, ‘Republic of Altai’ and ‘Altai Krai’, which imposed different trading time restrictions (Table 14). A google search for the term ‘Altaiskij Kraj: Biisk CR’ returns results for ‘Altai Krai’, which is included in Table 14. We thus assume that ‘Altaiskij Kraj: Biisk CR’ in the raw data represents ‘Altai Krai’ in the study by Kolosnitsyna *et al*. (2017).

The refined sample is shown in Table 15. Because the trading times differed by region, population-weighted average trading times are most appropriate in estimating the implied elasticity. We report the total population in each Russian region in 2010 in Table 15. Ideally we would only include the adult population. However, we faced the challenge that the data file containing information on the regional-level estimates of the Russian population by age available on the Russian Federal Service for State Statistics website is in Russian (despite that one is able to read the website in English). Our attempt to use Google Translate to understand the cells containing text within the data file proved fruitless. Importing the age categories given in Russian yields interpretations that do not make sense. For example, Google Translate returned terms such as ‘younger than able-bodied’ and ‘older than able-bodied’, which does not help us in identifying age groups from which to estimate the adult population in each region. We thus relied on the total population estimates in each provided on Wikipedia, which cites the Russian Federal Service for State Statistics as its source. Alleviating some of this concern is the fact that the World Bank estimates that only 15.16% of the total Russian population was younger than 15 in 2010 [55].

We calculate that the weighted average permissible alcohol trading time in the refined sample is just under 15 hours (Table 15). The percentage change implied by a one-hour increase in trading times is thus 6.74% (=1/14.84). Given that Kolosnitsyna *et al*. (2017) estimate that for every additional hour that alcohol may be sold, alcohol consumption increases by 4.2%, the elasticity implied by these data is 0.62 (=4.2%/6.74%).

TABLE 15. REFINED SAMPLE: TIME RESTRICTIONS ON THE SALES OF ALCOHOL (EXCLUDING BEER) IN REGIONS OF THE RUSSIAN FEDERATION, 2010 (N=35)

Region	Population in 2010 (millions)	Hours during which alcohol may not be sold	Number of hours during which alcohol may not be sold	Total number of during which alcohol may be sold
Leningrad oblast	1.72	11 pm to 7 am	8	16
Krasnodar Krai	5.23	10 pm to 11 am	13	11
Udmurt Republic	1.52	11 pm to 7 am	8	16
Perm krai	2.64	11 pm to 8 am	9	15
Kaluga oblast	1.01	11 pm to 8 am	9	15
Tambov oblast	1.09	11 pm to 8 am	9	15
Volgograd oblast	2.61	11 pm to 8 am	9	15
Republic of Tatarstan	3.79	10 pm to 10 am	12	12
Kurgan oblast	0.91	No restrictions	0	24
Orenburg oblast	2.03	10 pm to 10 am	12	12
Chuvash Republic	1.25	11 pm to 7 am	8	16
Stavropol krai	2.79	10 pm to 9 am	11	13
Republic of Altai	0.21	12 am to 7 am	7	17
Kaliningrad oblast	0.94	No restrictions	0	24
Saratov oblast	2.52	12 am to 6 am	6	18
Tomsk oblast	1.05	11 pm to 8 am	9	15
Lipetsk oblast	1.17	11 pm to 8 am	9	15
Krasnoyarsk oblast	2.83	No restrictions	0	24
Kabardino-Balkar Republic	0.86	10 pm to 10 am	12	12
Altai Krai	2.42	No restrictions	0	24
Komi Republic	0.90	11 pm to 8 am	9	15
Vladimir oblast	1.44	11 pm to 7 am	8	16
Amur oblast	0.83	11 pm to 8 am	9	15
Saratov oblast	2.52	12 am to 6 am	6	18
Komi Republic	0.90	11 pm to 8 am	9	15
Chelyabinsk oblast	3.48	11 pm to 7 am	8	16
Nizhniy Novgorod oblast	3.31	10 pm to 8 am	10	14
Penza oblast	1.39	11 pm to 6 am	7	17
Smolensk oblast	0.99	No restrictions	0	24
Tula oblast	1.55	11 pm to 7 am	8	16
Rostov oblast	4.28	11 pm to 7 am	8	16
Moscow Oblast	7.10	9 pm to 11 am	14	10
Moscow	11.50	10 pm to 10 am	12	12
St. Petersburg	4.88	11 pm to 7 am	8	16
Novosibirsk oblast	2.67	10 pm to 9 am	11	13

Weighted average:	
Number of hours open	14.84

Percentage change implied by a one hour increase in trading time	6.74%
Percentage change in alcohol consumption reported in the study	4.2%
Trading times elasticity	0.62

Although we have arrived at an elasticity estimate from these data, a final issue that arose in deriving the refined sample needs to be noted. When we use the raw data of the Russian Longitudinal Monitoring Survey to identify those regions that were relevant for estimating alcohol consumption from the broader sample of 83 regions shown in Table 14, we end up with 35 regions. This is three more than the number of regions that Kolosnitsyna *et al*. (2017) report in their footnote (N=32 according to the note). Because the authors do not indicate the names of the 32 regions included in their sample, we have no way of identifying which three regions we have included over and above those used by the authors in their analysis.

However, the footnote included in the original study does specify that, among the 32 regions represented in the Russian Longitudinal Monitoring Survey, time restrictions on alcohol sales were imposed in 30 regions [54]. This implies that the sample used by Kolosnitsyna *et al*. (2017) only included two regions in which no time restrictions were imposed. In our derived sample we have five regions in which no time restrictions were imposed (Table 15). This suggests that, in the refined analysis, we have included three additional regions that do not impose trading time restrictions.

Given that we are using population-weighted average trading times, our choice concerning which regions to remove is non-trivial. To avoid biasing the weighted average, we first removed the three regions with the smallest populations (call this new refined sample, group A) and recalculated the weighted average trading hours (panel A, Table 16). We then, using the original refined sample of 35 regions, removed the three regions with the largest populations (call this group B) and recalculated the weighted average trading hours (panel B, Table 16). The true average lies between that derived using sample A and that derived using sample B. From Table 16, the elasticity estimate derived using sample A is 0.61, while that derived using sample B is 0.59.

Because we cannot ascertain which estimate is most correct, and the elasticity estimates between the three samples we have analysed do not differ too markedly (0.62 when N=35, 0.61 from sample A and 0.59 for sample B), we take the simple average of these three elasticity values (=0.61) as our preferred elasticity estimate derived from this study. This is the value reported at the start of this section in Table 13.

TABLE 16. TIME RESTRICTIONS ON THE SALES OF ALCOHOL (EXCLUDING BEER) IN REGIONS OF THE RUSSIAN FEDERATION, 2010 IN GROUP A AND GROUP B (N=32)

Sample A			**Sample B**		
Region	Population 2010 (millions)	Total number of during which alcohol may be sold	Region	Population in 2010 (millions)	Total number of during which alcohol may be sold
Moscow	11.50	12	Moscow	11.,50	12
Moscow Oblast	7.10	10	Moscow Oblast	7.10	10
Krasnodar Krai	5.23	11	Krasnodar Krai	5.23	11
St. Petersburg	4.88	16	St. Petersburg	4.88	16
Rostov oblast	4.28	16	Rostov oblast	4.28	16
Republic of Tatarstan	3.79	12	Republic of Tatarstan	3.79	12
Chelyabinsk oblast	3.48	16	Chelyabinsk oblast	3.48	16
Nizhniy Novgorod oblast	3.31	14	Nizhniy Novgorod oblast	3.31	14
Krasnoyarsk oblast	2.83	24	Stavropol krai	2.79	13
Stavropol krai	2.79	13	Novosibirsk oblast	2.67	13
Novosibirsk oblast	2.67	13	Perm krai	2.64	15
Perm krai	2.64	15	Volgograd oblast	2.61	15
Volgograd oblast	2.61	15	Saratov oblast	2.52	18
Saratov oblast	2.52	18	Orenburg oblast	2.03	12
Altai Krai	2.42	24	Leningrad oblast	1.72	16
Orenburg oblast	2.03	12	Tula oblast	1.55	16
Leningrad oblast	1.72	16	Udmurt Republic	1.52	16
Tula oblast	1.55	16	Vladimir oblast	1.44	16
Udmurt Republic	1.52	16	Penza oblast	1.39	17
Vladimir oblast	1.44	16	Chuvash Republic	1.25	16
Penza oblast	1.39	17	Lipetsk oblast	1.17	15
Chuvash Republic	1.25	16	Tambov oblast	1.09	15
Lipetsk oblast	1.17	15	Tomsk oblast	1.05	15
Tambov oblast	1.09	15	Kaluga oblast	1.01	15
Tomsk oblast	1.05	15	Kaliningrad oblast	0.94	24
Kaluga oblast	1.01	15	Kurgan oblast	0.91	24
Komi Republic	0.90	15	Komi Republic	0.90	15
Kabardino-Balkar Republic	0.86	12	Kabardino-Balkar Republic	0.86	12
Amur oblast	0.83	15	Amur oblast	0.83	15
Republic of Altai	0.21	17	Republic of Altai	0.21	17
Weighted average: Number of hours open		14.41	Weighted average: Number of hours open		13.99

Percentage change implied by a one hour increase in trading time	6.94%	Percentage change implied by a one hour increase in trading time	7.15%
Percentage change in alcohol consumption reported in the study	4.20%	Percentage change in alcohol consumption reported in the study	4.20%
Trading times elasticity	0.61	Trading times elasticity	0.59

Another study that can be used to arrive at an elasticity estimate of the responsiveness of alcohol consumption to changes in trading times is that by Bassols and Castello (2018), who estimate the impact of a reduction in permissible bar trading hours in Spain on workplace accidents [60]. The study also assesses the impact of this policy on three proxies of alcohol consumption: household expenditure in bars, self-reported alcohol consumption and hospitalizations due to excessive alcohol consumption.

Spain is divided into 17 regions, called Autonomous Communities. Each of these Communities implemented a reduction in bar closing hours at some point between 1994 and 2011 [60]. Before the reforms, bars in Spain were allowed to stay open until 6am. This was reduced to 2am–3.30am, depending on the region [60]. Because the reforms were implemented in a staggered manner, there were no two regions that implemented the reduced trading hours at the same time. Utilizing the quasi-natural experiment arising from the non-uniform nature of the policy adoption, Bassols and Castello (2018) exploit the variation in policy implementation to compare alcohol consumption in those regions that had already implemented the policy with those that had not yet introduced it [60]. The authors employ a difference-in-difference approach in their analysis.

While Bassols and Castello (2018) provide the new trading time restrictions imposed in each of the 17 Spanish regions, they do not provide any indication of the bar opening hours before, or after, the policy change. We thus reviewed the legislation for each of the 17 Autonomous Communities cited in Bassols and Castello (2018) to see if the legislation applied restrictions on the times at which bars could open in each of Spain’s Autonomous Communities. This legislation is written in Spanish and needed to be translated using Google Translate. Table 17 summarizes the bar trading times policy landscape in Spain before and after the policy change.

TABLE 17. DAILY PERMISSIBLE BAR OPENING AND CLOSING TIMES IN SPAIN'S 17 AUTONOMOUS COMMUNITIES BEFORE AND AFTER THE LEGISLATED CLOSING TIME RESTRICTIONS

	Before closing time restrictions		**After closing time restrictions**	
Region (year of policy implementation)	Earliest permissible opening time before policy change	Latest permissible closing time before policy change	Earliest permissible opening time after the policy change	Latest permissible closing time after the policy change
Andalucía (1st quarter 2003)	12:00 (noon)	06:00	12:00 (noon)	03:00*
Aragon (1st quarter 2006)	12:00 (noon)	06:00	12:00 (noon)	03:30*
Canary Islands (2nd quarter 2002)	14:00	06:00	11:30	03:30
Cantabria (3rd quarter 1997)	10:00	06:00	06:00	02:00
Comunidad de Madrid (3rd quarter 2002)	13:00	06:00	13:00	3:00am**
Castilla Leon (4th quarter 2006)	12:00 (noon)	06:00	12:00 (noon)	3:00am
Castilla la mancha (1st quarter 1996)	10:00	06:00	10:00	1.30am or 2.30am ****
Catalunya (4th quarter 2011)	12:00 (noon)	06:00	12:00 (noon)	2:30am
Extremadura (3rd quarter 1996)	10:00	06:00	5:30am or 6:30am	1.30am or 2.30am ****
Galicia (2nd quarter 2005)	10:00	06:00	10:00	2:30am
Murica (1st quarter 1994)	06:00	06:00	06:30am or 7:30am	2:30am or 3:30am****
Navarra (2nd quarter 2004)	10:30	06:00	10:30	3:30am**
Comunidad Valenciana (1st quarter 2004)	12:00 (noon)	06:00	12:00 (noon)	3:30am
Balearic Islands (2nd quarter 1999)	08:00	06:00	08:00	3:00am
La Rioja (4th quarter 2000)	08:30	06:00	08:30	3:30**
Pais Vasco (3rd quarter 1998)	12:00 (noon)	06:00	08:00	2:00*
Asturias (1st quarter 2005)	11:00	06:00	11:00	03:30*

Notes: *On Fridays and Saturdays bars are allowed to stay open for one hour more. **On Fridays and Saturdays bars are allowed to stay open for half an hour more. ***On Fridays, Saturdays and the night before holidays are allowed to stay open for half an hour more ****The first time corresponds to the winter opening times, the second time corresponds to the summer opening times.

For 13 of the 17 regions, we could not find any evidence that the permissible opening times changed following the reductions in legal bar closing hours. The result is that the hours for which bars could trade on any given day decreased. However, in four regions (Canary Islands, Cantabria, Extremadura and Pais Vasco) bar opening times were not set at a particular time before the policy change. Instead, they were set according to rules on the minimum number of hours that were required to elapse between the bar's closing time and its opening time. In Cantabria and Extremadura, bars were not allowed to open without a minimum period of four hours having elapsed between the maximum official closing time and their re-opening the next day. In Pais Vasco, this minimum closure period required between a bar's opening and closing time was six hours, while the time required between open and closure in the Canary Islands stood at eight hours.

Because the rules governing legal permissible opening times are a function of the legal permissible closing times in these four Communities, the new closing time restrictions did not have an impact on the total number of hours for which bars could operate each week in these four regions. For example, before the policy change in Cantabria, bars were allowed to close at 6am. With the legal requirement that bars needed to wait 4 hours before reopening, bars in Cantabria were allowed to re-open at 10am later that day. This amounts to 20 legally permissible trading hours per day. Following the policy change, which limited bar closing times to 2am, bars could theoretically open their doors at 6am the next day. This still amounts to 20 legally permissible trading hours.

In three regions (Castilla la mancha, Murica and Extremadura), bar closing times differed by season (summer trading times vs winter trading times). In two of these regions (Murica and Extremadura), legislation showed that changes in opening times accommodated these changed closing times such that the total number of legally permissible trading hours did not change between the seasons. In Castilla la mancha, however, the permissible opening time did not change according to the season, which meant that bars were allowed to trade for one hour longer in summer than in winter.

In response to the restricted bar trading times, the authors find reductions in all three measures of alcohol consumption used in their study, but only the model that includes (the log of) annual household expenditure in bars yields a significant result. Using data from the Spanish Family Expenditure Survey, Bassols and Castello (2018) estimate that annual expenditure in bars decreased by 13% because of the restrictions imposed on bar closing hours. The result is significant at the 5% level.

While it is not mentioned in the main manuscript text, a footnote to the table reporting their regression results indicates that Bassols and Castello (2018) only used data from the Spanish Family Expenditure Survey for the years 1998 to 2004 to estimate that annual household expenditure at bars decreased by 13% following the introduction of the closing time restrictions [60]. This drops nine regions from the original sample reported in Table 17, which are those regions that implemented reduced bar trading hours in a year that falls outside the window for which data from the Spanish Family Expenditure Survey were available.

The weekly trading hours of those Autonomous Communities that implemented their policy changes in years corresponding to the available Spanish Family Expenditure Survey data are shown in Table 18. Estimating weekly, as opposed to the daily, permissible trading hours allows us to account for the fact that some regions were allowed to trade for up to one extra hour on select days of the week as was indicated in Table 17. It should be noted that, in the refined sample, there is no longer a need to distinguish between summer and winter trading times because Castilla la mancha is removed from the sample since it implemented its trading times restrictions in 1996, which falls outside of the period for which expenditure data were available.

We also include the adult population aged 15 and older in each of Spain's 17 autonomous regions in this table. We use these population estimates to construct the weighted average permissible trading time in Spain. These population estimates come from the Spanish National Institute of Statistics of Statistics, who report the population in Spain by each of its 50 provinces. Obtaining estimates of the adult population in the eight Autonomous Communities shown in Table 18 required us to map the relevant provinces to the appropriate region.

As can be seen, the average permissible trading hours decreased by 12.7 per cent following the legislative changes mandating reductions in bar trading hours. When incorporated into the trading times elasticity formula from above, alongside the reported 13 per cent reduction in annual household expenditure at bars, one obtains an elasticity estimate of 1, which is at the upper end of the plausible range of elasticity estimates. It should be noted that the refined sample poses limitations to the authors' analysis, since the population accounted for in the refined sample is 21.88 million, while the total adult population for Spain in 2010 was 39.60 million, nearly double that represented in the refined sample [55].

TABLE 18. CHANGES IN LEGALLY PERMISSIBLE TRADING HOURS IN EIGHT OF SPAIN'S AUTONOMOUS COMMUNITIES AND DERIVATION OF AN ELASTICITY ESTIMATE

Region	**Adult population in 2010 (millions)**	**Maximum number of hours that bars could operate each week before the policy change**	**Maximum number of hours that bars could operate each week following the policy change**
Andalucía (2003)	6.91	126	106
Canary Islands (2002)	1.73	112	112
Comunidad de Madrid (2002)	5.40	119	99
Navarra (2004)	0.54	136,5	120
Comunidad Valenciana (2004)	4.24	126	108,5
Balearic Islands (1999)	0.92	154	133
La Rioja (2000)	0.27	150,5	134
Pais Vasco (1998)	1.89	126	128
Weighted average: Weekly number of permissible trading hours		124.90	108.96
Percentage change in number of permissible trading hours	-12.77%		
Percentage change in alcohol expenditure reported in the study	-13.00%		
Trading times elasticity	1.02		

A significant limitation to the analysis by Bassols and Cassello (2018), which represents a significant limitation to the elasticity estimate that we derived from this study, stems from their use of expenditure on alcohol as a proxy for alcohol consumption. This is because expenditure involves both a price and a quantity component. If the price of alcohol sold in bars in Spain did not change over the period of interest, then expenditure is proportional to quantity, and spending on alcohol is a reasonable proxy for alcohol consumption. If the prices did change, however, the appropriateness of using expenditure as a proxy for consumption can be called into question.

The estimation strategy employed by the authors controls for the impact of price changes during the study period partially, though not perfectly. Because alcohol taxation policy in Spain is determined at the national level [60], tax changes are homogenous across all regions. Since tax increases generally result in price increases,[10] and price increases affect expenditure, the

[10] Except in the instance when the taxed industry fully absorbs the tax increase.

fact that the authors' estimate their model with time fixed effects means that any tax changes that occurred over the analysis period are controlled for. However, taxes are not the only factor that affects prices.

We therefore consulted the CPI for alcoholic beverages in Spain to ascertain price trends in the country so that we could provide comment on the direction of the bias in the results reported by the authors [62]. Unfortunately, the CPI excludes the prices of alcoholic beverages sold at onsite consumption venues, meaning that we cannot assess the change in prices sold at bars over the analysis period [62]. Calculating the percentage change between the average CPI for last six months of 1998[11] and the annual average for 2004, reveals that offsite alcohol prices increased by 12.84 per cent. That we cannot deduce what happened to onsite alcohol prices over this period represents a limitation of the analysis by Bassols and Cassello (2018) and, thus, a limitation of the elasticity derived from this study.

The final study that we consider to inform our elasticity estimate to be used in our model is that by Avdic and von Hinke (2021), which draws its sample from Sweden [13]. According to the authors, between 2008 and 2015, more than half of all alcohol retailers in Swedish municipalities extended their weekly opening hours, with 19% of municipalities increasing between two and eight hours per week [13]. Using annual panel data records on Systembolget trading hours in each of the 290 municipalities in Sweden over this period, the authors calculate that, on average, municipalities increased their weekly opening hours by just over one hour from 44.9 hours per week in 2008 to 46.1 hours per week in 2015. However, the observed distribution is skewed, with 47% of municipalities not changing their opening hours at all, 34% increasing them by one hour a week, and the remaining 19% increasing their opening hours between two and up to eight hours per week [13]. The authors further find that 43% of municipalities increased their opening hours just once over the study period, while 10% of retailers changed their hours more than once [13]. Like the earlier study by Gronqvuist *et al*. (2011) [14], Avdic and von Hinke (2021) also allude to the fact that the legislated trading times prevailing in each municipality are mandated.

Unlike any of the aforementioned studies, Avdic and von Hinke (2021) directly estimate the trading times elasticity resulting from these changes in offsite venue trading times. Using a difference-in-differences model for years 2008–2015, the authors find that extended opening hours significantly increased alcohol sales in Sweden. Specifically, they find that a one hour increase in weekly opening hours increases annual per capita purchases of strong alcohol in the municipality by 2%–3%, depending on alcohol type. In the absence of controls for cross-border substitution, these estimates imply an elasticity of demand with respect to retail trading hours of between 0.84–1.11, depending on the type of alcohol: for spirits the elasticity estimate is 0.842, for wine it is 0.984, for beer it is 1.110 and for cocktails and cider it is 0.955 [13]. All these elasticities are statistically significant at one per cent level. The overall trading times elasticity implied by these data is 0.942 ($p<.01$). In words, total retail alcohol sales increase by 0.942% when trading hours increase by 1%.

