Appraising the potential impact of a Minimum Unit Price of Alcohol in South Africa: a modelling study with a focus on equity

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Broad overview of thesis

In this thesis, I present my work modelling a hypothetical Minimum Unit Pricing (MUP[1]) policy for alcohol in South Africa. This represents the first detailed MUP epidemiological model built outside of a high-income country. I estimate MUP impacts on alcohol consumption, health harms, and various financial variables including retail and government revenue. My epidemiological policy appraisal model is equity-informative through its ability to demonstrate differential impact by wealth quintile. I built the model alongside the delivery of a programme of stakeholder engagement that ensured contextual and policy relevance for South Africa and increased opportunity for impact. I have drawn on methods from the disciplines of public health alcohol research and health economics and provided two distinct, though complimentary, results papers. I have situated my work in the literature of equity-informative health economic modelling of policy appraisal in low- and middle-income countries (LMICs).

[1] Minimum Unit Price: A retail floor price is introduced which depends on the pure alcohol content of the drink

Abbreviations

AAF	Alcohol Attributable Fraction
ABV	Alcohol By Volume
AIC	Akaike Information Criterion
AIDS	Acquired Immune Deficiency Syndrome
ART	Antiretroviral Therapy
BMJ	British Medical Journal
CEA	Cost Effectiveness Analysis
CHE	Catastrophic Health Expenditure
COPD	Chronic Obstructive Pulmonary Disease
CPI	Consumer Price Index
CVD	Cardiovascular Disease
DALY	Disability Adjusted Life Year
DCEA	Distributional Cost Effectiveness Analysis
DGMT	Douglas Murray Trust
ECEA	Extended Cost Effectiveness Analysis
FASD	Foetal Alcohol Spectrum Disorder
FRP	Financial Risk Protection
GBD	Global Burden of Disease
GBP	Great British Pound
GBV	Gender Based Violence

GDP	Gross Domestic Product
GHS	General Household Survey
GISAH	Global Information System on Alcohol and Health
HALE	Health Adjusted Life Expectancy
HED	Heavy Episodic Drinking
HIC	High Income Country
HIV	Human Immunodeficiency Virus
IAC	International Alcohol Control (Study)
ICER	Incremental Cost