This relatively high elasticity estimate corresponds with that which we derived from the study of conducted by Bassels and Castello (2018) in Spain (Table 13). However, one potential

[11] Pais Vasco, the earliest region implementing the reform to permissible trading hours only did so in the third quarter of 1998 (refer to Table 17).

caveat when interpreting the elasticity derived by Avdic and von Hinke (2021) is that the model from which this estimate was derived does not account for the reality that extended trading hours in one municipality may have attracted customers from neighbouring municipalities where retail trading hours were more strict [13]. As noted by Avdic and von Hinke (2021), the existence of these “spillover effects” would overstate the estimated impact of extended opening hours on retail purchases of alcohol because changes in alcohol sales from substituting consumers would be counted twice: once as an increase in the municipality consumers substitute to, and also as a decrease in the municipality consumers substitute from [13].

To address this potential source of bias, the authors re-estimate their difference-in-difference model and include weekly trading hours of alcohol retailers in neighbouring municipalities as additional controls. The authors restrict the number of neighbouring retail outlets to five, or to the total number of outlets within a distance of 100 km (a distance that one can travel by car within the additional hour of the retailer being open) from the midpoint of the municipality, whichever restriction was found to bind first. The revised model is only run for total retail sales of pure alcohol, not alcohol sales by alcohol-type as was done in the original model specification. The original trading times elasticity of 0.942 reduces to 0.481 when the first neighbouring municipality is added, and reduces to 0.267 when the second neighbouring municipality is added. The elasticity estimate further decreases to 0.213 and 0.169 when the third and fourth neighbouring municipalities are added, respectively. Adding the trading times of the fifth nearest municipality moves the elasticity estimate up to 0.271. F-tests on the marginal effect of trading hours, taking into account any spatial Spillovers with neighbouring municipalities, are only statistically significant for the addition of the trading times elasticities of the first two nearest neighbours [13]. We therefore take the elasticity estimates of 0.481 ($p<.05$) and 0.267 ($p<.1$) as the preferred elasticity estimates derived in this study.

The final list of elasticity estimates derived through this literature review, and the associated additional analysis, are summarised in Table 19. The estimates range quite widely from 0.27 to slightly more that 1. The Swedish estimates all lie within a close range (0.27-0.48) at the lower end of the spectrum, while the estimate from Spain, at 1.02, though still plausible, represents a relative extreme. A distinct benefit of the Swedish studies, which we deduced from statements made in two [13, 14] of the three studies drawing their data from the country, is that the legislated trading hours in each region appear to be mandatory given that all offsite alcohol retailers operate under the banner of a state monopoly. These are the only three studies listed in Table 19 that use actual as opposed to legislated trading hours to estimate changes in alcohol consumption. As discussed in the introduction to this section, the studies that based their analyses of changes in alcohol consumption in response to legislated trading hours are likely to produce elasticity estimates that overstate the association.

TABLE 19. SUMMARY OF DERIVED ELASTICITY ESTIMATES

Author (publication year)	Place of study	Onsite vs Offsite	Changes in hours of sale vs days of sale	Extension or restriction of hours/days of sale	Implied trading times elasticity
Kolosnitsyna et al. (2017) [54]	Russia	Offsite	Hours of sale	Restrictions	0.61
Bassols and Castello (2018) [60]	Spain	Onsite	Hours of sale	Restrictions	1.02
Gronqvist et al. (2011) [14]	Sweden	Offsite	Days of sale	Extension	0.35
Norström and Skog (2005) [48]	Sweden	Offsite	Days of sale	Extension	0.29
Avdic and von Hinke (2021) [13]	Sweden	Offsite	Hours of sale	Extension	0.481 for the specification that controls for the nearest neighbouring county and 0.267 for the model that controls for the second-nearest neighbouring county

On the basis of these elasticity estimates, our proposal is that we forecast each policy scenario using three different elasticities, a lower and upper bound and a mid-range estimate. Our elasticity values used in the model will be rounded to one decimal place.

To ascertain the lower bound, we take the average of the elasticities derived from the three Swedish studies [13, 14, 48]. Because the study by Avdic and von Hinke (2021) reports two statistically significant elasticity estimates, we choose the lowest estimate obtained in this study. We do this because it will produce a lower average across the three studies than would be obtained if we were to use the higher elasticity estimate of 0.481, despite the fact that this higher elasticity estimate fetches a higher level of statistical significance than the lower elasticity estimate of 0.267 reported on in the study. Being conservative in the selection of these elasticities will mitigate the inevitable criticism from the South African liquor industry that the assumptions regarding the responsiveness of alcohol consumption to changes in trading times adopted in this report are biased in favour of estimates that will overstate the impact of the proposed trading time restrictions at onsite venues in the Western Cape. Taking the simple average of the elasticities from the three Swedish studies yields a trading times elasticity of 0.3.

At the highest extreme, we will use an elasticity value of 1, in line with the findings from Spain [60]. We documented the limitations of the elasticity estimate derived from this study in detail, but it still represents the best estimate of an upper bound elasticity value that we have available to us. We determine the mid-range elasticity as the average between the upper and lower bound values, which is equal to 0.65. We will round this down to 0.6 to err on the conservative side. It is fortuitous that this mid-range estimate is near identical to that which we derived for Russia since it is the only evidence available in the literature to inform us of the impact of such a policy in an upper-middle income country like South Africa. That said, the limitations in our approach to deriving an elasticity estimate from the Russian study still apply [54].

TABLE 20. ELASTICITY ESTIMATES THAT WILL BE USED IN EACH POLICY SCENARIO

	Elasticity estimates		
Simulated closing time	Low	Middle	High
00:00	0.3	0.6	1.0
01:00	0.3	0.6	1.0
02:00	0.3	0.6	1.0

In our modelling framework, the trading times elasticity estimate, denoted ε_{TT}, is used to estimate the impact of changes in trading times on alcohol consumption in the next year. To do this, we need to apply the relevant ε_{TT} to the percentage change in onsite trading hours using the following equation:

$$\%\text{ change in onsite trading hours} \times \varepsilon_{TT} = \%\text{ change in consumption}$$

This will allow the calculation of new consumption levels in response to the change in trading times created by the proposed policy.

To obtain the trading percentage change in trading times required to estimate the equation shown above, we use the output of Phase 1 of this research project. As has been mentioned, this output takes the form a dashboard that allows the user to estimate the impact of amending trading times of liquor outlets in the Western Cape in terms of the number of liquor retail outlets affected, and the reduction in the number of legally permissible trading hours lost under each closing time scenario. Based on the data underpinning the dashboard, we calculate that the total permissible liquor trading hours at onsite venues is 578 776 hours each week. The total weekly number of trading hours lost under each policy scenario is shown in Table 21. We estimate 9.44%, 5.07% and 0.77% reductions in permissible onsite trading times under a midnight, 1am and 2am closing time, respectively.

TABLE 21. HOURS LOST PER WEEK IN THE WC ACROSS ALL ONSITE OUTLET TYPES

Closing time (policy)	Total hours lost	Ratio of hours lost to total hours	% change in trading hours
00:00	54 663	54 663/578 776	9.44%
01:00	29 338	29 338/578 776	5.07%
02:00	4 449	4 449/578 776	0.77%

Importantly, while the proposed closing time scenarios apply only to onsite alcohol consumption, the estimated changes in onsite alcohol consumption at each closing time scenario need to be translated to changes in total alcohol consumption. There are both analytical and practical reasons for this to be done.

At an analytical level, as will be discussed in section 3.4.1, our model uses relative risk equations to determine the health impact of each proposed closing time. To allocate relative risks on the basis of changes in onsite consumption only would be to overestimate the potential health impact of the proposed policy intervention. This is because when we consider a percentage change in onsite alcohol consumption only, we ignore the fact that alcohol consumption at offsite venues is still occurring. The percentage change in alcohol consumption at onsite venues thus needs to be 'scaled down' by subtracting the estimated absolute reduction in onsite drinking from consumption that is occurring at both onsite and offsite drinking locations. In addition, the relative risk equation for HIV gives a pre-determined value for the risk depending on the level of alcohol consumption at baseline and under each policy scenario (Table 22). To assign these values on the basis of onsite alcohol consumption would constitute a misallocation of relative risk of HIV at baseline and under each policy scenario.

The more practical reason for expressing the estimated percentage changes in alcohol consumption at onsite drinking locations in terms of alcohol consumption deriving from both onsite and offsite sources is that it helps to scale the impact of restrictions in onsite trading times on the variables of interest in a manner that is meaningful to policy makers. For example, if, hypothetically, a midnight closing time scenario corresponds to a 5 per cent reduction in onsite alcohol consumption, it needs to be clearly communicated that this will translate to a less than 5 per cent reduction in alcohol consumption across all venues types (offsite and onsite). It is of limited value to report that onsite consumption decreases by 5 per cent, without accounting for the fact that approximately 64 per cent of alcohol consumption occurring at offsite trading locations is not subject to the policy. Adopting this approach also helps to ensure that the estimated impacts of the proposed closing time scenarios are not taken out of context and reported as changes in total expenditure/revenue, when they, in fact, represent changes in onsite expenditure/revenue only.

3.4 Consumption to harm data inputs

As mentioned at the start of this chapter, the modelling framework is divided into two distinct sections. The first part of the model deals with the link between trading hours and alcohol consumption; the second part of the model quantifies the link between alcohol consumption and its associated health harms and economic costs. In terms of model execution, we use both mean and peak consumption levels at baseline, and for each policy scenario, to calculate the impact of different trading time restrictions on a range of health outcomes (HIV, TB, road injury, intentional injury, liver cirrhosis and breast cancer). This will require us to use potential impact fractions and multi-state life tables for each of the disease/injury conditions of interest in this study. Below we document the main health data inputs that will be employed in our model.

3.4.1 Relative risk data

Relative risk is a ratio of the probability of an event occurring in the exposed group versus the probability of the event occurring in the non-exposed group [63]. For example, the relative risk of developing liver cirrhosis (event) in drinkers (exposed group) versus non-drinkers (non-exposed group) would be the probability of developing liver cirrhosis for drinkers divided by the probability of developing liver cirrhosis for non-drinkers. The relative risk does not provide any information about the absolute risk of the event occurring, but rather the higher or lower likelihood of the event in the exposure versus the non-exposure group [63].

For all disease/injury condition of interest, except HIV, we use published relative risk equations for each of the health outcomes of interest at the baseline, and in each policy scenario, derived by Shield *et al*. (2020) [64]. The relative risk for HIV is taken from Probst *et al*. (2018), who provide South Africa-specific evidence that the risk of HIV differs not only by drinking level, but also by socioeconomic status, with the poorer groups significantly more at risk than their more affluent counterparts [65].

Probst *et al*. (2018) calculate an asset score and split it at the median, resulting in two groups, high socioeconomic status and low socioeconomic status (SES) and calculate their risks accordingly. Consistent with the approach adopted by Gibbs *et al.* (2021), we allocate the bottom two wealth quintiles to the low SES relative risk and the top three to the high SES relative risk [30]. We use the same relative risk equations for prevalence (the proportion of people with disease in the total population) and mortality (the proportion of deaths due to a particular condition in the total population).

The relative risk equations derived from the literature estimate intentional injuries and road injury as a continuous positive function of mean drinking (varied by whether the individual binge drinks) [64]; HIV as a stepwise function of average drinking (by socioeconomic status) [65]; and liver cirrhosis and breast cancer as a continuous function of mean drinking [64]. The relative risks we will employ in our analysis and their corresponding ICD-10 codes are summarized in Table 22 below. The term ‘x’ in the table refers to the grams of alcohol consumed per day among current drinkers.

TABLE 22. RELATIVE RISKS USED IN THE WESTERN CAPE MODEL

Health condition	Relative risk for current drinkers	Relative risk for former drinkers	ICD-10 codes
HIV	Lower SES: RR= 2.99 if x > 61/49 grams per day (males/females) RR= 1.94 if x > 0 but < 61/94 grams per day (M/F) RR= 1 otherwise	RR=1	B20-B24
	Higher SES: RR= 1.54 if x > 61/49 grams per day (males/females) RR= 1 otherwise		
TB	RR= exp(0.0179695 .x)	RR=1	A15-19, B90
Intentional injuries	Drinkers: RR=exp(0.0199800266267306 .x)	RR=1	X60 – Y09 Y35 –36 Y870 Y871
	Heavy episodic drinkers: RR=exp(0.0199800266267306 .x + 0.647103242058538)		
Road Injury	Drinkers: RR=exp(0.00299550897979837 .x)	RR=1	V01–04, V06, V09–80, V87, V89, V99
	Heavy episodic drinkers: RR=exp(0.00299550897979837 .x + 0.959350221334602)		
Breast cancer	Females only: RR= exp(0.01018 .x)	RR=1	C50
Liver cirrhosis	If x <= 1: RR= 1+ x.exp ((β1+ β2).$\left(\sqrt{\frac{1+0.1699981689453125}{100}}\right)$ If x>1: 1 RR= 1 + x.exp ((β1+ β2).$\left(\sqrt{\frac{x+0.1699981689453125}{100}}\right)$ Where for females: β1= 2.351821 β_2 =0.9002139 Where for males: β_1= 1.687111 β_2 =1.106413	RR = 3.26 for both females and males	K70, K74

Notes: RR= Relative Risk; x = grams of alcohol consumed per day among current drinkers; heavy episodic drinking refers to drinking 60 grams of alcohol or more on one drinking occasion.

3.4.2 Baseline health data

The ideal dataset for baseline health would be provincially representative, include prevalence and mortality for each of the six health conditions of interest, be disaggregated by age and sex at the very minimum, and provide data for the baseline year. Unfortunately, such a dataset does not exist.

However, province-specific data on the number of deaths due to each of the disease/injury conditions of interest in this study can be derived from Statistics South Africa (2021) [66], the Second National Burden of Disease Study (2016) [67], and the Second Injury and Mortality Study (2017) [68]. Estimates of the number of deaths derived from these sources are shown in the top panel of Table 23. Baseline estimates of the number of deaths due to HIV and TB were derived from linear projections using the Second National Burden of Disease Study (2016) [67]. For injuries, we used 2017 population totals from the Second Injury Mortality Survey.

TABLE 23. ESTIMATED NUMBER OF DEATHS AND PREVALENCE IN THE WESTERN CAPE IN 2018 BY SEX ACROSS SIX CONDITIONS

	Males (aged 15+)	Females (aged 15+)	Total deaths (aged 15+)
Deaths			
HIV	1756	1643	3399
Liver cirrhosis	201	136	337
TB	1104	544	1648
Road Injury	988	244	1 236
Breast cancer	20	824	844
Intentional Injury	3 904	444	4350
Prevalence			
HIV	153 042	283 957	436 999
Liver cirrhosis	4903	5050	9953
TB	382 605	709 892	1 092 497
Road Injury	45 003	42 871	87 874
Breast cancer	194	10 289	10 483
Intentional Injury	99 746	124 204	223 950

In terms of the prevalence of each disease/injury condition, we draw on data from the Western Cape Burden of Disease Review [69] to obtain a baseline estimate of HIV and TB prevalence in the province. We were unable to find locally produced sources of prevalence for all other disease/injury conditions. We thus draw on estimates of prevalence derived from the Global Burden of Disease study [70], which reports on the prevalence of each of the remaining disease/injury conditions by sex and age in the Western Cape in 2018.

Gibbs and Van Walbeek (2021) do not use the raw prevalence estimates reported by the Global Burden of Disease study, and instead use the number of deaths they estimated using local data sources and multiply these deaths by the ratio between prevalence and deaths reported in the Global Burden of Disease study to obtain prevalence data for the Western Cape. These estimates are shown in the lower panel of Table 23.

To account for the reality that health outcomes in South Africa are not evenly distributed throughout the population, with the poor often bearing a higher burden of disease, depending on the illness, we draw on the percentage share of illness by wealth quintile for each of these alcohol-related health conditions included in this study, as estimated by Gibbs *et al*. (2021) using national-level data from the General Household Survey (GHS) (2018) [31]. The percentage share of disease, by wealth quintile, is shown in Table 24 below.

TABLE 24. SOCIOECONOMIC GRADIENTS OF HEALTH

	Quintile 1 (poorest)	Quintile 2	Quintile 3	Quintile 4	Quintile 5 (richest)
HIV	20%	36%	32%	9%	3%
Intentional injury	9%	29%	26%	26%	10%
Road injury	9%	29%	26%	26%	10%
Liver cirrhosis	9%	29%	26%	26%	10%
Breast cancer	7%	7%	22%	18%	47%
TB	25%	30%	31%	12%	3%

Source: Based on the estimates reported by Gibbs *et al*. (2021) using data from the General Household Survey of 2018 [30].

Liver cirrhosis is not included in the GHS. For liver cirrhosis, Gibbs *et al*. (2021) therefore use the same gradient as for injuries and justify this with reference to a study on health inequality in 22 European countries, which shows that inequalities in alcohol-related deaths (which are dominated by liver disease) are broadly similar to inequalities in injuries [71]. Gibbs *et al*. (2021) also use the broader category of cancer, which is included in the GHS, as a proxy for the prevalence of breast cancer within each wealth quintile since breast cancer is not explicitly included in the GHS [30].

3.4.2.1 Hospital cost data

Our model estimates the hospital cost-savings associated with each of the proposed closing time scenarios. This requires baseline estimates of the hospitalization costs associated with each disease and injury condition of interest in the Western Cape. We draw on the work of Gibbs *et al*. (2021) [30] to acquire these cost estimates, which are shown Table 25. Only the cost for treatment of breast cancer and TB come from the Western Cape, while the others are derived from national figures. The fact that the cost of treatment of four of the six conditions are taken from national data is a limitation of the model results.

While some of these costs were collected in the baseline year, those collected before 2018 are increased to 2018 prices in the model. This is done to account for inflation. Our approach to this inflation adjustment differs to that adopted by Gibbs *et al*. (2021) [30]. This is because we opt to use the CPI for medical products, not the overall CPI, as was done by Gibbs *et al*. (2021) [30], since we believe that this sector-specific CPI is a more appropriate indicator of changes in medical costs than the general CPI.

TABLE 25. BASELINE HEALTH CARE COSTS AND DATA SOURCES

Condition	Hospital cost (year cost was estimated) [cost in 2018 prices, where necessary]	Description and data source
HIV	R 3 318.62 (2017/18)	This is an annual cost, taken from a systematic literature review of the cost per patient for HIV services in South Africa [72]. Consistent with Van Walbeek and Gibbs (2021) [31], the cost we will use is for first-line treatment only, making it a modest estimate of the cost of HIV treatment in South Africa.
TB	R3193 (2011) [R 4 634 in 2018]	Costs of treating DS/MDR/XDR TB with a total cost of cases was $86 mill/$50 mill/$20 mill for 336,332/7,386/741 cases in a 2011 study. The annual cost per patient was $156 million divided by 344,459, or about $453. These are annual costs. All costs were expressed in 2011 $US at an exchange rate of $1USD = R7.05; $453 = R3,193 [73]. These costs were drawn from a Western Cape hospital.
Intentional Injury	R 58 928 (2013) [R 76 570 in 2018]	This cost is derived from a study that analysed violence-related emergency hospital admissions between January and March 2013 at a tertiary hospital in Northern KwaZulu-Natal [74]. This cost is estimated based on an average patient stay of 9.8 days.
Road injury	R 56 592.17 (2012) [R 77 770.85 in 2018]	This cost is based on a study that followed 100 patients admitted at Edendale hospital following a road traffic injury between late 2011 and early 2012 [75]. The cost is reported in dollars in the original article. We rely on the exchange rate adjustment applied by Van Walbeek and Gibbs (2021) [31] to arrive at this 2012 cost.
Liver Cirrhosis	R2 502 per day (2018)	We could not find a study that estimates the hospitalization costs of liver cirrhosis in the Western Cape, or South Africa. We will therefore use the general costs given in the District Health Barometer [76] as was done by Van Walbeek and Gibbs (2021) [31]. Based on these data, expenditure per patient day in district hospitals in the Western Cape in 2018 was R2 502. Van Walbeek and Gibbs (2021) make the conservative assumption of one patient day in their MUP model. We will validate this assumption with stakeholders.
Breast Cancer	Early stage: R 14 915 (2015) Late stage: R 16 869 (2015) Weighted average: R 15 775 (2015) [Weighted average: R 18 475 in 2018]	This cost comes from a study of 200 women at a government hospital in Cape Town (Groote Schuur) [77]. The average cost for breast cancer treatment varies depending on whether the individual was diagnosed at an early stage (56%), or at a late stage (44%). We take the weighted average of these costs.

Source: Gibbs *et al.* (2021) [30]

It should also be noted that, based on our reading of the Department of Health's guidelines for pharmacoeconomic submissions [31], future costs should be discounted at 5 per cent.

The proportion of people who go on to receive hospital treatment for a disease/injury condition is known as the multiplier. Table 26 shows the multipliers from population prevalence to hospital admission that will be used in our model, as well as the data sources from which they are derived. As was the case with hospital costs, the multipliers presented below are those used by Gibbs *et al*. (2021) [30].

TABLE 26. ESTIMATED MULTIPLIER FROM POPULATION PREVALENCE TO HOSPITAL ADMISSION

Condition	Multiplier	Description and data source
HIV	0.62	This multiplier was derived by Gibbs et al (2021) [30] using data from UNAIDS [78], which reports that 62% of people living with HIV in South Africa in 2018 were on treatment.
Intentional Injury	0.41	This multiplier was calculated by Gibbs et al (2021) [30] using research documenting trauma admissions in South Africa [79] combined with the Institute for Health Metric and Evaluation's Global Burden of Disease data [70] from the same year
Road Injury	0.19	This multiplier was calculated by Gibbs et al (2021) [30] using research documenting trauma admissions in South Africa [79] combined with data from the Institute for Health Metric and Evaluation's Burden of Disease data [70] from the same year.
Liver Cirrhosis	0.50	Following Gibbs *et al*. (2021) [30], we rely on liver cirrhosis in sub-Saharan Africa to inform this multiplier [80]. According to the study, 50% of patients are admitted to hospital with end-stage liver disease.
Breast Cancer	0.75	Gibbs et al (2021) found one study that shows the proportion of patients that have late-stage breast cancer (51%), but the paper does not provide information on the proportion that never receive hospital treatment [81]. We have been unable to find any updated research on this topic. Consistent with the previous research [30], we will use an estimate of 0.75 in our model.

Source: Gibbs *et al*. (2021) [30]

To estimate the healthcare cost savings associated with each of the trading time policy scenarios, we multiply the number of cases saved as a result of the policy by the proportion we would expect to receive healthcare (the multiplier, Table 26) and the associated cost (Table 25), discounted by 5 per cent.

3.5 Modelling consumption to harms

The consumption levels at baseline and for each policy scenario are taken from the part of the model that considers trading times to consumption, and these are used to calculate the impact on the six aforementioned alcohol-related harms.

3.5.1 Potential impact fractions

To link alcohol consumption to harms, we model the potential impact fractions for the Western Cape using our estimates of both mean and peak alcohol consumption. Potential impact fractions (PIF) are ratios between the lower level of risk of the alcohol-related condition after the policy to the level of risk before the policy [30]. We use them to adjust the underlying probability of disease or death from each of the six included health conditions under the policy. We calculate the potential impact fractions by dividing the relative risk under each policy by relative risk at baseline. Following Gibbs *et al.* (2021) our potential impact fractions incorporated population weights and were computed by sex (i), wealth group (j) and drinker group (k) using the following equation:

$$PIF_{ijk} = \left(\frac{RelativeRisk_{ijk}(policy)}{RelativeRisk_{ijk}(baseline)}\right)$$

3.5.2 Modelling the population and health outcomes under each policy scenario

The Western Cape population is projected forward 20 years to allow the full effect of the restrictions in onsite trading times on health outcomes to be realised for all of the included health conditions. This is done especially to account for the impact of decreases in alcohol consumption on breast cancer and liver cirrhosis. HIV, road injuries, intentional injuries, and TB realise the full impact of the reduction in drinking from the first year of the reduction in alcohol consumption, while the impact of decreased alcohol consumption on liver cirrhosis and breast cancer are subject to lags. Breast cancer only starts to see an impact at year 11 and it is 20 years until full effect, liver cirrhosis sees some impact from year one but does not realise the full effect until year 20 [82]. The way we quantify these lags in the model is shown in Table 27.

TABLE 27. MODELLED TIME-LAGS BY CONDITION – PROPORTION OF OVERALL CHANGE IN RISK EXPERIENCED IN EACH YEAR FOLLOWING A CHANGE IN CONSUMPTION

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Breast cancer	0	0	0	0	0	0	0	0	0	0	10	20	30	40	50	60	70	80	90	100
Liver cirrhosis	21	34	43	50	56	61	65	69	73	76	79	82	85	88	90	92	94	96	98	100

Source: Holmes *et al.* (2012) [82]

When projecting the Western Cape's population 20 years forward, we only model alcohol consumption for those aged 15 and over. To ensure that we do not miss any 15 year-olds in the 20th year of the model, we create a life table, starting at age 0, to which we added births for 5 years after the baseline (i.e., births occurring between 2019 and 2023). Data on these births are obtained from Statistics South Africa's provincial projections by sex and age [83]. The population was split into wealth quintiles and drinker groups using the proportions from the SADHS dataset. Multistate life tables were then created in which the population faces a probability of mortality for each of the six disease/injury conditions and for other cause mortality each year [84]. The population for the following year is then calculated by taking the deaths away from the population at the beginning of the time period. This approach allows for the simulation of multiple diseases simultaneously. The approach assumes diseases are independent of one another.

The model generates alternative potential impact fractions (as described above) for each policy scenario which allowed us to rerun the multistate life table model for each scenario. The life tables for the 20 year model were saved for each of the policy scenarios. They were then used in combination with the probability of having the disease under each policy to estimate the number of cases/prevalence.

3.6 Economic costs

The final component of our model requires estimating the impact of the three different onsite trading time restrictions on individual alcohol spend, alcohol excise taxes, Value Added Tax (VAT), retail revenue, and crime costs. To construct estimates of the spending and tax variables in the baseline, we use data from the International Alcohol Control Study (2014) [85], wave 4 of the National Income and Dynamics Study [43], and the 'actual collections' of excise taxes of revenue for the 2018/2019 fiscal year reported in the 2020 National Treasury Budget Review [86]. For the impact of the various trading time restrictions on crime costs, we draw on the estimated costs of crime in South Africa derived by Alda *et al*. (2021) [87] and the estimates of alcohol-attributable fractions of crime reported by Matzopolous *et al*. (2014) [88].

3.6.1 Baseline alcohol expenditure

The central variable required to calculate individual alcohol expenditure in the baseline is alcohol prices. After scanning the survey landscape, we found four surveys that provide information on alcohol prices. These are the 2014/2015 National Income Dynamic Study (NIDS), the 2010/2011Income and Expenditure Survey (IES), the 2014/2015 International Alcohol Control (IAC) Study (the data we explored only represent the South African arm of this multi-country study) and the 2019 South Africa Wine Industry Information and Systems (SAWIS) [89].

After exploring each of these datasets, and the literature that has invoked their use in estimating alcohol prices [30, 31, 90], we select the IAC dataset as our preferred data source. An added benefit of the IAC dataset is that it has been previously used to estimate the impact of other alcohol-control policies in the Western Cape [31], which would facilitate comparison between different policy options for controlling alcohol use in the province.

The IAC is a household survey that was conducted in the metropolitan district of Tshwane in 2014. Eligible participants were adults between the ages of 18 and 65 who had consumed alcohol in the past 6 months [91]. The total sample of adults in the IAC study is 1 975. The survey uses a multi-stage stratified cluster random sampling design [91]. That the data were sampled from the metropolitan district of Tshwane only represents a limitation of these data for our purpose of understanding alcohol prices in the Western Cape. Of the total IAC sample of 1975 observations, 949 individuals provided information about their consumption and prices paid across at least 12 alcoholic beverages purchased across 11 onsite locations and 8 offsite locations [85].

There are two ways that one can go about using the IAC price data to estimate baseline expenditure on alcohol in the Western Cape. The first is to estimate expenditure directly using the variables that capture the frequency of drinking or purchasing drinks at each location, the number of drinks purchased at each location, and the price paid per drink at these locations contained in the IAC dataset. The specific questions regarding these data employ a timeframe of the past 6 months, and generally ask about the typical quantities purchased and typical expenditure per unit of alcohol across a variety of different alcoholic beverages. As a result, we are able to calculate the typical annual spend on alcohol for each individual *i* by using the following equation:

$$Annual\ spend_i = \sum_{location=k} \sum_{beverage=j} \left(frequency_{ijk} \times typical\ quantity_{ijk} \times typical\ price_{ijk}\right) \times 2$$

In this equation, $frequency_{ijk}$ represents the number of times individual i drinks alcoholic beverage j at location k; $typical\ quantity_{ijk}$ represents the typical number of drinks of beverage j that individual i would drink on an outing to location k; and $typical\ price_{ijk}$ represents the typical price that individual i would pay for alcoholic beverage j at location k. Given that all figures in the IAC data are reported for the previous six months, the final expenditure is multiplied by 2 in order to derive an estimate of annual spend. The drawback of this approach is that it relies on consumption patterns in Tshwane to establish baseline alcohol expenditure, which are not necessarily representative of those in the Western Cape.

An alternative is to only make use of the price data contained in the IAC to arrive at estimates of alcohol prices in the baseline year, and map these onto the consumption patterns of the Western Cape drinking population. Since this approach allows us to account for baseline alcohol consumption in the Western Cape, and it reflects the approach adopted by Van Walbeek and Gibbs (2021) to estimate the impact of an implementing a minimum unit price in the Western Cape [31], we opt for this second approach.

Gibbs *et al*. (2021) [30] apply well-documented downward adjustments to the IAC prices using data from the South African Wine Industry Information and Systems (SAWIS) [89], which reports on price data relating only to offsite prices of wine, as well as the cheapest prices obtained from a promotional drinks flier, which showed prices for boxed wine and beer. Following these adjustments, documented in detail in Gibbs *et al*. (2021) [30], prices were then adjusted for inflation to the baseline year of 2018.

Consistent with Gibbs *et al*. (2021) [30], we group IAC prices by wealth and drinker group definitions (the latter of which are provided in section 3.2.7) and weight each price by the number of standard drinks over six months using the container size, drink strength and the frequency of purchase variables provided in the IAC dataset. We then merge these 'grouped' prices with the raked SADHS consumption data. Mean alcohol prices, consumption and expenditure are shown in Table 28.

TABLE 28. BASELINE AVERAGES: ALCOHOL PRICES, WEEKLY CONSUMPTION AND WEEKLY ALCOHOL EXPENDITURE, BY DRINKER GROUP

Drinker group	Price	Consumption	Expenditure
Moderate drinker	R10.83	4.1	R44
Occasional binge	R11.45	5.1	R58
Heavy drinker	R11.01	37.2	R409

Notes: Own calculations based on South African IAC price data (2015) [35], and raked SADHS (2016) consumption data [15]. Expenditure estimates are rounded to the nearest whole number.

In modelling the impact of the proposed closing times at onsite alcohol trading venues on all individual-level alcohol expenditure, we assume that alcohol prices remain unchanged and apply the modelled one-year impact of the various onsite trading time scenarios on alcohol consumption to the baseline prices and then calculate the difference between expenditure under the policy and baseline.

To arrive at a measure of aggregate alcohol expenditure in the baseline year, we apply our raked population weights to the individual-level expenditure figures that make up the averages presented in Table 28. Aggregate spend is estimated on an annual basis. This value is then increased by 1.25 (100/80) to account for the fact that we have only calibrated consumption to 80% of Euromonitor (2018) sales volume data.[12] This approach, which is consistent with that of Gibbs *et al*. (2021) [30], is repeated for each proposed closing time scenario to arrive at an estimate of aggregate alcohol spend under each policy scenario. We estimate that aggregate annual alcohol spend in the Western Cape stands at R 42 687 million in the baseline year (Table 29).

Since this measure of aggregate alcohol spend is used to derive other important baseline 'economic' variables such as VAT and total alcohol retail revenue, we list the baseline estimates of all aggregate economic variables in Table 29, for ease of reference, and discuss their derivation below.

TABLE 29. BASELINE AGGREGATE ECONOMIC VARIABLE ESTIMATES, R MILLION (2018 PRICES)

(1) Aggregate spend	42 687
(2) Excise tax	4 420
(3) Value Added Tax	5 568
(4) Retail revenue = (1) – (2) – (3)	32 669

[12] As detailed in section 3.2.3, when the SADHS consumption estimates were shifted to calibrate to Euromonitor market research sales data, only 80% of the consumption figure was used (to take account of spillage, stockpiling and consumption by foreign visitors). The remaining 20% of alcohol consumption needs to be included in the headline sales revenue.

3.6.2 Excise tax revenue and VAT

We derived our baseline excise tax data from the Statistical Annexure of the National Treasury’s 2019 Budget Review [86], which presents revenue and taxes for the 2018/2019 financial year. The value of alcohol excise taxes in the 2018/2019 financial year stood at around R 25 998 million [86]. Because the Treasury provides a national picture of alcohol excise tax revenue, we needed to estimate the proportion of this revenue that reflects the Western Cape's contribution to the total alcohol excise tax pot. We use the data contained in NIDS Wave 4 to estimate this proportion [43]. From the NIDS data, we estimate that 17% of total expenditure on alcohol in South Africa came from the Western Cape [43]. Applying this proportion of expenditure to Treasury’s estimate of national alcohol excise tax suggests that alcohol consumption in the Western Cape contributed to R4 420 million to the national excise tax pot.

A limitation of using the NIDS data to estimate this proportion is that the NIDS does not provide information on the categories of alcohol consumed. Our estimate of the excise tax proportion in the baseline year is thus based on the assumption that the drinking patterns (by beverage type) in the Western Cape are similar to those of the country. It is likely, however, that drinkers in the Western Cape consume more wine than drinkers in other provinces. Since wine is taxed at a lower rate than other alcoholic beverages, our baseline estimate of the Western Cape’s contribution to the national excise tax pot may be an overestimate.

To model changes in our tax-related variables, we calculate the total *volume* of alcohol consumed at baseline and each of our nine policy scenarios. We then calculate the percentage change in volume from the baseline for each of the nine onsite closing time scenarios and apply the percentage change in volume to the base excise tax. Implicit in this approach is the assumption of a fixed ratio between the volume of alcohol and excise tax.

We calculate VAT by assuming 13 per cent (15/(100+15)) of the base retail expenditure is VAT. This accounts for the fact that the VAT is levied on the net-of-VAT retail price, not the VAT-included retail price. Our baseline estimate of VAT derived from all alcohol sales in the Western Cape, as derived in section 3.6.2 above, is R 5 568 million (=R42 687 million/115x15). Our estimate of VAT revenue under each closing time scenario is calculated using the same principle.

3.6.3 Retail revenue

Our baseline estimate of alcohol retail revenue across all alcohol retailers (onsite and offsite) is constructed as the Aggregate Spend less VAT and Excise Tax revenue. We estimate that the revenue to alcohol retailers at all trading locations in the Western Cape was R 32 669 million in the baseline. This calculation is performed under each onsite closing time scenario, with the difference between baseline and ‘policy’ retail revenue measuring the change due to the modelled closing time restriction.

3.6.4 Cost of combatting alcohol-related crime

Data on the cost of alcohol-attributable crime in the Western Cape do not exist [92]. To estimate the cost of combatting alcohol-attributable crime in the baseline year, we follow the work of Van Walbeek and Gibbs (2021) [31] and draw on (1) the available literature that provides national estimates of the cost of crime as a proportion of GDP by three broad categories: correctional services, police and public security, and justice [36], (2) literature that reports on the alcohol-attributable fractions of the aforementioned national proportions [37], and (3) estimates of the Western Cape's GDP provided by Statistics South Africa (2019) [92]. Through this process, we estimate that the cost of alcohol-attributable crime in the Western Cape was R3 889 million in the baseline year (column 5, Table 30). The method used to derive this estimate is presented below Table 30.

TABLE 30. DERIVATION OF THE COST OF ALCOHOL-RELATED CRIME IN THE WESTERN CAPE, 2018

(1) Activity	(2) Cost of combatting crime in South Africa (% of national GDP)	(3) Alcohol-attributable fractions (%)	(4) Alcohol-attributable costs of crime (% of national GDP)	(5) Cost of alcohol-attributable crime in the Western Cape (R million)
Correctional services	0.54	38.5	0.208	1379
Police and public security	1.65	22.5	0.371	2462
Justice	0.36	2.0	0.007	48
Total				3 889

The crime costs reported in Table 30 are calculated as a percentage of the Western Cape's GDP. In the absence of provincial level data on this percentage, we draw on the results of a 2011 study that estimates the costs of crime in South Africa as a percentage of GDP on the basis of three components: correctional services, police and public security, and justice [36]. These were estimated at 0.54, 1.65 and 0.36 per cent of national GDP, respectively [36]. These are reported in column 2 of Table 30.

We then use the alcohol-attributable fractions from the literature to allocate how much of those costs are incurred because of alcohol (column 3 of Table 30). These alcohol-attributable fractions are taken from Matzopoulos *et al*. (2014) [88], who took them from Budlender (2009) [93]. These are estimated at 38.5 per cent for correctional services, 22.5 per cent for police and public security, and 2 per cent for justice (column 3, Table 30). We then use these alcohol-attributable fractions from the literature to estimate the alcohol-attributable costs of crime as a percentage of national GDP (column 4 of Table 30). Multiplying these fractions by the Western Cape's 2018 GDP, which Statistics South Africa (2019) reports was R 663 276 million [92], yields the cost of crime estimates reported in the final column, which sums to the R3 889 million reported at the start of this section.

Our modelling assumptions follow those of Van Walbeek and Gibbs (2021) [31], who assume that a percentage reduction in alcohol consumption translates to an exact percentage reduction in the cost of combatting alcohol-attributable crime in the Western Cape.

4. RESULTS

This section of the report provides the results of the model. The estimated impact of the proposed closing time scenarios on alcohol consumption are shown in section 4.1. Section 4.2 shows the estimated impact of the proposed closing times on alcohol expenditure, tax and retail revenue. The estimated impact on the cost of combatting alcohol-related crime is reported in section 4.3, section 4.4 provides the estimated impact of each closing time scenario on health outcomes and costs, and section 4.5 provides the results of an alternative model specification to derive estimates of the impact of the proposed trading times intervention on intentional injuries and its associated hospital costs

4.1 Consumption estimates

In the baseline, drinkers in the Western Cape consume, on average, 8.42 standard drinks per week at onsite locations, with heavy drinkers averaging 13.1 drinks per week at onsite venues.

Each proposed closing time scenario corresponds to a reduction in weekly alcohol consumption at onsite drinking locations. Depending on the elasticity applied, we estimate a mean reduction in total onsite consumption of between 0.2 and 0.8 standard drinks per week following a midnight closing time (Figure 16). This translates to a reduction of between 2.8 and 9.4 per cent in weekly alcohol consumption at onsite venues (Figure 17).

We estimate a mean reduction in overall onsite consumption of between 0.1 and 0.4 standard per week drinks following a 1am closing time, depending on the elasticity applied (Figure 16). This translates to a reduction of between 1.5 and 5.1 per cent in weekly alcohol consumption at onsite venues (Figure 17). A 2am closing time has a negligible impact on weekly standard drinks consumed at onsite drinking locations. Mean weekly consumption at onsite venues decreases by -0.02 standard drinks per week under the low elasticity scenario (ε_{TT}=0.3) and 0.1 standard drinks per week under the high elasticity scenario (ε_{TT}=1) (Figure 16). In percentage terms, mean weekly standard drinks decrease by between 0.2 and 0.8 per cent at a 2am closing time (Figure 17).

FIGURE 16. MEAN CHANGE IN STANDARD DRINKS AT ONSITE VENUES PER WEEK AT 12AM, 1AM AND 2AM CLOSING TIMES, BY DRINKER TYPE (3 ELASTICITIES PER SCENARIO)

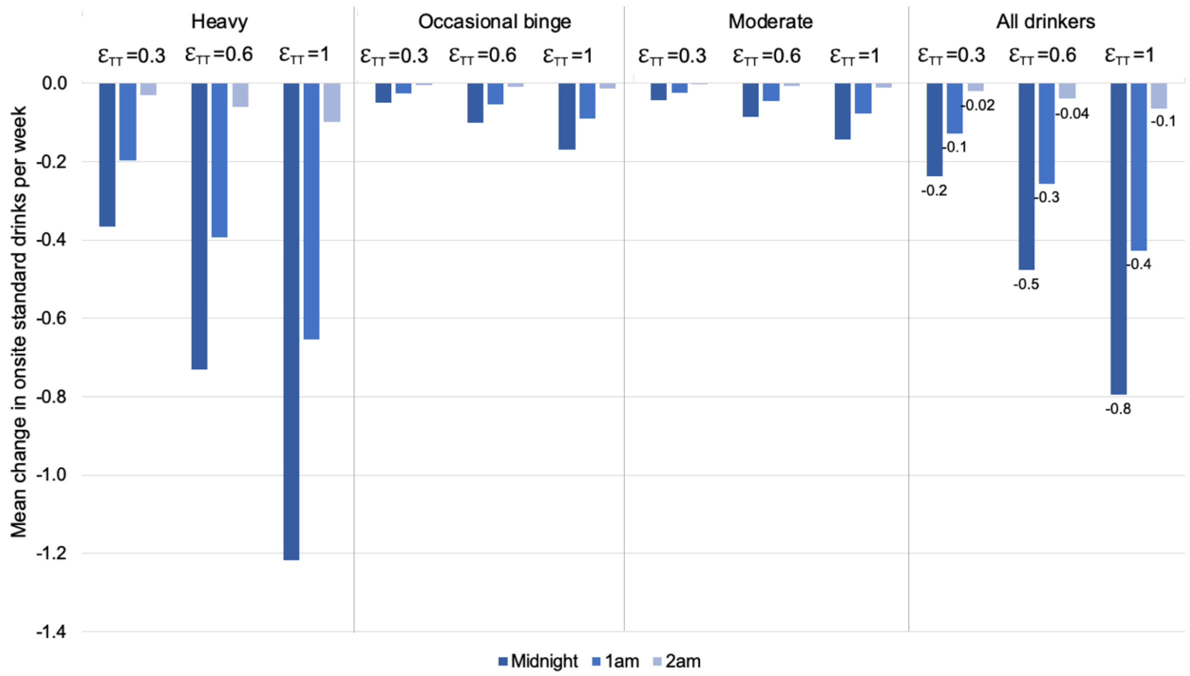
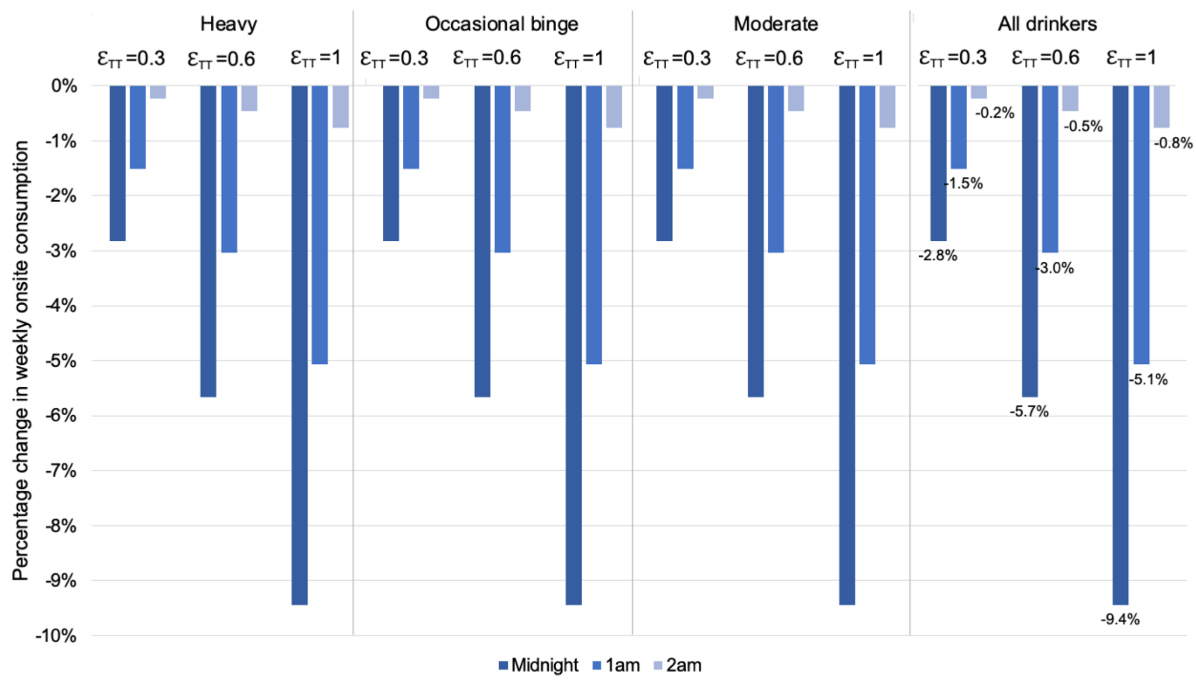


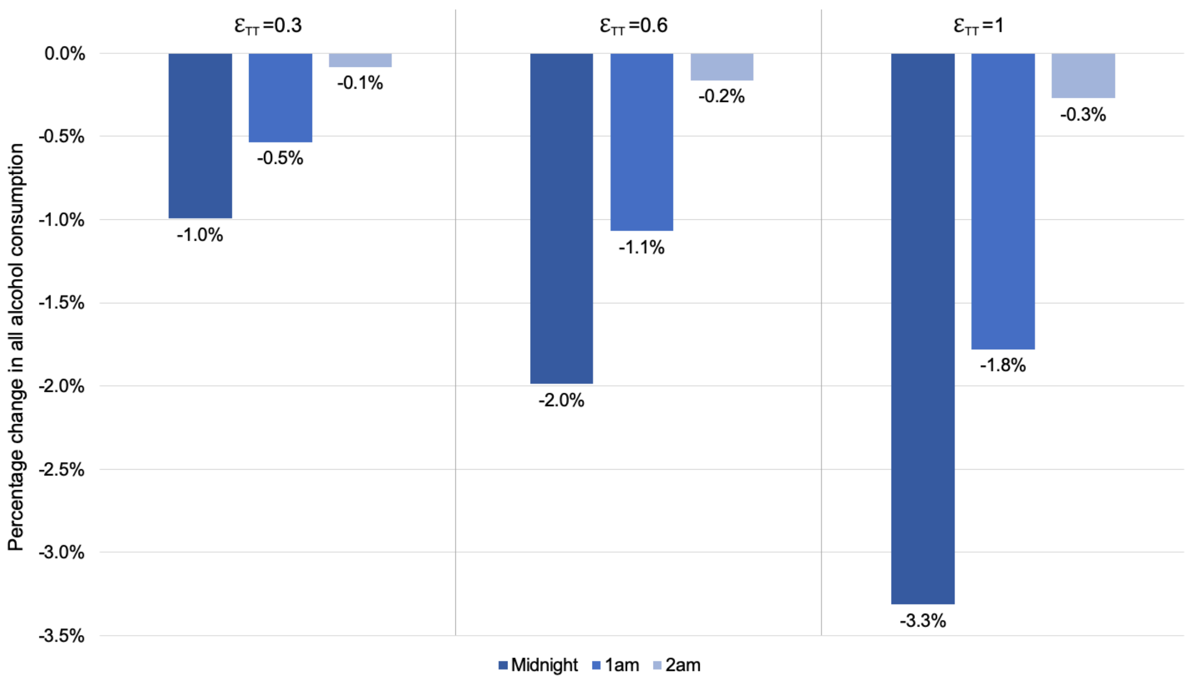
FIGURE 17. PERCENTAGE CHANGE IN CONSUMPTION AT ONSITE VENUES FOR 12AM, 1AM AND 2AM CLOSING TIMES, BY DRINKER TYPE (3 ELASTICITIES PER SCENARIO)



In absolute terms, the reduction in weekly onsite consumption is largest for heavy drinkers at all closing times, though these changes translate to equivalent percentage changes across drinker types since the trading time elasticities do not vary by drinker group. Under a midnight closing scenario, using the mid-range elasticity estimate (ε_{TT}=0.6), we estimate a mean reduction of around 0.7 standard drinks at onsite venues per week for heavy drinkers, and a mean decrease of 0.1 standard drinks at onsite venues per week for occasional binge drinkers and moderate drinkers (Figure 16).

Assuming that there is no change in alcohol consumption at offsite drinking locations following the one-year impact of the modelled changes in onsite trading times, Figure 18 shows how restricting onsite trading times affects total alcohol consumption in the Western Cape, where total alcohol consumption refers alcohol consumption at both onsite and offsite trading locations. With a trading times elasticity of 0.6, we estimate a mean reduction in total alcohol consumption of 2 per cent at a midnight closing time, a reduction of 1.1 per cent at a 1am closing time, and 0.2 per cent at a 2am closing time.

FIGURE 18. PERCENTAGE CHANGE IN WEEKLY TOTAL ALCOHOL CONSUMPTION FOR 12AM, 1AM AND 2AM CLOSING TIMES (3 ELASTICITIES PER SCENARIO)



4.2 Expenditure estimates

4.2.1 Individual alcohol expenditure estimates

Each proposed closing time scenario corresponds to a reduction in average annual alcohol expenditure per individual drinker. Figure 19 reports on the absolute change in annual alcohol expenditure under each policy scenario. Figure 20 shows the change in percentage terms. Depending on the elasticity applied, we estimate a reduction in average individual alcohol expenditure of between 1 per cent and 3.3 per cent at a midnight closing time (Figure 20), a reduction of between 0.5 per cent and 1.8 per cent at a 1am closing time and a reduction of between 0.1 per cent and 0.3 per cent at a 2am closing time.

FIGURE 19. ESTIMATED IMPACT OF 12AM, 1AM AND 2AM CLOSING TIMES AT ONSITE VENUES ON MEAN ANNUAL ALCOHOL EXPENDITURE, BY DRINKER TYPE (3 ELASTICITIES PER SCENARIO)

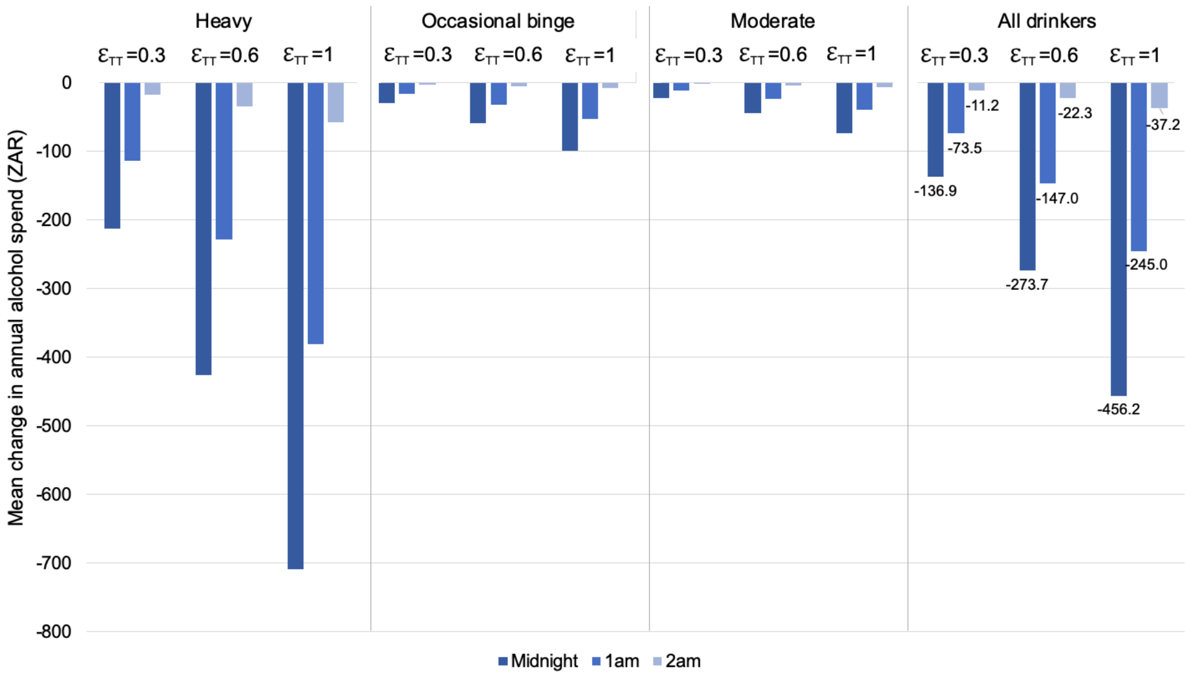
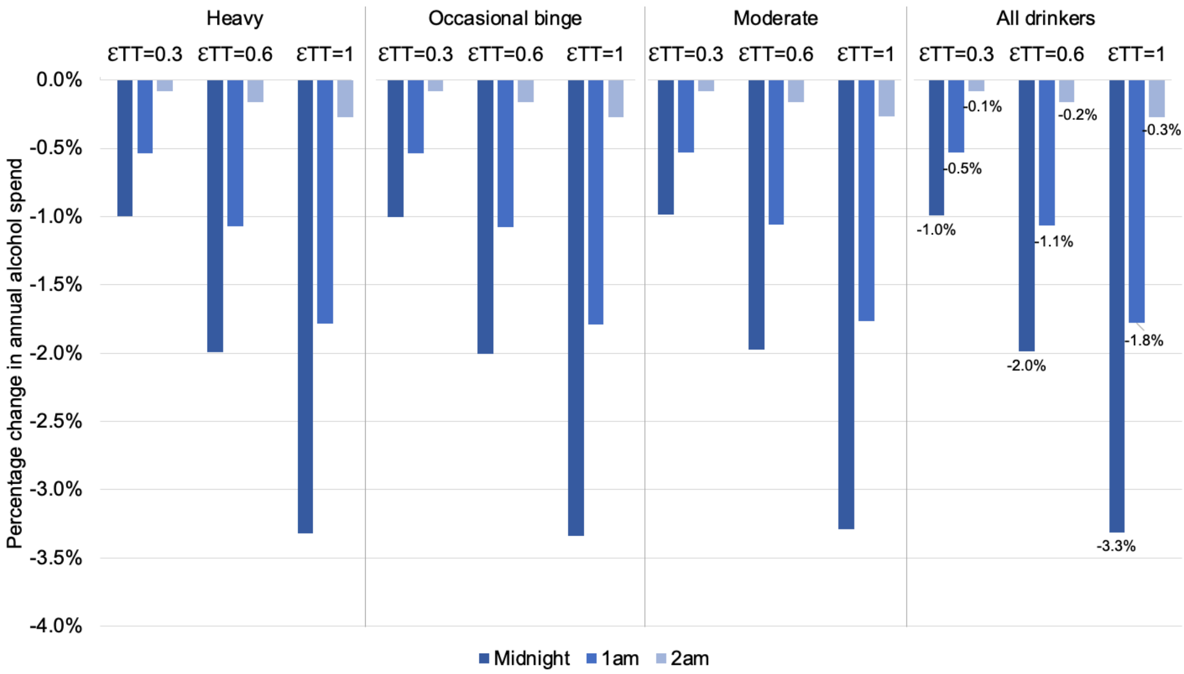


FIGURE 20. ESTIMATED PERCENTAGE CHANGE IMPACT OF 12AM, 1AM AND 2AM CLOSING TIMES AT ONSITE VENUES ON MEAN ANNUAL ALCOHOL EXPENDITURE BY DRINKER TYPE (3 ELASTICITIES PER SCENARIO)



4.2.2 Aggregate alcohol expenditure, tax and retail revenue estimates

The impact of each proposed closing scenario at onsite trading locations on aggregate alcohol spend, tax, and retail revenue is shown in Table 31. The percentage decrease relative to the baseline is shown in the final row for each elasticity scenario. These are identical given our assumptions documented in section 3.6.2. Each proposed closing time scenario is associated with a decrease in our tax and revenue variables of interest. The reduction in aggregate alcohol spend, VAT, excise tax and retail revenue is largest under a midnight closing scenario and lowest under a 2am closing time scenario.

TABLE 31. IMPACT OF A MIDNIGHT, 1AM AND 2AM CLOSING TIME SCENARIO AT ONSITE TRADING LOCATIONS ON TOTAL TAX AND TOTAL RETAIL REVENUE, ESTIMATED ON AN ANNUAL BASIS

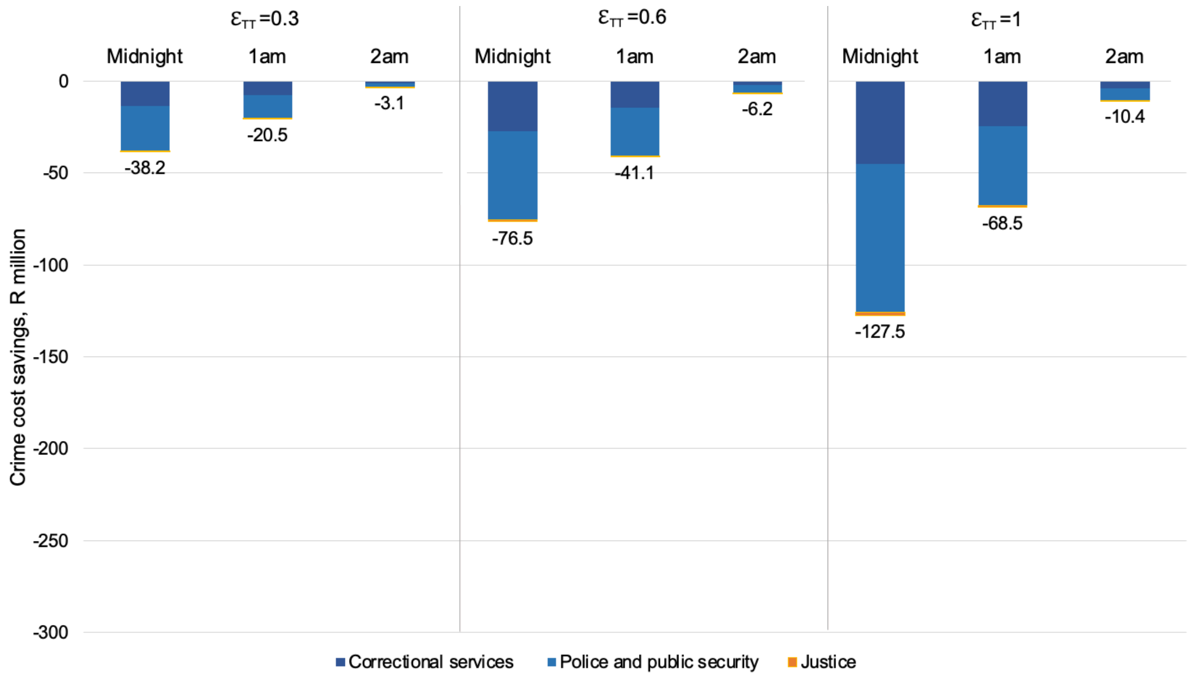
	Midnight	**1am**	**2am**
	ε_{TT}=0.3 (R, million)		
Change in aggregate alcohol spend	-428	-230	-35
Change in VAT	-56	-30	-5
Change in excise tax	-44	-24	-4
Change in retail revenue	-328	-176	-27
Percentage change for (1), (2), (3), (4)	-1.0%	-0.5%	-0.1%
	ε_{TT}=0.6 (R, million)		
Change in aggregate alcohol spend	-856	-460	-70
Change in VAT	-112	-60	-9
Change in excise tax	-88	-47	-7
Change retail revenue	-656	-352	-53
Percentage change for (1), (2), (3), (4)	-2.0%	-1.1%	-0.2%
	ε_{TT}=1 (R, million)		
(1) Change in aggregate alcohol spend	-1426	-766	-116
(2) Change in VAT	-186	-100	-15
(3) Change in excise tax	-147	-79	-12
(4) Change retail revenue	-1093	-587	-89
Percentage change for (1), (2), (3), (4)	-3.3%	-1.8%	-0.3%

Under the mid-range elasticity scenario (ε_{TT}=0.6), we estimate that a midnight closing time is associated with R 112 million decrease in annual government revenue from VAT; a R 88 million decrease in annual government revenue from excise tax; and alcohol retailers lose R 656 million. These decreases reduce to an annual loss in VAT and excise tax revenue of R 60 million and R 47 million, and retail revenue loses of R 352 million at a 1am closing time, reducing further to estimated losses of R9 million in annual VAT revenue, R 7 million in annual excise tax revenue and R53 million in annual retail revenue at a 2am closing time.

4.3 Cost of combatting alcohol-related crime estimates

The cost of combatting alcohol-related crime in the Western Cape is reduced under each proposed closing time scenario (Figure 21.). Depending on the elasticity applied, we estimate a reduction in the costs of combatting alcohol-related crime of between R38.2 million (1.0 per cent) and R127.5 million (3.3 per cent) under a midnight closing time, a reduction of between R20.5 million (0.5 per cent) and R68.5 million (1.8 per cent) at a 1am closing time, and reduction of between R3.1 million (0.1 per cent) and R10.4 million (0.3 per cent) at a 2am closing time.

FIGURE 21. CRIME COST SAVINGS AT A MIDNIGHT, 1AM AND 2AM CLOSING TIME, ESTIMATED ON AN ANNUAL BASIS (3 ELASTICITIES PER SCENARIO)



4.4 Health estimates

4.4.1 Estimated impact on deaths and prevalence

Headline deaths and cases averted under each proposed closing time scenario are presented in Table 32. Estimates for deaths are rounded to the nearest ten. Estimates for prevalence are rounded to the nearest hundred.

We estimate that between 570 and 1 500 alcohol-related deaths are averted over 20 years at a midnight closing time, between 240 and 810 alcohol-related deaths are averted at a 1am closing time, and between 40 and 80 alcohol-related deaths are averted over 20 years at a 2am closing time. In terms of disease prevalence, we estimate that between 163 800 and 453 000 cases of the alcohol-related conditions included in this study will be averted over 20 years under a midnight closing time scenario, between 68 500 and 193 200 cases will be averted under 1am closing time scenario, and between 12 600 and 28 300 cases will be averted under a 2am closing time scenario.

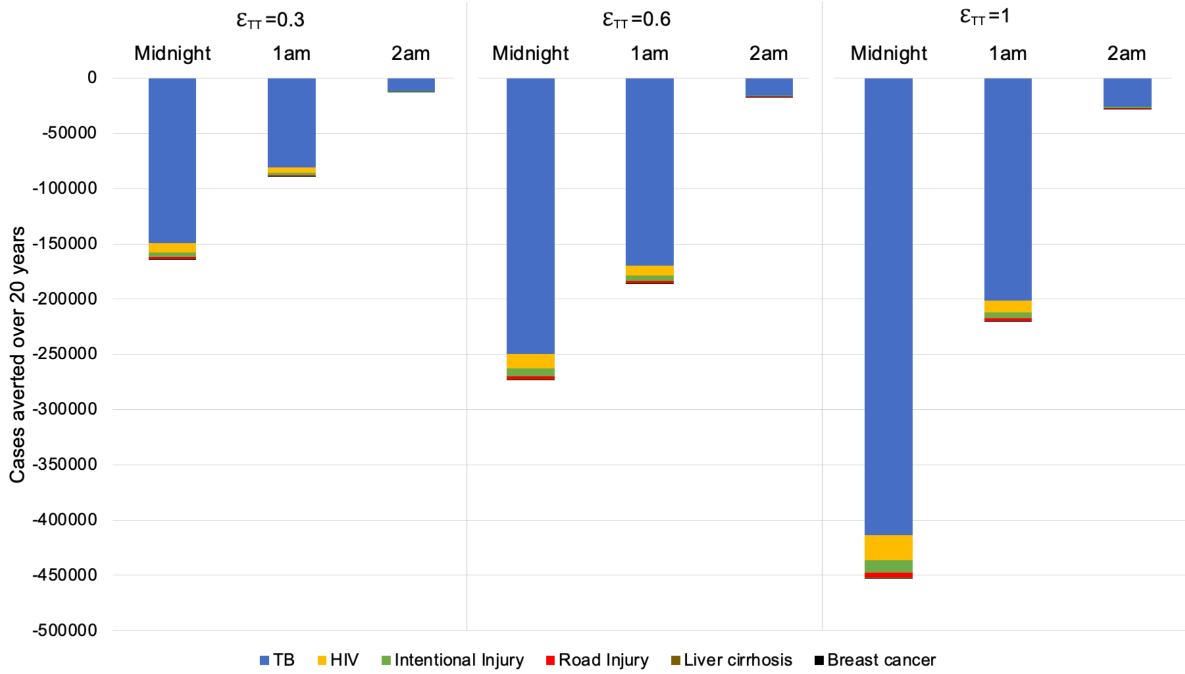
TABLE 32. HEADLINE DEATHS AND CASES AVERTED OVER 20 YEARS FOLLOWING A MIDNIGHT, 1AM AND 2AM CLOSING TIME AT ONSITE TRADING LOCATIONS

	Elasticity applied	**Midnight**	**1am**	**2am**
Deaths averted	ε_{TT}= 0.3	570	240	40
	ε_{TT}= 0.6	950	660	50
	ε_{TT}= 1	1500	810	80
Cases averted	ε_{TT}= 0.3	163 800	88 700	12 600
	ε_{TT}= 0.6	273 000	185 700	17 000
	ε_{TT}= 1	453 000	220 300	28 300

Notes: The six conditions included in our reporting of headline deaths and cases are: HIV, intentional injury, road injury, TB, liver cirrhosis and breast cancer. Estimates for deaths are rounded to the nearest ten. Estimates for prevalence are rounded to the nearest hundred.

Figure 22 shows the cases averted over 20 years by health condition. Our model suggests that the largest impact of the reductions in alcohol consumption resulting from the proposed closing time scenarios is on the prevalence of TB (over 90 per cent). This is due to the steepness of TB's relative risk curve (see Appendix 4) and because TB accounts for around 59 per cent of all disease cases in the Western Cape in the model baseline (refer to Table 23).

FIGURE 22. COMPARING CASES AVERTED OVER 20 YEARS BY DISEASE CATEGORY, 3 ELASTICITIES PER SCENARIO



4.4.2 Hospital cost saving estimates

Estimates of the hospital cost savings associated with each of the proposed closing time scenarios are shown in Table 33. The largest cost savings are for TB, followed by intentional injury. Depending on the elasticity applied, we estimate a total hospital cost saving due to reductions in the prevalence of the six alcohol-related conditions included in our analysis of between R 326.8 million and R890.2 million under a midnight closing time scenario, a reduction of between R 130.5 million and R381.2 million under a 1 am closing time scenario, and a reduction of between R 18.7 million and R 46 million under a 2am closing time scenario.

TABLE 33. ESTIMATED HOSPITAL COST SAVINGS IN R MILLION AT A MIDNIGHT, 1AM AND 2AM CLOSING TIME, DISCOUNTED AT 5 PER CENT, 3 ELASTICITES PER SCENARIO

	ε_{TT}= 0.3			**ε_{TT}= 0.6**			**ε_{TT}= 1**		
	Midnight	**1am**	**2am**	**Midnight**	**1am**	**2am**	**Midnight**	**1am**	**2am**
Total hospital cost savings	**326.8**	**130.5**	**18.7**	**503.5**	**353.0**	**29.1**	**890.2**	**381.2**	**46.0**
Breast cancer	0.3	0.3	0.1	0.5	0.3	0.1	0.9	0.4	0.1
HIV (first-line treatment	8.8	3.0	0.0	11.7	9.5	0.0	15.0	10.2	0.0
Intentional injury	72.0	28.8	1.2	85.5	77.8	3.9	185.1	84.0	5.4
Liver cirrhosis	1.3	0.6	0.2	2.7	1.4	0.3	4.4	1.5	0.4
Road injury	29.8	11.9	0.7	43.0	32.2	2.0	89.7	34.7	2.8
TB	214.7	85.9	16.5	360.0	231.8	23.0	595.1	250.4	37.3

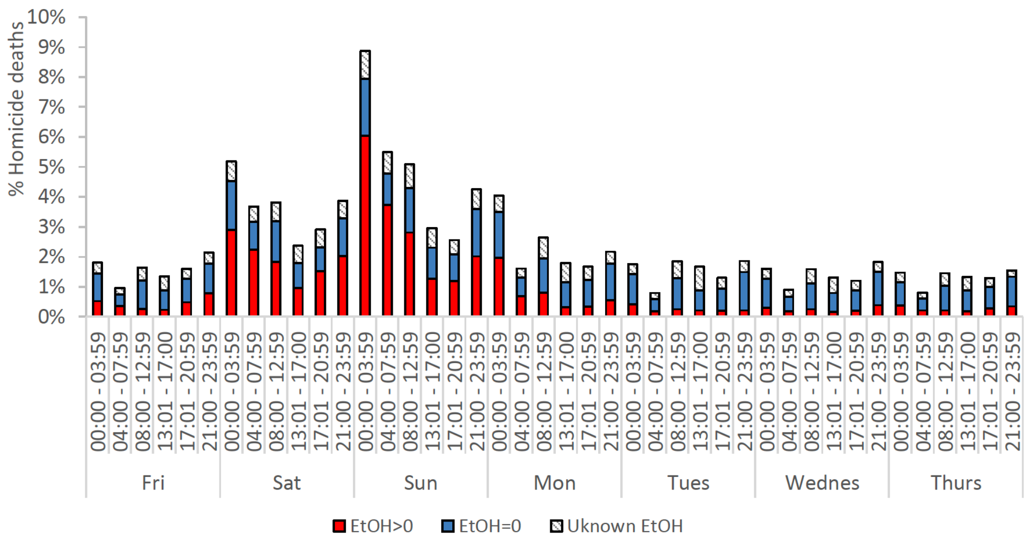
4.5 Alternate model specification for acute alcohol related harms

Though we use a range of elasticity estimates in our model to forecast the likely health impact associated with each of the proposed closing times at onsite retailers, our results for the acute health outcomes of interest (road injury and intentional injury) are likely conservative estimates. This is because the trading time elasticities used up to this point do not account for the fact that a drinkers' blood alcohol concentration increases as the duration of their drinking occasion increases and that such increases in blood alcohol concentration are associated with increases in acute alcohol-related harms [94]. Put differently, our model weights all drinking hours equally in terms of the risk of experiencing an acute alcohol-related harm, when they are not. The risk of harm increases with each drinking hour. It is therefore conservative to weight all drinking hours equally, as our model has done.

We considered two ways to account for this. One way is to adjust the relative risk equations used in our model to account for escalated acute-harm risk between midnight and 2am. The basis on which this adjustment could be made is with blood alcohol data for injuries at different times of day. Using this information, we could then upscale the relative risks for acute harms by a 'correction factor', which reflects the proportion of positive values for blood alcohol content by hour of day. To this end, we reviewed the Western Cape Injury Mortality Profile Report covering the period 2010–2016 [95], which uses Forensic Pathology Services (FPS) data to provide an analysis of the frequency of road and intentional injuries by day of week, time of day, and alcohol level.

Unfortunately, the way the data are presented is not suitable for adopting this approach since the 'time of day' is lumped into groups, making it impossible to disaggregate by hour in the absence of the raw data. We show the figure presented in the Western Cape Injury Mortality Profile Report for the homicides (figure 4.8 in the original report), as an example.

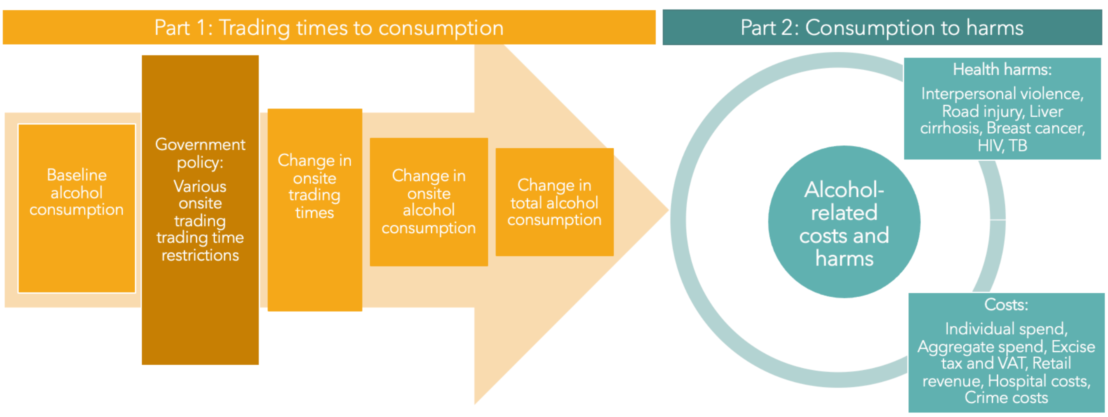
FIGURE 23. FREQUENCY OF HOMICIDES BY DAY OF WEEK, TIME OF DAY, AND ALCOHOL LEVEL



Source: Western Cape Injury Mortality Profile Report [95]

The second way to account for this is to alter our modelling framework, originally shown in Figure 6, and reproduced in Figure 24, such that the link between changes in trading times and acute alcohol-related harms does not work through the channel of alcohol consumption, but rather works directly through a harm elasticity that measures the responsiveness of acute alcohol-related death and disease to changes in outlet trading times. The revised framework is shown in Figure 25.

FIGURE 24. REPRODUCTION OF FIGURE 6: MODELLING APPROACH FOR ESTIMATING THE HEALTH AND ECONOMIC IMPACTS OF REDUCTIONS IN ONSITE TRADING TIMES FOR ESTABLISHMENTS SELLING ALCOHOL



Source: Adapted from Gibbs et al. (2021) [30]

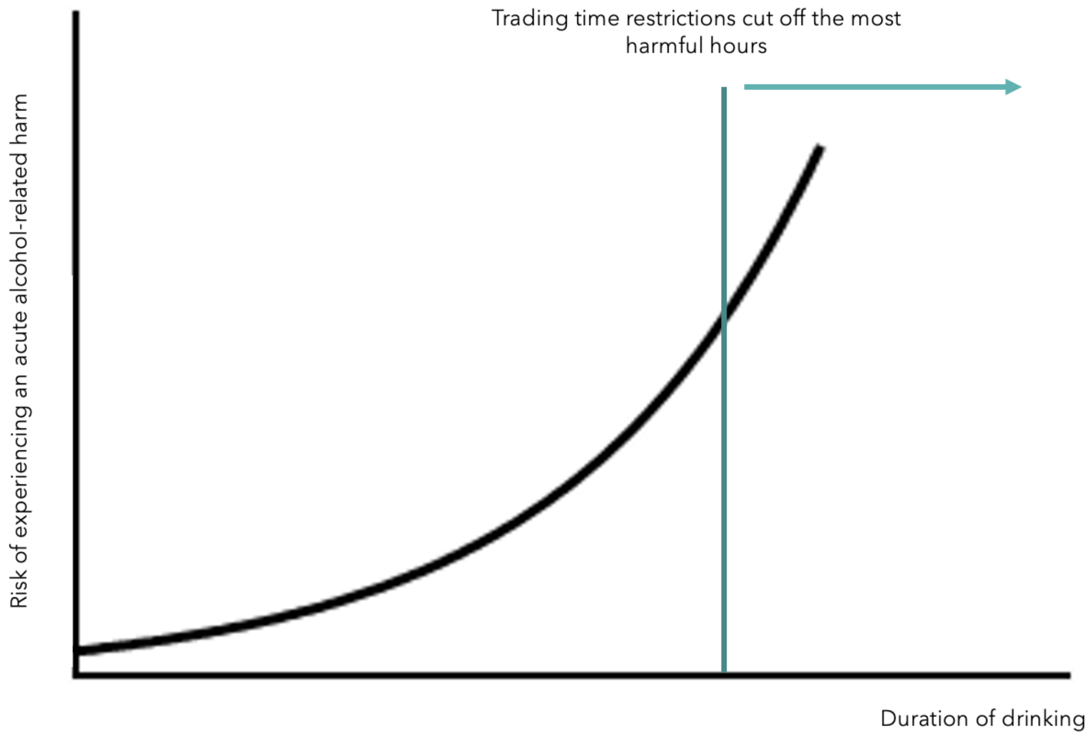
FIGURE 25. REVISED MODELLING FRAMEWORK: A DIRECT LINK BETWEEN CHANGES IN ALCOHOL TRADING TIMES AND ACUTE ALCOHOL-RELATED HARMS

Given the broad international literature that links changes in alcohol retailers' trading times to changes in acute alcohol-related harms [19-21] from which we could derive a harm elasticity for the acute conditions, we opted for this approach. This harm elasticity can be thought of as a measure of the responsiveness of acute alcohol-related harms to a percentage change in alcohol trading times. It is calculated using the equation given below.

$$Harm\ elasticity = \frac{\%\ change\ in\ acute\ alcohol\text{–}related\ harm}{\%\ change\ in\ trading\ hours}$$

This approach differs from the original model in that it does not weight all drinking hours equally in terms of the harms that are caused by drinking. Since the risk of acute harm increases with each drinking hour [94], and the proposed policy cuts off the final drinking hours (at least at onsite drinking locations), we can account for the fact that the impact of the policy is larger than our original model framework would suggest. We do this by using an elasticity framework that directly links changes in trading times to changes in acute alcohol-related harms. Put differently, these elasticities account for the marginal impact of the last few drinks that are more likely to cause people to fall victim to acute alcohol-related death and injury.

FIGURE 26. ALTERNATE MODEL SPECIFICATION LOGIC



To derive these estimates, we return to the systematic review of studies assessing the effects of changes in outlet trading times on alcohol-related harms by Sanchez-Ramirez and Voaklander (2017) [20] and use the research listed in this study to identify peer-reviewed journal articles from which a range of harm elasticities can be derived. Of the studies listed in this review (Table 34), four investigate the impact of reductions in trading times at onsite drinking locations on acute intentional injuries (blue-highlighted cells). However, none of these studies assess the impact of trading time restrictions on road injury.

On examination of each of the studies linking changes in trading times to changes in road injuries, we find that the information provided in some of the studies is insufficient to allow the derivation of a harm elasticity for road accidents. For example, the study by Chikritzhs *et al.* (2006), which draws its sample from Perth (Australia) uses data on impaired driver road crashes from police records to identify those crashes associated with drinking at pubs that had been granted trading time extensions between 1 July 1990 and 30 June 1997 [47].

According to the authors, in Western Australia, where Perth is located, the Liquor Licensing Act of 1988 stipulates closing times for licensed premises serving alcohol, but allows pubs to make applications to trade for an additional hour beyond the legally permissible closing time [47]. Between 1990 and 1997, 43 (23%) of the 186 pubs meeting the study's selection criteria were granted an Extended Trading Permit (ETP) for a 1 am closing time, while the rest continued to close at midnight. The trading time extension is modelled by way of a policy dummy that delineates between a single 'before', in which no ETPs had been granted, and a single 'after' period, in which they had been granted to some pubs.

Unfortunately, the manner in which the authors report their regression results is not conducive to the derivation of a harm elasticity for road accidents. The authors present their regression coefficients as 'standard Beta coefficients for ETPs granted when variable entered'. The authors, oddly, do not provide a version of their regression results that includes the coefficients obtained under the full regression specification. The implication is that we cannot know what the value of the coefficient on the policy dummy is in the full regression specification. Because we do not know the coefficient on the policy dummy obtained in the full regression specification, we do not use the elasticity derived from this study.

We also face a barrier to deriving an elasticity estimate in the study by McMillan *et al.* (2006), which analyses the impact of legislation that permitted the sale of packaged alcohol between noon and midnight on Sundays in New Mexico from 1 July 1995 on car crashes and car crash fatalities [96].[13] Prior to this date, it was illegal to sell packaged alcohol on Sundays [96].

Using data from police reports on alcohol-related car crash deaths in the city collected between July 1990 and June 2000, the authors report that all days of the week had excess alcohol-related crash fatality counts, but none of these except Sunday were statistically significant. Specifically, the authors report that alcohol-related car crash deaths increased by 44 per cent (29 per cent for the crashes), on Sundays, after the ban on Sunday packaged alcohol sales was lifted.

Trying to derive an elasticity estimate on the basis of the results presented in this study forces us to make one of two uncomfortable decisions. Either we calculate the road accident elasticity as 44%/100% = 0.44. This reflects the fact that trading hours increased by 100 per cent on Sundays, and alcohol-attributable road crash accidents increased by 44 per cent on Sundays. However, this estimate ignores the statistically insignificant effect on the other days of the week.

To account for this, we can express the statistically significant change reported on Sundays as a function of total crashes that occurred during the week. If we had the average number of crashes for each day of the week, then we could calculate the elasticity based on the weekly crash data, and the weekly number of trading hours. However, we face a hinderance at this juncture because the authors do not provide information on the weekly distribution of car crashes over the study period. To derive a harm elasticity estimate on the basis of this study would therefore require us to invoke an assumption regarding this distribution to arrive at an elasticity estimate. To avoid making heroic assumptions about this distribution, we opted not to use the results of this study. We found that we faced a similar barrier in trying to estimate an elasticity on the basis of the results presented in Stehr *et al*. (2010) [97], and McMillan *et al.* (2007) [98].

Since four of the eight studies included in the review by Sanchez-Ramirez & Voaklander (2017) [20] could not be used to derive an elasticity estimate, and three remaining four studies showed the association between road accidents and trading times to be statistically

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[13] The sale of unopened liquor in its original container in a package by the licensee at the premises specified in the license for consumption off the licensee's premises.

insignificant, we abandoned this endeavour. Only including those studies that would yield elasticity estimates of zero is not a true reflection of the state of evidence.

We therefore use the four studies that report on the impact of trading time restrictions at onsite locations on indicators of intentional injury to yield elasticity estimates for deaths and cases of intentional injury, and forgo an analysis of the impact of the proposed trading times intervention on road accidents under an alternate model specification, for the reasons listed above.

TABLE 34. EFFECTS OF CHANGES IN OUTLET TRADING TIMES ON ALCOHOL-RELATED HARMS

Author, publication year, place of the study	Policy description; Direction of change in trading time (↑ inc / ↓ dec)		Outcome (source); harm direction (↑ inc / ↓ dec / - insignificant)	
Chikritzhs et al, 2002 Perth, Australia	Extended: trading permits (1 hr).	↑	Violent assaults (police records).	↑
Chikritzhs et al, 2006 Perth, Australia	Extended: trading permits (1 hr).	↑	Impaired driver road crashes (police records).	↑
Duailibi et al, 2007 Diadema,Brazil	Restricted: all bars have to close at 23:00 (before remained open until midnight).	↓	Violence against women (police records).	-
Duailibi et al, 2007 Diadema, Brazil			Homicides (police records).	↓
Green et al, 2014 UK	Extended: trading permits (max 6 hrs).	↑	Traffic accidents (Department of the Environment, Transport and the Regions database)	↓ a
Gronqvist et al, 2011 Sweden	Extended: allowed alcohol outlets to open on Saturdays.	↑	Crime (Swedish conviction register kept by National Council for Crime Prevention (BRA)).	↑
Han et al, 2016 Pennsylvania, USA	Extended: lifted ban on Sunday package alcohol sales.	↑	Violent crime (police records).	-
Han et al, 2016 Pennsylvania, USA	Extended: lifted ban on Sunday package alcohol sales.	↑	Total crime and property crime (police records).	↑
Humphreys et al, 2013 Manchester, England	Extended: removed fixed closing times in favour of staggered closing times for alcohol outlets.	↑	Violent incidents (police records).	↑ b
Humphreys et al, 2014 Manchester, England	Extended: removed fixed closing times in favour of staggered closing times for alcohol outlets.	↑	Violent incidents (police records).	-
Kypri et al, 2010 Newcastle, Australia	Restricted: reduce pub closing times (1.5–2 hrs).	↓	Assaults (police records).	↓
Kypri et al, 2014 Newcastle, Australia	Restricted: reduce pub closing times (1.5 hrs).	↓	Assaults (police records).	↓
Maloney et al, 2009 New Mexico, USA	Extended: lifted ban on Sunday package alcohol sales.	↑	Motor vehicle accidents and fatalities (accident-level analysis files maintained by the University of New Mexico Division of Government Research).	-
McMillan et al, 2006 New Mexico, USA	Extended: lifted ban on Sunday package alcohol sales.	↑	Motor vehicle accidents and fatalities (accident-level analysis files maintained by	↑

Author, publication year, place of the study	Policy description; Direction of change in trading time (↑ inc / ↓ dec)		Outcome (source); harm direction (↑ inc / ↓ dec / - insignificant)	
			the University of New Mexico Division of Government Research).	
McMillan et al, 2007 New Mexico, USA	Extended: lifted ban on Sunday package alcohol sales.	↑	Motor vehicle accidents and fatalities (accident-level analysis files maintained by the University of New Mexico Division of Government Research).	-
Newton et al, 2007 London, UK	Extended: removed fixed closing times in favour of staggered closing times for alcohol outlets.	↑	Alcohol-related assault attendances to the emergency department (ED) (hospital and patient records).	↑
Norstrom et al, 2005 Sweden	Extended: Saturday opening of alcohol retail shops.	↑	Assault (Swedish National Council for Crime Prevention database).	=
Rossow et al, 2011 Norway	Extended: Flexible, extended or restricted closing hrs (<2 hrs).	↑	Violence (police records).	↑
Sanchez et al, 2011 Cali, Colombia	Restricted sales and consumption of alcohol (6–8 hrs).	↓	Homicides (The Cali Crime Observatory's fatal injury surveillance system).	↓
Stehr et al, 2010 USA	Extended: lifted ban on Sunday package alcohol sales.	↑	Crash fatalities (The Fatality Analysis Reporting System (FARS) database)	↑c
Vingilis et al, 2005 Ontario, Canada; New York and Michigan, USA	Extended the hrs of alcohol sales (1 hr).	↑	Motor vehicle fatalities (The Traffic Injury Research Foundation (TIRF) and the US Fatal Analysis FARS databases).	=
Vingilis et al, 2007 Ontario, Canada	Extended the hrs of alcohol sales (1 hr).	↑	Motor vehicle crash injury (The Ontario Trauma Registry).	-
Vingilis et al, 2008 London and Windsor, Ontario	Extended: alcohol sales (1 hr).	↑	Assault charges (police records).	-
a – The authors provide this explanation: "These controversial results were explained by the fact that fixed closing times can lead people, especially younger drivers (18–25 years), drinking to beat the clock to a massive mobilisation at closing time. In contrast, flexible closing time allows customers to remain in the bar and spread out their drinking leading to a larger apparent decline in traffic accidents."; b - Night only. Overall unchanged; c – New Mexico only				

Source: Adapted from Sanchez-Ramirez & Voaklander (2017) [20] by Matzopoulos *et al*. 2020 [45], which is the source from which we have taken this table.

4.5.1 Derivation of an elasticity linking changes in trading times to changes in intentional injury

4.5.1.1 Elasticities for deaths due to intentional injury

The first study we analyse is that by Duailibi *et al*. (2007), situated in Diadema (Brazil), which assesses the impact of legislation mandating that bars close during the hours of 23:00 and 06:00 on homicides and assaults against women [99]. Previously, bars in the region were permitted to stay open for 24 hours each day [99]. The legislation enacting the trading time restriction on bars was passed in July 2002.

Duailibi *et al*. (2007) use data from Diadema police records for the period 1995-2005 to assess the impact of the bar trading time restriction. Their regressions control for monthly unemployment rates in the São Paulo metropolitan region, which includes Diadema, two dummy variables to control for the influence of unrelated law enforcement interventions during the first half of 2000, and a linear time-trend variable to control for unmeasured changes over time in other social, economic, and policy factors that may have affected violence [99].

The authors report a statistically significant coefficient for the policy's impact on homicides amongst women and use this to estimate that 319 homicides were prevented during the first 3 years of the new law, a 44% decline from what would be expected over this period in the absence of the policy change [99]. Table 35 uses the information given regarding reductions in homicides to derive an implied harm's elasticity of 1.5, which suggests that a 1 per cent decrease in trading times results in a 1.5 per cent decrease in homicides.

TABLE 35. PERCENTAGE CHANGE IN WEEKLY LEGAL PERMISSIBLE TRADING HOURS OF BARS IN DIADEMA, BRAZIL AND DERIVATION OF A HARM ELASTICITY

Before the policy change			After the policy change	
Day	Legally permissible trading times	Number of hours during which alcohol may be sold	Legally permissible trading times	Number of hours during which alcohol may be sold
Monday	00:00–00:00	24	06:00–23:00	17
Tuesday	00:00–00:00	24	06:00–23:00	17
Wednesday	00:00–00:00	24	06:00–23:00	17
Thursday	00:00–00:00	24	06:00–23:00	17
Friday	00:00–00:00	24	06:00–23:00	17
Saturday	00:00–00:00	24	06:00–23:00	17
Sunday	00:00–00:00	24	06:00–23:00	17
Number of permissible trading		168		119
Percentage change in number		- 29%		
Percentage change in		-44%		
Implied harms elasticity for		1.5		

The second and final study we analyse to derive a harm's elasticity that links changes in trading times to changes in deaths caused by intentional injury is that by Sanchez *et al*. (2011), which draws its sample from Cali, Columbia [100]. According to the authors, in the 1827 days between 1 January 2004 and 31 December 2008, policies that restricted alcohol sales and consumption were continuously in effect in Cali, but with variations in the number of hours that alcohol was permitted to be sold under the different period of restriction [100]. The most restrictive policies implemented during this period prohibited alcohol sales between 2 am and 10 am for 446 non-consecutive days. 'Moderately restrictive' policies prohibited alcohol sales between 3 am and 10 am for 1277 non-consecutive days, and 'lax policies' prohibited alcohol sales between 4 am and 10 am for 104 non-consecutive days [100].

The authors use conditional autoregressive negative binomial regressions to compare the number of deaths from interpersonal violence under each of these three forms of trading time restrictions [100]. For the purposes of deriving a harm's elasticity for use in our model, we use only the results that compare the number of deaths due to interpersonal violence under the most restrictive and least restrictive trading time policies implemented during the analysis period. The number of legally permissible trading hours under the lax and most restrictive alcohol trading time policies are shown in Table 36.

The authors report an incidence rate ratio (IRR) comparing the lax and most restrictive trading time regulations of 1.42 ($p<0.001$), which indicates that the risk of homicide was higher under the lax trading time environment, compared to during the restrictive trading time environment. We use the percentage change in the number of homicide deaths underpinning the IRR as an input to our harm's elasticity formula. According to the study, 594 homicide deaths occurred under the most restrictive policy, 1 724 occurred under the most lax, a change of 65.5 per cent. This implies a harm elasticity of 5.9, meaning that one per cent change in trading hours translates to a 5.9 per cent reduction in deaths due to homicide.

TABLE 36. CHANGE IN WEEKLY LEGALLY PERMISSIBLE TRADING HOURS IN CALI, COLUMBIA: LAX VS. RESTRICTIVE SCENARIOS AND DERIVATION OF A HARM ELASTICITY

Before the policy change			After the policy change	
Day	Times during which alcohol not be sold	Number of hours during which alcohol may be sold	Times during which alcohol not be sold	Number of hours during which alcohol may be sold
Monday	04:00-10:00	18	02:00–10:00	16
Tuesday	04:00-10:00	18	02:00–10:00	16
Wednesday	04:00-10:00	18	02:00–10:00	16
Thursday	04:00-10:00	18	02:00–10:00	16
Friday	04:00-10:00	18	02:00–10:00	16
Saturday	04:00-10:00	18	02:00–10:00	16
Sunday	04:00-10:00	18	02:00–10:00	16
Number of permissible trading hours per week		126		112
Percentage change in number of permissible trading hours		- 11.1%		
Percentage change in the number of deaths due to interpersonal violence reported		-65.5%		
Implied harm elasticity for deaths due to intentional injury		5.9		

The difference between the elasticity estimate of intentional injury deaths of 1.5 derived from the Brazilian study by Duailibi *et al*. (2007) [99] and that of 5.9 derived from the Columbian study by Sanchez *et al*. (2011) [100] is large. Because of this, we brand the elasticity of 1.5 a lower-bound estimate, and the elasticity of 5.9 an upper-bound estimate and run our sensitivity analysis for deaths due to intentional injury using both elasticity estimates.

4.5.1.2 Elasticities for cases of intentional injury

The aforementioned study by Duailibi *et al*. (2007) also assesses the impact of the legislation mandating that bars in Diadema close during the hours of 23:00 and 06:00 on assaults against women [99]. The authors report that the impact of the policy on assaults against women is only statistically significant in the regression specification that does not include a linear time-trend [99]. In the preferred regression specification, the impact of the trading time restrictions on assaults against women is not statistically significant from zero. We therefore take the harm elasticity for cases of intentional injuries derived from this study to be zero.

The second study from which we a harm elasticity for intentional injury cases can be derived is that by Kypri *et al*. (2010), who examine the impact of restrictions on pub trading times, introduced in the central business district of Newcastle (Australia) in 2008, on the incidence of assault in the city [101]. According to the authors, in March 2008, the liquor licensing authority of New South Wales imposed a restriction on 14 pubs in the central business district of Newcastle which required them to close by 3am and to disallow patrons from entering their venues after 1am [101]. After a legal challenge, this was relaxed to 3.30am and 1.30am, respectively, with the amended legislation taking effect from July 2008. Prior to the policy's introduction, these bars were permitted to remain open until 5am [101]. The authors use data on police-recorded assaults occurring between from 10 pm and 6 am from January 2001–September 2009 in the city to estimate the impact of the policy.

Using a non-equivalent control group design with before and after observations, the authors estimate that there was a 34 per cent reduction in assault incidence in the intervention area and a non-significant increase of 2 per cent in the control area in the same period [101]. The relative effect, i.e. the effect of the intervention adjusting for the assault incidence in the control area, is estimated by the authors as being a 37 per cent relative reduction in assaults [101].

The authors do not provide an indication of bar opening times, which required us to access the relevant legislation. Using the information contained in the study, as well as our interpretation of New South Wales's legislation on the legally permissible opening times for bars [102], we estimate a harms elasticity for intentional injury of 5.4 (Table 37). This suggests that a 1 per cent reduction in legally permissible bar trading times translates to a 1.8 per cent reduction in assaults.

It should be noted that, in addition to restricted trading hours, the bar owners in the central business district of Newcastle also had to employ a dedicated 'Responsible Service of Alcohol' officer from 11pm until closing, could not serve shots after 10pm, had to cease selling alcohol 30 minutes before closing, and could not permit drink stockpiling [101]. Whether it was these additional interventions, the lockout imposed alongside the trading time restrictions, or a combination of all these legislated changes to the ways bars in the Newcastle CBD operated, was not assessed by the authors. This is a limitation of the analysis because these other (unquantified) interventions may reduce the impact of the reduced trading times. This implies that the harm elasticity of 5.4 is at best a higher limit.

TABLE 37. CHANGE IN WEEKLY LEGAL PERMISSIBLE TRADING HOURS OF 14 BARS IN THE CBD OF NEW SOUTH WALES AND DERIVATION OF A HARM ELASTICITY

Before the policy change			After the policy change	
Day	Hours during which alcohol be sold	Number of hours during which alcohol may be sold	Hours during which alcohol be sold	Number of hours during which alcohol may be sold
Monday	05:00–05:00	24	05:00–03:30	18.5
Tuesday	05:00–05:00	24	05:00–03:30	18.5
Wednesday	05:00–05:00	24	05:00–03:30	18.5
Thursday	05:00–05:00	24	05:00–03:30	18.5
Friday	05:00–05:00	24	05:00–03:30	18.5
Saturday	05:00–05:00	24	05:00–03:30	18.5
Sunday	05:00–22:00	12	10:00–22:00	12
Number of permissible trading hours per week		156		123
Percentage change in number of permissible trading hours		- 21.2%		
Percentage change in assaults reported in the study		-37.0%		
Implied harm elasticity		1.8		

In a later paper, Kypri *et al*. (2014) [103], revisit their original analysis with the objective of determining whether the changes in assault incidents they had observed following the introduction of trading time restrictions in their original analysis [101], had been sustained in the subsequent 3.5 years. The assault incidence ratio they report in their original study (=0.67, 95% CI: 0.55 to 0.82) is almost identical to that which considers the subsequent 3.5 years (0.68, 95% CI: 0.55 to 0.85). The authors also address the potential confounding effects of the aforementioned management practises on their estimates of the impact of the trading time restrictions on assaults. They do this with reference to the fact that the identical legislated changes in management practises were introduced in a neighbouring city, Hamilton, without changes trading times. Since the authors find no significant impact of these changes on assaults in Hamilton, they conclude that it was the restriction in legislated trading hours that drove the observed decreases in assaults in the Newcastle central business district, rather than any of the other policy changes implemented during that period [103].

Taken together, the studies analysed above yield harm elasticity estimates for cases of interpersonal violence of 0 [99] and 1.8 [101, 103]. We use the simple average of these two estimates in our sensitivity analysis (= 0.9).

4.5.2 Employing the harm elasticities in our model

In this revised framework, the harm elasticity estimates for intentional injury, denoted ε_H, are used to estimate the one-year impact of changes in trading times on intentional injuries. To do this, we apply the relevant ε_H to the percentage change in onsite trading hours using the following equation:

$$\% \text{ change in onsite trading hours} \times \varepsilon_H = \% \text{ change in intentional injury deaths/cases}$$

This allows the calculation of the new level of deaths/cases in response to the change in trading times created by the proposed policy. To get the 20-year impact of the proposed changes on acute alcohol-related harms in the Western Cape, we employ the following approach for baseline deaths/cases due to intentional injuries:

Number of premature deaths/cases avoided in year *n* = number of alcohol-related premature deaths/cases in year 0 x % change in acute alcohol-related harms

Implicit in this approach is the assumption that the one-year impact of the trading time restrictions is the same in every subsequent year.

4.5.3 Alternate model specification results

The results of the alternate model specification for the acute alcohol-related harm of intentional injury are shown in Table 38. All estimates are rounded to the nearest hundred. We derived two harm elasticity estimates for deaths due to intentional injury from the literature linking changes in alcohol trading times to changes in acute alcohol-related harms.

Using our low elasticity estimate for deaths (ε_H = 1.5), we estimate that, over 20 years, deaths due to intentional injury averted stand at approximately 12 300 under a midnight closing time scenario; 6 600 under a 1am closing time; and 1 000 under a 2am closing time. Under the upper bound harm elasticity estimate (ε_H= 5.4), we estimate that, over 20 years, deaths due to intentional injury averted stand at 44 300 under a midnight closing time scenario, 23 800 under a 1am closing time; and 3 600 under a 2am closing time scenario.

In terms of prevalence of intentional injury, we estimate that, over 20 years, approximately 380 500 cases of intentional injury are averted under a midnight closing time scenario, approximately 204 300 cases are averted under a 1am closing time, and around 31 000 cases are avoided under a 2am closing time.

TABLE 38. DEATHS AND CASES OF INTENTIONAL INJURIES AVERTED OVER 20 YEARS UNDER AN ALTERNATE MODEL SPECIFICATION

	Elasticity applied	Midnight	1am	2am
Deaths averted	ε_H= 1.5	12 300	6 600	1000
	ε_H= 5.4	44 300	23 800	3 600
Cases averted	ε_H= 0.9	380 500	204 300	31 000

Commensurate with these decreases in cases of intentional injury are significant reductions in the hospital costs of treating them. Discounting future hospital costs at 5 per cent, we estimate hospital cost savings to government of R7.4 billion at a midnight closing time, of R4 billion at a 1am closing time, and R0.6 billion at a 2am closing time.

5. LIMITATIONS AND CAVEATS

The analysis conducted in this report is subject to limitations.

The first limitation arises because of our use of *legally permissible* trading times, rather than *actual* trading times, to arrive at elasticity estimates from the international literature and to calculate the reduction in trading times in the Western Cape under each of the proposed policy scenarios. On the matter of the elasticity estimates derived from the limited international literature that links changes in trading times to changes in alcohol consumption, we drew on studies from Russia [54], Spain [60] and Sweden [13, 14, 48]. In both the Russian and Spanish studies, the trading hours analysed in the studies relied on legislated as opposed to actual trading times. If actual trading times are less than those permitted by law, the resulting elasticity would be lower than that obtained using the hours stipulated in legislation.[14]

In the absence of conducting a large-scale web-scraping exercise of the actual trading times of all bars in Spain, where the 'upper bound' elasticity estimate is derived, we cannot control for this overestimation of our 'upper bound' elasticity estimate. That said, it should be acknowledged that the elasticity estimate derived from the Spanish study [60] still falls within the range of what we believe a trading times elasticity could feasibly be. Our 'lower bound' elasticity estimate may not suffer the same limitation since it is derived from three studies conducted in Sweden, where the existence of a state monopoly on offsite alcohol retail may imply that the legislated trading hours are those executed in practise.

On the estimation of the reduction in trading times in the Western Cape under each policy scenario, we use the data collated under Phase 1 of this project. The Phase 1 deliverable reports on legally permissible trading times in the Western Cape, rather than actual trading times in the province. A key input into our model is the percentage change in trading times at each of the proposed closing times. Since this can only be estimated using the legislated trading times provided in Phase 1, the percentage changes we calculate may not be reflective of the actual reduction in trading hours that will occur, which could overestimate the impact of each proposed closing time scenario on alcohol consumption and, correspondingly, the various health and economic impacts.

For example, if a bar in Cape Town closes at 11pm it will not be affected by any of the proposed trading time restrictions, yet, because the bar can legally stay open until 2am, our model will calculate that its trading hours have been reduced, causing us to estimate reductions in alcohol consumption that will not manifest. Development of a web-scraper to trawl Google for the opening and closing times of all onsite establishments in the Western Cape could overcome this issue, alternatively the WCG could mandate that all licensed retailers submit their opening and closing hours on each weekday to inform an understanding of the actual trading times of onsite establishments in the province. That the estimated negative impact of the proposed trading time restrictions on alcohol retail revenue will be overstated because of our reliance on legally permissible trading hours as an input to the

[14] For example, if the legal hours are say 15 hours a day, and the actual hours are 12 hours a day, a 1-hour reduction in the trading hours would have a greater percentage effect on the actual opening hours, relative to the legal opening hours, which would mean that the trading time elasticity for actual hours would be smaller than the trading time elasticity based on legal hours, because the denominator in the elasticity formula is larger.

model must be borne in mind when the alcohol industry voices concern that the legislation will be too costly for the industry to implement.

A second limitation arises because of our inability to account for trading time elasticities among different drinker groups. Effects such as the six o'clock swill[15] have been observed historically [104], but there is no research on the responsiveness of different drinker groups to changes in trading hours to inform the adjustment of our elasticities to account for these differential impacts, should they exist.

The third limitation of this analysis arises because of the lack of data specific to the Western Cape for key variables. For example, estimating baseline alcohol consumption required us to recalibrate the SADHS national population estimates to be representative of the Western Cape, which we did using NIDS Wave 4. NIDS Wave 4 was not designed to be provincially representative. Also, over time, some groups in the NIDS sample experienced more attrition than others, which means that the NIDS Wave 4 sample is less representative than it was intended to be, which has implications for the precision of the provincial-level proportions that we apply. The limitation of using price data collected in Tshwane to inform estimates of alcohol expenditure in the Western Cape is obvious. In all instances, however, we have made use of the best data available to estimate the model baseline. These limitations to the model could be addressed if the alcohol industry provided us with their sales data (since sales are a good proxy for consumption) and the prices paid by drinkers at their venues. Should the alcohol industry wish to dismiss the findings of this report, on the grounds that the baseline assumptions are unrealistic, we are happy to re-run the model with verified sales and price data provided by the industry.

Related to the above limitation stemming from the lack of alcohol consumption data specific to the Western Cape is the fact that the reweighting procedure that we employed to estimate alcohol consumption in the baseline year is but one of many possible reweighting procedures that could have been employed [105]. It fell beyond the scope of this project to run a sensitivity analysis of these different reweighting procedures. While this is something that should be explored in future work, the absence of a sensitivity analysis for the baseline consumption estimates employed in our model represents the fourth limitation of the analysis provided in this report.

A fifth limitation arises from our inability to account for unlicensed retailers selling alcohol for onsite consumption. In South Africa there are many unlicensed alcohol outlets, particularly in townships [106]. Because these unlicensed outlets operate in a lawless space, the full health and economic benefits accompanying this policy cannot be quantified or realized until these outlets become licensed and regulated. We advise that the WCG conduct a study to ascertain the prevalence of unlicensed outlets in the Western Cape so that these retailers can be incorporated into the legal space.

The sixth limitation to our analysis arises from the fact that we cannot accurately control for substitution effects. Our model assumes that offsite consumption remains unchanged when onsite trading hours are reduced. It is conceivable that, in the face of legislated earlier closing

[15] The six o'clock swill was an Australian and New Zealand slang term for the last-minute rush to buy drinks at a bar before it closed since for most of the 20th century, bars closed at 6pm.

hours at onsite venues, people will stock up on alcohol at offsite retailers during the day so that they can continue drinking when bars/clubs close at an earlier time. Based on the current state of evidence, both locally and internationally, we do not have reliable estimates on what proportion of drinkers will do this. If such substitution were to occur, the estimated positive health, hospital cost and crime cost savings estimated in this report would be dampened. That said, the estimated negative tax and retail revenue impacts would be reduced.

The substitution of alcohol consumed at onsite drinking premises with alcohol purchased at offsite retailers is not conducive to realising public health gains. This points to the need for government to implement trading time restrictions at onsite retailers as part of a broader suite of policy measures to reduce alcohol consumption in the province. We elaborate on these policy measures in the following subsection in which we provide our recommendations, but briefly note that these measures include policies to reduce the affordability of alcohol, policies to assist people in dealing with alcohol addiction, and policies to reduce the social acceptability of excessive alcohol consumption. On the latter, as South Africa's experience with the ban on tobacco advertising has shown, a ban on alcohol advertising will be instrumental in this regard.

The seventh limitation is that we assume that the trading times elasticities, both with respect to consumption and harms, are constant. By consequence, a 10 per cent decrease in trading hours has the same proportional impact as a 5 per cent or a 2 per cent decrease in trading hours. The estimates produced by our primary model are thus conservative. As it pertains to the acute harms associated with alcohol consumption in particular, literature shows that a drinkers' blood alcohol concentration increases as the duration of their drinking occasion increases and that such increases in blood alcohol concentration are associated with increases in acute alcohol-related harms [94].

We attempted to account for this by replacing our trading times elasticity framework, with a direct harm elasticity that measures the percentage change in acute-alcohol-related harms following a percentage change in alcohol trading times. This approach accounts for the marginal impact of the last few drinks that are more likely to cause people to fall victim to acute alcohol-related death and injury. The provision of insufficient information in half of the studies listed in a systematic review on the association between alcohol trading times and acute alcohol-related harms prevented us from deriving this elasticity for road injuries.

The eighth and final limitation arises from the limited range of health outcomes considered in our model. There are many other conditions related to alcohol consumption which have not been modelled, including, but not limited to, diabetes, heart disease, and many other forms of cancer. Not accounting for a broader range of health outcomes in the model means that we have under-estimated the total health benefit and healthcare cost savings arising from implementing trading time restrictions at onsite retailers in the Western Cape. We have also not estimated the reduction in some of the harms experienced by non-drinkers (for example from intimate partner violence and foetal alcohol spectrum disorders) which would result from reduced alcohol consumption brought on by restricting onsite trading times. Moreover, we have conservatively estimated hospital costs: for example, HIV-related costs were estimated only for first line antiretroviral therapy.

It should also be noted that while it may be tempting to use the estimates provided in this report as the basis of a cost-benefit analysis of implementing trading time restrictions for onsite retailers of alcohol, this would not constitute an appropriate interpretation of the results provided in this study. This because our model has not accounted for: (1) all the health conditions related to alcohol use, (2) the reduction in all harms to non-drinkers, (3) the productivity gains from fewer alcohol-related deaths and fewer instances of alcohol-related diseases and (4) the potential income tax losses that may result from the policy.

6. CONCLUSION AND RECOMMENDATIONS

This report has provided estimates of the impact of restricting the legally permissible trading times of retailers selling alcohol for onsite consumption in the Western Cape. We modelled three closing time scenarios: midnight, 1am, and 2am. Our estimates suggest that all closing time scenarios correspond to decreases in the number of deaths and cases of six alcohol-related conditions, decreases in the hospital costs of addressing these six alcohol-related conditions, decreases in the cost of combatting alcohol-related crime, and decreases in the revenue accruing from alcohol sales and alcohol taxation.

The choice of which closing time to implement is a political decision that needs to balance the costs and benefits of such a policy. The costs of such a policy that we have modelled are reductions in revenue to alcohol retailers and tax revenue while the benefits we have modelled are improved health and the associated healthcare cost savings, and reductions in the costs of combatting crime in the Western Cape. Regardless of the elasticity applied, our estimates suggest that a midnight closing time will have a greater positive health impact, and a larger negative revenue impact than a 2am closing time. Conversely, a 2am closing time will have a lower health impact, and a less negative revenue impact than midnight closing time.

Outside of providing decision makers with estimates of the impact of restricting onsite alcohol trading times in the Western Cape to inform their decision-making, we offer **five recommendations**. These recommendations stem from the overarching finding of this study: that trading time restrictions will reduce alcohol consumption and its associated harms and costs in the Western Cape.

The **first recommendation** is that trading time restrictions at onsite retailers should be enacted alongside other targeted policy interventions geared toward reducing alcohol consumption and its associated harms. Our estimates suggest that, on its own, a policy that restricts the legally permissible trading times of onsite alcohol retailers will not be a total ‘game changer’ in terms of reducing alcohol-related harms. It will, however, contribute positively to achieving this outcome and amplify the impact of a more broad-based approach to reducing alcohol consumption and its related harms in the province.

To this end, we advise decisionmakers to consult the World Health Organization’s identified ‘best buys’ and other recommended interventions for reducing alcohol use [17]. These are shown in Table 39. Each type of intervention has a corresponding cost effectiveness analysis (CEA), which shows the cost in dollars of implementing the policy per disability-adjusted life year averted.

TABLE 39. ‘BEST BUYS’ AND OTHER RECOMMENDED INTERVENTIONS

Type of intervention	Description of intervention
‘Best buys’: effective interventions with cost effectiveness analysis (CEA) ≤ I$100 per DALY averted in LMICs	• Increase excise taxes on alcoholic beverages • Enact and enforce bans or comprehensive restrictions on exposure to alcohol advertising (across multiple types of media) • **Enact and enforce restrictions on the physical availability of retailed alcohol (via reduced hours of sale)**
Effective interventions with CEA >I$100 per DALY averted in LMICs	• Enact and enforce drink-driving laws and blood alcohol concentration limits via sobriety checkpoints • Provide brief psychosocial intervention for persons with hazardous and harmful alcohol use
Other recommended interventions from WHO guidance (CEA not available)	• Carry out regular reviews of prices in relation to level of inflation and income • Establish minimum prices for alcohol where applicable • Enact and enforce an appropriate minimum age for purchase or consumption of alcoholic beverages and reduce density of retail outlets • Restrict or ban promotions of alcoholic beverages in connection with sponsorships and activities targeting young people • Provide prevention, treatment and care for alcohol use disorders and comorbid conditions in health and social services • Provide consumer information about, and label, alcoholic beverages to indicate, the harm related to alcohol

Source: World Health Organization, 2017 [17].

The World Health Organization (WHO) also indicates that the success of these policies will be amplified if they are implemented within an enabling policy environment [17]. Such a policy context is characterised by implementation of the WHO’s global strategy to reduce harmful use of alcohol through multisectoral actions in the recommended target areas, strong leadership and heightened commitment and capacity to address the harmful use of alcohol, and increased awareness and information-sharing on the magnitude and nature of problems caused by harmful alcohol use [17].

The **second recommendation** concerns the need for verified alcohol sales data to be reported to the Western Cape Liquor Authority as a condition of license for selling alcohol. Legislative provision should be made for an audit of these sales data. Relatedly, we offer as a **third recommendation** that the handover of these sales data include both historical and future alcohol sales.

The handover of historical sales data will have two benefits for WCG. The first is that it will assist government in obtaining a more accurate picture of the levels of alcohol consumption in the province. The second is that it will assist government in assessing the past tax compliance of alcohol retailers. Benefits to government that will be derived from the provision of all future alcohol sales data include monitoring trends in alcohol consumption, allowing the impact of any future policies that target alcohol consumption to be monitored and assessed, and increasing tax compliance among alcohol retailers.

Our **fourth recommendation** is that the handover of these sales data to a centralised agency should be accompanied by a research protocol that provides researchers with access to these sales data. To ensure the most useful application of these data, they should be made available to researchers in a manner that allows for their disaggregation at the municipal level, by day of the week, and hour of day.

Our recommendations on the need for verified alcohol sales data to be shared with researchers arises from the data adjustment processes we have had to employ to estimate alcohol consumption in the model baseline. The need for these adjustments stem from the absence of data on alcohol consumption that are specific to the Western Cape. While all these adjustments conform to scientifically sound standards, they reduce the precision of our estimates. The required data reweighting and adjustment can be avoided if sales data are available.

Our need to rely on the international literature to estimate elasticities that quantify the association between alcohol trading times, alcohol consumption and its related harms also stems from the absence of a centralised system that collects data on alcohol sales in the Western Cape. Because there are several municipalities that have changed their legally permissible alcohol trading times historically, access to historical sales data will provide researchers an opportunity to produce local evidence on the impact that these changes in trading times have had on alcohol consumption, its related harms and costs, and industry revenue. While we were unable to access verified alcohol sales data for this study, we will gladly re-run the model with these data as inputs to improve the precision of the estimates provided in this report.

Beyond the provision of access to historical alcohol sales data, continued access to these data will assist researchers in supporting government in its efforts to understand the likely impact of any future policies geared toward reducing alcohol-related harms in the province.

The **fifth and final recommendation** concerns the need for any legislative amendments to alcohol trading times to be implemented uniformly across the Western Cape. Our model results show that changes in alcohol trading times reduce alcohol-related harms. The enactment of trading times restrictions that vary by province will therefore not be conducive to WCG achieving its stated objective of reducing these harms across the province.

APPENDIX

Appendix 1. EMS data incident counts by category, 2021

Broad category	Incident Type	Frequency	Percentage of total incidents
Accidental injury	Accidental Injury - Domestic	18 488	6.47%
	Accidental Injury - Industrial	3 111	1.09%
	Accidental Injury - Sports	936	0.33%
Assault	Assault - Physical	17 729	6.20%
	Assault - Poisoning	850	0.30%
	Assault - Sexual	240	0.08%
	Assault - Weapon (Gunshot)	5 209	1.82%
	Assault - Weapon (Other)	53 194	18.61%
Environmental	Environmental-Bites And Stings	647	0.23%
	Environmental-Bites and Stings	3 894	1.36%
	Environmental-Cold Exposure	36	0.01%
	Environmental-Heat Exposure	180	0.06%
	Forensic Pathology	20 436	7.15%
Pain	Pain (Non-Cardiac)	143 012	50.03%
Self-harm	Self-Harm - Other	7375	2.58%
	Self-Harm - Poisoning	4030	1.41%
	Self-Harm - Weapon (Gunshot)	104	0.04%
	Self-Harm - Weapon (Other)	590	0.21%
Other	Bleeding	353	0.12%
	Burns and Corrosives	4 737	1.66%
	CPR in Progress	202	0.07%
	Electrocution	93	0.03%
	Forensic Pathology	20 436	7.15%
	Near Drowning	426	0.15%
	Total	**285 872**	**100%**

Appendix 2. Appraising the quality of the data sources used in our analysis

Data source	Appropriate sample size	Relevance for project purposes	Actual data vs proxies for use	Does not require adjustments for use	Availability and ease of access	Prior use in publications	No ethical or other limitations	Total
South African Demographic and Health Survey (2016)	1	1	1	0	1	1	1	**6**
NIDS Wave 4 (2015)	1	1	1	0	1	1	1	**6**
Euromonitor data on recorded per capita alcohol consumption (2018)	1	1	1	1	0	1	1	**6**
Phase 1 deliverable	1	1	1	1	1	0	1	**6**
Second Injury Mortality Survey (2021)	1	1	1	0	1	1	1	**6**
Second National Burden of Disease Study (2016)	1	1	1	0	1	1	1	**6**
Second Injury Mortality Survey (2021)	1	1	1	0	1	1	1	**6**
Second National Burden of Disease Study (2016)	1	1	1	0	1	1	1	**6**
Statistics South Africa Report on mortality and causes of death in South Africa (2017)	1	1	1	0	1	1	1	**6**
Second National Burden of Disease Study (2016)	1	1	1	0	1	1	1	**6**
Statistics South Africa Report on mortality and causes of death in South Africa (2017)	1	1	1	0	1	1	1	**6**
Second National Burden of Disease Study (2016)	1	1	1	0	1	1	1	**6**
Western Cape Burden of Disease Review (2020)	1	1	1	0	1	1	1	**6**
Global Burden of Disease study Institute for Health Metrics Evaluation (2018)	1	1	0	0	1	1	1	**5**
Global Burden of Disease study Institute for Health Metrics Evaluation (2018)	1	1	0	0	1	1	1	**5**
Global Burden of Disease study Institute for Health Metrics Evaluation (2018)	1	1	0	0	1	1	1	**5**
Global Burden of Disease study Institute for Health Metrics Evaluation (2018)	1	1	0	0	1	1	1	**5**
Shield *et al.* (2020)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
UNAIDS (2020)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Global Burden of Disease study Institute for Health Metrics Evaluation (2018)	1	1	1	0	1	1	1	**6**

Matzopoulos *et al*. (2006)	0	1	1	0	1	1	1	**5**
Global Burden of Disease study Institute for Health Metrics Evaluation (2018)	1	1	1	0	1	1	1	**6**
Matzopoulos *et al*. (2006)	0	1	1	0	1	1	1	**5**
Ventoet et al. (2018)	0	1	1	0	1	1	1	**5**
Joffe *et al.* (2018)	0	1	1	0	1	1	1	**5**
Meyer-Rath *et al*. (2019)	0	1	1	0	1	1	1	**5**
Parkinson *et al*. (2014)	0	1	1	0	1	1	1	**5**
Bola *et al*. (2016)	0	1	1	0	1	1	1	**5**
Health Systems Trust (2020)	1	1	1	0	1	1	1	**6**
Guzha *et al.* (2020)	0	1	1	0	1	1	1	**5**
International Alcohol Control Study (2014/2015)	0	1	1	0	0	1	1	**4**
Treasury's annual Budget Review (2018)	1	1	1	0	1	1	1	**6**
NIDS Wave 4 (2014/2014)	1	1	1	0	1	1	1	**6**
Matzopoulos *et al*. (2014)	1	1	1	0	1	1	1	**6**
Statistics South Africa (2018)	1	1	1	0	1	1	1	**6**

Appendix 3. Overview of alcohol-related questions asked in South African surveys

Survey	Alcohol questions and answer prompts
South African Demographic and Health Survey (SADHS) 2016	Have you ever consumed a drink that contains alcohol such as beer, wine, ciders, spirits, or sorghum beer? Probe: Even one drink? [yes, no] Was this within the last 12 months? [yes, no] In the last 12 months, how frequently have you had at least one drink? [5 or more days a week, 1-4 days per week, 1-3 days a month, less often than once a month] During each of the last 7 days, how many standard drinks did you have? [use showcard, record total number of drinks consumed each day starting with the day before the day of the interview and proceeding backwards] During the last 7 days, how many standard home-made beers or other homemade alcohol did you have? [use showcard, record number] In the past 30 days, have you consumed five or more standard drinks on at least one occasion? [yes, no]
National Income Dynamic Study 2014/15	How often do you drink alcohol? [I have never drank alcohol, I no longer drink alcohol, I drink very rarely, Less than once a week, on 1 or 2 days a week, on 3 or 4 days a week, on 5 or 6 days a week, every day, refused, don't know] On a day that you have an alcoholic drink, how many standard drinks do you usually have? A standard drink is a small glass of wine; a 330 ml can of regular beer, a tot of spirits, or a mixed drink. [13 or more standard drinks, 9 to 12 standard drinks, 7 to 8 standard drinks, 5 to 6 standard drinks, 3 or 4 standard drinks, 1 or 2 standard drinks, Refused, Don't Know]
All Media and Product Survey 2015	How many bottles/cans/glasses of flavoured alcoholic beverages (i.e. alcoholic fruit beverages, cider and spirit coolers) have you personally consumed during the past 7 days? [write in number below] It then goes on to ask about which brands they have consumed using tick boxes. This is repeated for liqueur (Advocaat, Baileys etc), beer, sorghum beer, wine, fortified wine, white spirits, brandy, whisky, rum, other spirits.
International Alcohol Control (IAC) Study (2014/2015)	How often do you usually drink alcohol? (repeated for 16 different locations) [2 or more times a day (?), daily, 5-6 times a week, 3-4 times a week, twice a week, once a week, once every 10 days, once every 2 weeks, once a month, 4-5 times in 6 months, 2-3 times in 6 months, at least once in 6 months, less than once in 6 months, never, don't drink anywhere, refused, don't know] I would now like you to think of one drinking occasion that would be most typical of your drinking [location]. Can you tell me what you would usually be drinking on this occasion? [Runs through every alcohol type at each of the 16 drinking locations] If (Q4.) or (Q5.) includes 'beer' ask: on this typical occasion how much beer would you be drinking? [The answer requires the number of containers, and then asks about typical container size for every drink type for every location]

Appendix 4. Visual depiction of the Relative Risk functions used in the model

These are taken directly from Shield et al. (2020) [64] and Probst et al. (2018) [65]. We have not produced these diagrams ourselves.

FIGURE 27. RELATIVE RISKS FOR HIV

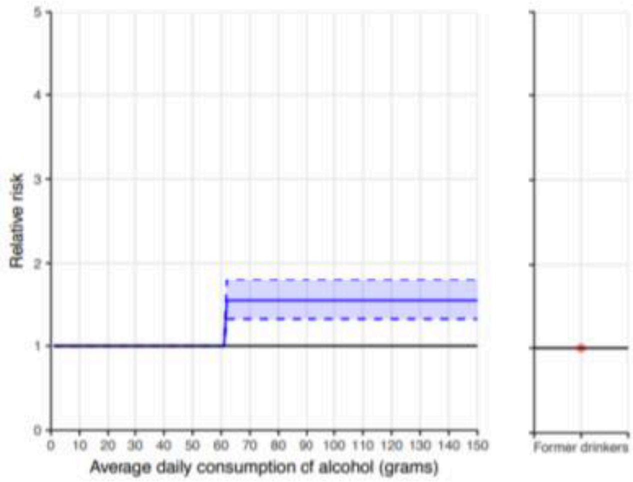


Figure A2. Relative Risks and 95% confidence intervals for HIV/AIDS among male current and former drinkers (as compared to lifetime abstainers)

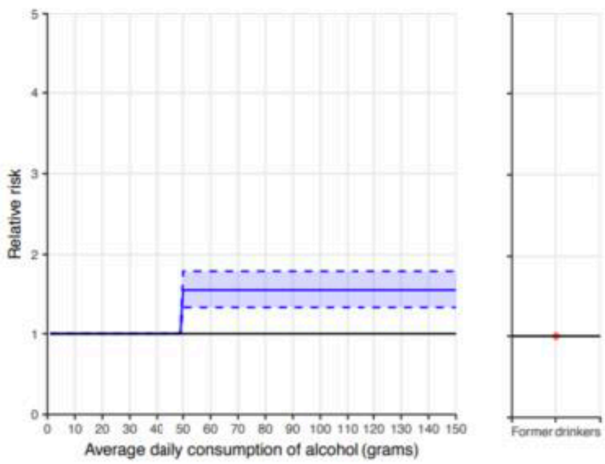
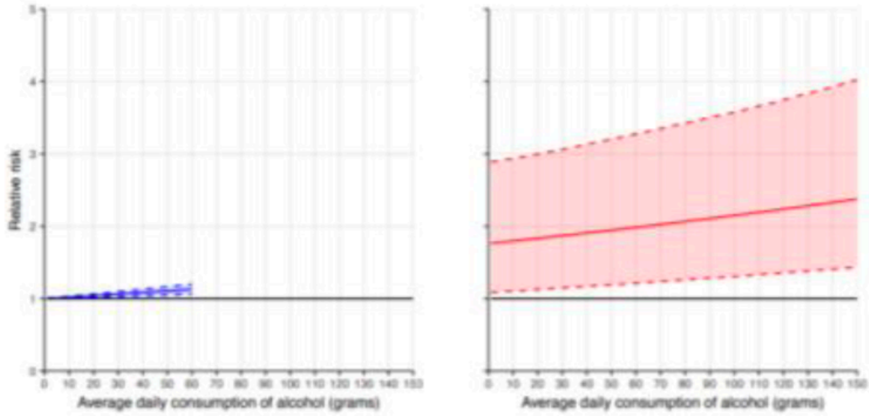


Figure A3. Relative Risks and 95% confidence intervals for HIV/AIDS among female current and former drinkers (as compared to lifetime abstainers)

FIGURE 28. RELATIVE RISKS FOR INTENTIONAL INJURIES



re A39. Relative risks and 95% confidence intervals for self-harm and interpersonal violence among male and female ıeavy episodic drinkers (blue) and heavy episodic drinkers (red)

FIGURE 29. RELATIVE RISKS FOR ROAD INJURIES

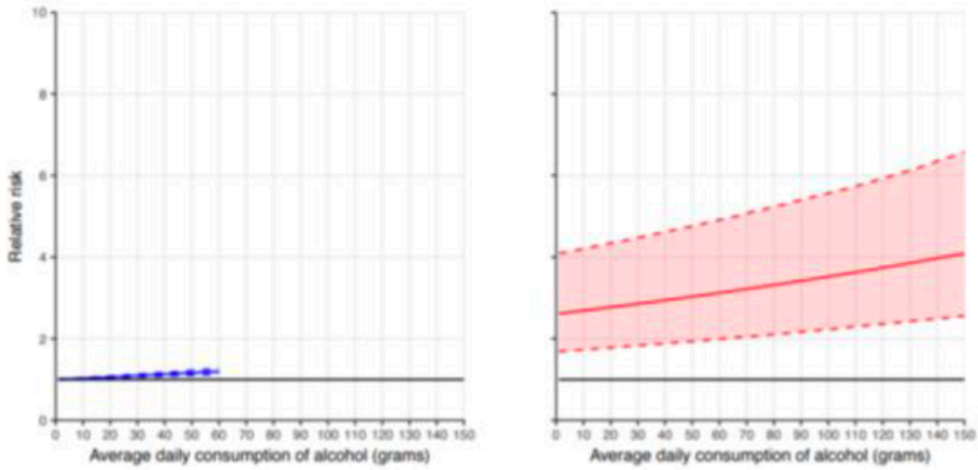


Figure A37. Relative risks and 95% confidence intervals for road injury among male and female non-heavy episodic drinkers (blue) and heavy episodic drinkers (red)

FIGURE 30. RELATIVE RISKS FOR BREAST CANCER

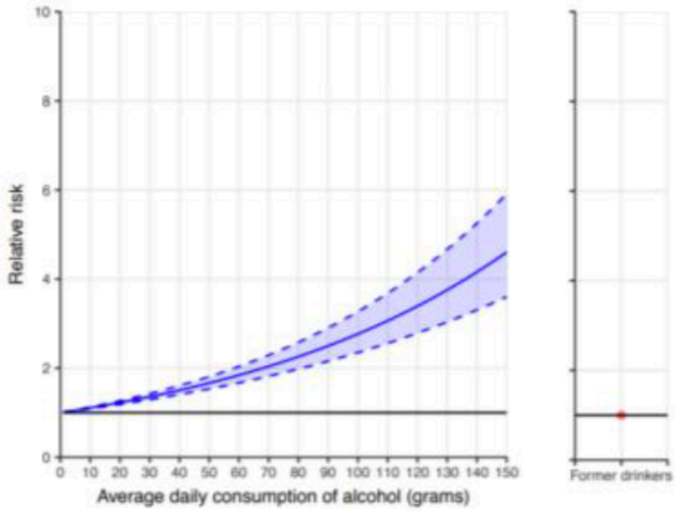


Figure A12. Relative Risks and 95% confidence intervals for breast cancer among female current and former drinkers (as compared to lifetime abstainers)

FIGURE 31. RELATIVE RISKS FOR LIVER CIRRHOSIS

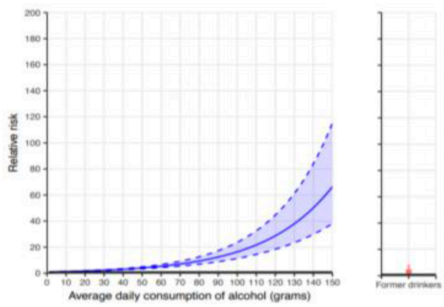


Figure A33. Relative risks and 95% confidence intervals for liver cirrhosis among male current and former drinkers (as compared to lifetime abstainers)

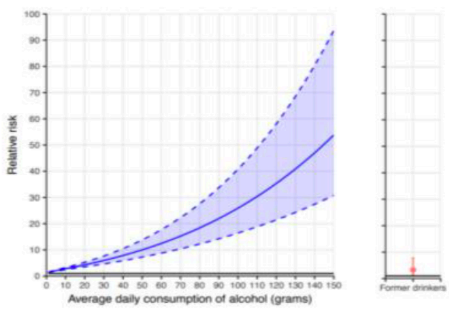


Figure A34. Relative risks and 95% confidence intervals for liver cirrhosis among female current and former drinkers (as compared to lifetime abstainers)

FIGURE 32. RELATIVE RISKS FOR TB

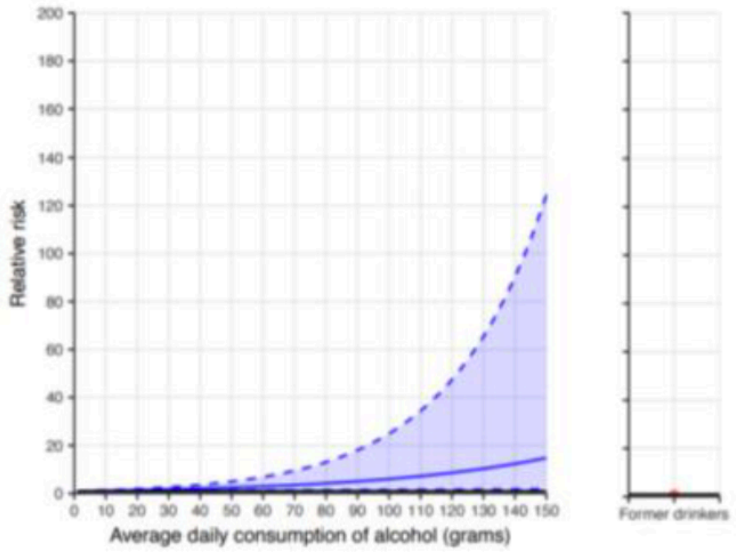


Figure A1. Relative Risks and 95% confidence intervals for tuberculosis among male and female, current and former drinkers (as compared to lifetime abstainers)

LIST OF REFERENCES

[1] Bardach AE, Alcaraz AO, Ciapponi A*, et al.* Alcohol consumption's attributable disease burden and cost-effectiveness of targeted public health interventions: a systematic review of mathematical models. *BMC Public Health* 2019;**19**(1):1378.

[2] World Health Organization. Global status report on alcohol and health 2018. 2018.

[3] Vos T, Lim SS, Abbafati C*, et al.* Global burden of 369 diseases and injuries in 204 countries and territories, 1990–2019: a systematic analysis for the Global Burden of Disease Study 2019. *The Lancet* 2020;**396**(10258):1204-1222.

[4] Probst C, Parry CDH, Wittchen H-U*, et al.* The socioeconomic profile of alcohol-attributable mortality in South Africa: a modelling study. *BMC Medicine* 2018;**16**(1):97.

[5] Ferreira-Borges C, Parry CD, Babor TF. Harmful Use of Alcohol: A Shadow over Sub-Saharan Africa in Need of Workable Solutions. *Int J Environ Res Public Health* 2017;**14**(4).

[6] Schneider M, Norman R, Parry C*, et al.* Estimating the burden of disease attributable to alcohol use in South Africa in 2000. *S Afr Med J* 2007;**97**(8 Pt 2):664-672.

[7] Popova S, Lange S, Probst C*, et al.* Global prevalence of alcohol use and binge drinking during pregnancy, and fetal alcohol spectrum disorder. *Biochem Cell Biol* 2018;**96**(2):237-240.

[8] Pitpitan EV, Kalichman SC, Eaton LA*, et al.* Gender-based violence, alcohol use, and sexual risk among female patrons of drinking venues in Cape Town, South Africa. *J Behav Med* 2013;**36**(3):295-304.

[9] Rehm J, Mathers C, Popova S*, et al.* Global burden of disease and injury and economic cost attributable to alcohol use and alcohol-use disorders. *Lancet* 2009;**373**(9682):2223-2233.

[10] Rehm J, Parry CD. Alcohol consumption and infectious diseases in South Africa. *Lancet* 2009;**374**(9707):2053.

[11] Harker Burnhams N, Parry C, Laubscher R*, et al.* Prevalence and predictors of problematic alcohol use, risky sexual practices and other negative consequences associated with alcohol use among safety and security employees in the Western Cape, South Africa. *Substance Abuse Treatment, Prevention, and Policy* 2014;**9**(1):14.

[12] Matzopoulos RG, Truen S, Bowman B*, et al.* The cost of harmful alcohol use in South Africa 2013.

[13] Avdic D, von Hinke S. Extending alcohol retailers' opening hours: Evidence from Sweden. *European Economic Review* 2021;**138**:103830.

[14] Grönqvist H, Niknami S. Alcohol availability and crime: Lessons from liberalized weekend sales restrictions. *Journal of Urban Economics* 2014;**81**:77-84.

[15] National Department of Health, Statistics South Africa, South African Medical Research Council. Demographic and Health Survey 2016, South Africa [dataset]. Version 1. Pretoria: NDoH, SAMRC & Statistics SA [producers], 2019. Rockville: DHS Program [distributors], 2019. 2019.

[16] Barron K, Bradshaw D, Parry CD*, et al.* Alcohol and short-run mortality: Evidence from a modern-day prohibition. Available at SSRN 3744031. 2020.

[17] World Health Organization. Tackling NCDs: Best buys. 2017.

[18] Department of the Premier Western Cape Government Strategic Programmes Branch Policy and Strategy Chief-Directorate. Western Cape alcohol-related harms reduction policy White Paper. 2017.

[19] Popova S, Giesbrecht N, Bekmuradov D*, et al.* Hours and Days of Sale and Density of Alcohol Outlets: Impacts on Alcohol Consumption and Damage: A Systematic Review. *Alcohol and Alcoholism* 2009;**44**(5):500-516.
[20] Sanchez-Ramirez DC, Voaklander D. The impact of policies regulating alcohol trading hours and days on specific alcohol-related harms: a systematic review. *Inj Prev* 2018;**24**(1):94-100.
[21] Wilkinson C, Livingston M, Room R. Impacts of changes to trading hours of liquor licences on alcohol-related harm: a systematic review 2005-2015. *Public Health Res Pract* 2016;**26**(4).
[22] Town SALaDRUUoC. National Income Dynamics Study, Wave 5. . In: Town. SALaDRUUoC, ed. 2017.
[23] London L. The `dop' system, alcohol abuse and social control amongst farm workers in South Africa: a public health challenge. *Social Science & Medicine* 1999;**48**(10):1407-1414.
[24] Navsaria PH, Nicol AJ, Parry CDH*, et al.* The effect of lockdown on intentional and nonintentional injury during the COVID-19 pandemic in Cape Town, South Africa: A preliminary report. *S Afr Med J* 2020;**0**(0):13183.
[25] Chu KM, Marco JL, Owolabi EO*, et al.* Trauma trends during COVID-19 alcohol prohibition at a South African regional hospital. *Drug Alcohol Rev* 2022;**41**(1):13-19.
[26] Western Cape Government. Western Cape Strategic Plan 2019-2024. Available: https://www.westerncape.gov.za/text/2020/February/western_cape_strategic_plan_2019-2024.pdf [2023, January 2]. 2018.
[27] Sekhejane P, Tirivanhu P, Motala S*, et al.* Socio-Economic Impacts of Liquor in Mpumalanga Province. Africa Institute of South Africa.ISBN: 978-0-7983-0478-8. Available: https://www.researchgate.net/publication/343473590_Socio-Economic_Impacts_of_Liquor_in_Mpumalanga_Province [2022, 8 January]. 2020.
[28] Statistics South Africa (Stats SA). 2018. P0302 – Mid-year population estimates, 2018 [dataset]. Available: https://www.statssa.gov.za/?page_id=1854&PPN=P0302&SCH=7362 [2022, December 20]. 2018.
[29] Iranpour A, Nakhaee N. A Review of Alcohol-Related Harms: A Recent Update. *Addict Health* 2019;**11**(2):129-137.
[30] Gibbs N, Angus C, Dixon S*, et al.* Effects of minimum unit pricing for alcohol in South Africa across different drinker groups and wealth quintiles: a modelling study. *BMJ Open* 2021;**11**(8):e052879.
[31] van Walbeek CP, Gibbs N. Modelling the impact of a minimum unit price (MUP) on alcohol consumption in the Western Cape. Unpublished report for DGMT. . 2021.
[32] Stockwell T, Donath S, Cooper-Stanbury M*, et al.* Under-reporting of alcohol consumption in household surveys: a comparison of quantity-frequency, graduated-frequency and recent recall. *Addiction* 2004;**99**(8):1024-1033.
[33] Unit. SALaDR. National Income Dynamics Study 2014-2015, Wave 4 [dataset]. Version 2.0.0. Pretoria: Department of Planning, Monitoring, and Evaluation [funding agency]. Cape Town: Southern Africa Labour and Development Research Unit [implementer]. Cape Town: DataFirst [distributor]. . 2018.
[34] Foundation SAAR. South Africa - All Media and Products Survey. In: Foundation SAAR, ed. 2015.
[35] South African Medical Research Council. International Alcohol Control Study: South African data. [Not publically available]. 2015.
[36] Probst C, Shuper PA, Rehm J. Coverage of alcohol consumption by national surveys in South Africa. *Addiction* 2017;**112**(4):705-710.

[37] World Health Organization. Global status report on alcohol and health 2018. Geneva: World Health Organization. . 2018

[38] Cupido J. The demand for alcohol is South Africa during the national lockdown. International Society of Substance Use Professionals. pp.2021-02. Available: https://www.issup.net/knowledge-share/publications/2021-02/demand-alcohol-south-africa-during-national-lockdown [2022, December 20]. 2021.

[39] Euromonitor International. Passport: Total Volume Litres of Pure Alcohol [dataset]. Market sizes. Available: https://www.portal.euromonitor.com/portal/statisticsevolution/index [2022, December 16]. 2022.

[40] Gmel G, Shield KD, Kehoe-Chan TAK*, et al.* The effects of capping the alcohol consumption distribution and relative risk functions on the estimated number of deaths attributable to alcohol consumption in the European Union in 2004. *BMC Medical Research Methodology* 2013;**13**(1):24.

[41] Rehm J, Kehoe T, Gmel G*, et al.* Statistical modeling of volume of alcohol exposure for epidemiological studies of population health: the US example. *Population Health Metrics* 2010;**8**(1):3.

[42] Brennan A, Meier P, Purshouse R*, et al.* The Sheffield Alcohol Policy Model – A Mathematical Description. *Health Economics* 2015;**24**(10):1368-1388.

[43] Southern Africa Labour and Development Research Unit. National Income Dynamics Study 2014-2015, Wave 4 [dataset]. Version 2.0.0. Pretoria: Department of Planning, Monitoring, and Evaluation [funding agency]. Cape Town: Southern Africa Labour and Development Research Unit [implementer], 2018. Cape Town: DataFirst [distributor]. Available: https://doi.org/10.25828/f4ws-8a78 [2022, December 16]. 2018.

[44] Londani M, Morojele NK, Egbe CO*, et al.* On- and off-licensed premises drinking behaviour among adults in the city of Tshwane, South Africa: An analysis of data from the International Alcohol Control study. *Drug Alcohol Rev* 2021;**40**(3):443-453.

[45] RG M, Salau S, Smithers M. Using locally derived empirical data to guide alcohol access restrictions in the Western Cape., Report for DGMT. 2020.

[46] Chikritzhs T, Stockwell T. The impact of later trading hours for Australian public houses (hotels) on levels of violence. *Journal of Studies on Alcohol* 2002:591+.

[47] Chikritzhs T, Stockwell T. The impact of later trading hours for hotels on levels of impaired driver road crashes and driver breath alcohol levels. *Addiction* 2006;**101**(9):1254-1264.

[48] Norström T, Skog O-J. Saturday opening of alcohol retail shops in Sweden: an experiment in two phases. *Addiction* 2005;**100**(6):767-776.

[49] Norström T, Skog OJ. Saturday opening of alcohol retail shops in Sweden: an impact analysis. *J Stud Alcohol* 2003;**64**(3):393-401.

[50] Vingilis E, McLeod AI, Seeley J*, et al.* Road safety impact of extended drinking hours in Ontario. *Accid Anal Prev* 2005;**37**(3):549-556.

[51] Government of Western Australia. Western Australia Liquor Licensing Act of 1988 (No. 54 of 1988). Available: https://www.legislation.wa.gov.au/legislation/prod/filestore.nsf/FileURL/mrdoc_7926.pdf/$FILE/Liquor%20Licensing%20Act%201988%20-%20%5B00-00-01%5D.pdf?OpenElement [2022, December 21]. 1988.

[52] Stockwell T, Sherk A, Norström T*, et al.* Estimating the public health impact of disbanding a government alcohol monopoly: application of new methods to the case of Sweden. *BMC Public Health* 2018;**18**(1):1400.

[53] Norström T, Miller T, Holder H*, et al.* Potential consequences of replacing a retail alcohol monopoly with a private licence system: results from Sweden. *Addiction* 2010;**105**(12):2113-2119.
[54] Kolosnitsyna MG, Khorkina NA, Sitdikov MT. Alcohol trade restrictions and alcohol consumption: On the effectiveness of state policy. *Studies on Russian Economic Development* 2017;**28**(5):548-557.
[55] World Bank. World Bank Development Indicators. Available: https://databank.worldbank.org/source/world-development-indicators [2022, December 26]. 2022.
[56] Chikritzhs T, Stockwell T, Masters L. Evaluation of the Public Health and Safety Impact of Extended Trading Permits for Perth Hotels and Nightclubs. National Centre for Research into the Prevention of Drug Abuse. Available: https://espace.curtin.edu.au/bitstream/handle/20.500.11937/34082/19222_downloaded_stream_314.pdf?sequence=2 [2022, December 21].
. 1997.
[57] Carpenter CS, Eisenberg D. Effects of Sunday sales restrictions on overall and day-specific alcohol consumption: evidence from Canada. *J Stud Alcohol Drugs* 2009;**70**(1):126-133.
[58] Middleton JC, Hahn RA, Kuzara JL*, et al.* Effectiveness of policies maintaining or restricting days of alcohol sales on excessive alcohol consumption and related harms. *Am J Prev Med* 2010;**39**(6):575-589.
[59] Hunter M, Hough G. The 2003 Licensing Act's impact on crime and disorder: An evaluation. Criminology & Criminal Justice. DOI: 10.1177/1748895808092428. 2008.
[60] Martin Bassols N, Vall Castello J. Bar opening hours, alcohol consumption and workplace accidents. *Labour Economics* 2018;**53**:172-181.
[61] Aliyev H, Souleimanov EA. Why Do De Facto States Fail? *Problems of Post-Communism* 2019;**66**(3):161-171.
[62] St Louis Fed. Harmonized Index of Consumer Prices: Alcoholic Beverages for Spain. Available: https://fred.stlouisfed.org/series/CP0210ESM086NEST [2023 January 2]. 2002.
[63] Tenny S, Hoffman M. Relative Risk. In: StatPearls [Online]. Treasure Island (FL): StatPearls Publishing. Available from: https://www.ncbi.nlm.nih.gov/books/NBK430824/ [01 January 2023]. 2022.
[64] Shield K, Manthey J, Rylett M*, et al.* National, regional, and global burdens of disease from 2000 to 2016 attributable to alcohol use: a comparative risk assessment study. *The Lancet Public Health* 2020;**5**(1):e51-e61.
[65] Probst C, Parry CDH, Rehm J. HIV/AIDS mortality attributable to alcohol use in South Africa: a comparative risk assessment by socioeconomic status. *BMJ Open* 2018;**8**(2):e017955.
[66] Statistics South Africa. Mortality and causes of death in South Africa: Findings from death notification. Available: https://www.statssa.gov.za/publications/P03093/P030932017.pdf. 2021.
[67] Pillay-van Wyk V, Msemburi W, Laubscher R*, et al.* Mortality trends and differentials in South Africa from 1997 to 2012: second National Burden of Disease Study. *Lancet Glob Health* 2016;**4**(9):e642-653.
[68] South African Medical Research Council. The 2nd Inury Mortality Survey: A national study of injury mortality levels and causes in South Africa in 2017. Available: https://www.samrc.ac.za/sites/default/files/files/2021-10-11/The%202nd%20Injury%20Mortality%20Survey%20Report_Final.pdf. 2021.

[69] Davies MA, Mden, E., Mosidi, T., Zinyakatira, N. & Vallabhjee, K. Burden of disease rapid review update 2019. Available: https://www.westerncape.gov.za/assets/departments/health/bod_a5_booklet_0.pdf. 2020.
[70] Institute for Health Metrics and Evaluation. GBD Compare. [Online]. Available: https://vizhub.healthdata.org/gbd-compare/ [2022, December 30]. 2019.
[71] Mackenbach JP, Kulhánová I, Bopp M*, et al.* Inequalities in Alcohol-Related Mortality in 17 European Countries: A Retrospective Analysis of Mortality Registers. *PLoS Med* 2015;**12**(12):e1001909.
[72] Meyer-Rath G, van Rensburg C, Chiu C*, et al.* The per-patient costs of HIV services in South Africa: Systematic review and application in the South African HIV Investment Case. PloS one. 14(2): e0210497. . 2019.
[73] Pooran A, Pieterson E, Davids M*, et al.* What is the cost of diagnosis and management of drug resistant tuberculosis in South Africa? *PLoS One* 2013;**8**(1):e54587.
[74] Bola S, Dash I, Naidoo M*, et al.* Interpersonal violence: quantifying the burden of injury in a South African trauma centre. Emergency Medicine Journal. 33(3): 208-12. 2016.
[75] Parkinson F, Kent S, Aldous C*, et al.* The hospital cost of road traffic accidents at a South African regional trauma centre: A micro-costing study. Injury. 45(1): 342-5. . 2014.
[76] Health Systems Trust. District Health Barometer 2018/19. Available: https://www.hst.org.za/publications/Pages/DISTRICT-HEALTH-BAROMETER-201819.aspx. 2020.
[77] Guzha N, Thebe T, Butler N*, et al.* Development of a method to determine the cost of breast cancer treatment with chemotherapy at Groote Schuur Hospital, Cape Town, South Africa. South African Medical Journal. 110(4): 296-301. . 2020.
[78] UNAIDS. UNAIDS South Africa: Overview [Online]. Available: https://www.unaids.org/en/regionscountries/countries/southafrica 2020.
[79] Matzopoulos RG, Prinsloo M, Butchart A*, et al.* Estimating the South African trauma caseload. International Journal of Injury Control and Safety Promotion. 13(1):49-51. 2006.
[80] Vento S, Dzudzor B, Cainelli F*, et al.* Liver cirrhosis in sub-Saharan Africa: neglected, yet important. The Lancet Global Health. 6(10): e1060-e1. . 2018.
[81] Joffe M, Ayeni O, Norris SA. Barriers to early presentation of breast cancer among women in Soweto, South Africa. PloS one. 13(2): e0192071. . 2018.
[82] Holmes J, Meier PS, Booth A*, et al.* The temporal relationship between per capita alcohol consumption and harm: a systematic review of time lag specifications in aggregate time series analyses. *Drug Alcohol Depend* 2012;**123**(1-3):7-14.
[83] Statistics South Africa. Province projections by sex and age. Available: https://www.statssa.gov.za/publications/P0302/P03022019.pdf [January 10, 2023]. 2018.
[84] Briggs AD, Wolstenholme J, Blakely T*, et al.* Choosing an epidemiological model structure for the economic evaluation of non-communicable disease public health interventions. *Popul Health Metr* 2016;**14**:17.
[85] International Alcohol Control Policy Evaluation Study. South Africa IAC survey. Available: https://www.iacstudy.org/. 2015.
[86] National Treasury Republic of South Africa. Budget Review. Available: https://www.treasury.gov.za/documents/national%20budget/2018/review/fullbr.pdf [2022, December 22]. 2018.
[87] Alda EC, J. . A comprehensive estimation of costs of crime in South Africa and its implications for effective policy making. Journal of International Development. 23, 926-935. 2011.

[88] Matzopoulos RG, Truen, S., Bowman, B. & Corrigall, J. The cost of harmful alcohol use in South Africa. South African Medical Journal, 104, 127-132. 2014.

[89] South African Wine Industry Information and Systems. South African Wine Industry Information and Systems data. Available: https://www.sawis.co.za/ [2022, December 11]. 2019.

[90] Van Walbeek C, Chelwa G. The case for minimum unit prices on alcohol in South Africa. *S Afr Med J* 2021;**111**(7):680-684.

[91] Londani M, Morojele NK, Egbe CO*, et al.* On- and off-licensed premises drinking behaviour among adults in the city of Tshwane, South Africa: An analysis of data from the International Alcohol Control study. *Drug and Alcohol Review* 2021;**40**(3):443-453.

[92] Statistics South Africa. Annual quarterly and regional GDP 2019. Available: https://www.statssa.gov.za/?p=14171 [2023, January 2]. 2020.

[93] Budlender D. National and provincial government spending and revenue related to alcohol abuse. Johannesburg: Soul City. No link available. . 2009.

[94] Mäkelä P, Warpenius K. Night-time is the right time? Late-night drinking and assaults in Finnish public and private settings. *Drug and Alcohol Review* 2020;**39**(4):321-329.

[95] Western Cape Department of Health. Western Cape Injury Mortality Profile Report, 2010-2016. Available: https://www.westerncape.gov.za/assets/departments/health/mortality_profile_2016.pdf [2023, January 20]. 2018.

[96] McMillan GP, Lapham S. Effectiveness of bans and laws in reducing traffic deaths: legalized Sunday packaged alcohol sales and alcohol-related traffic crashes and crash fatalities in New Mexico. *Am J Public Health* 2006;**96**(11):1944-1948.

[97] Stehr MF. The Effect of Sunday Sales of Alcohol on Highway Crash Fatalities. *The BE Journal of Economic Analysis & Policy* 2010;**10**(1).

[98] McMillan GP, Hanson TE, Lapham SC. Geographic variability in alcohol-related crashes in response to legalized Sunday packaged alcohol sales in New Mexico. *Accid Anal Prev* 2007;**39**(2):252-257.

[99] Duailibi S, Ponicki W, Grube J*, et al.* The effect of restricting opening hours on alcohol-related violence. *Am J Public Health* 2007;**97**(12):2276-2280.

[100] Sánchez AI, Villaveces A, Krafty RT*, et al.* Policies for alcohol restriction and their association with interpersonal violence: a time-series analysis of homicides in Cali, Colombia. *Int J Epidemiol* 2011;**40**(4):1037-1046.

[101] Kypri K, Jones C, McElduff P*, et al.* Effects of restricting pub closing times on night-time assaults in an Australian city. *Addiction* 2011;**106**(2):303-310.

[102] Government of New South Wales. Liquor Act 1982 No 147. Available: https://legislation.nsw.gov.au/view/html/repealed/current/act-1982-147#pt.3-div.3 [2023, January 31]. 2008.

[103] Kypri K, McElduff P, Miller P. Restrictions in pub closing times and lockouts in Newcastle, Australia five years on. *Drug and Alcohol Review* 2014;**33**(3):323-326.

[104] Room R. The long reaction against the wowser: The prehistory of alcohol deregulation in Australia. *Health Sociology Review* 2010;**19**(2):151-163.

[105] Cois A, Matzopoulos R, Pillay-van Wyk V*, et al.* Bayesian modelling of population trends in alcohol consumption provides empirically based country estimates for South Africa. *Popul Health Metr* 2021;**19**(1):43.

[106] Parry CD. Alcohol policy in South Africa: a review of policy development processes between 1994 and 2009. *Addiction* 2010;**105**(8):1340-1345.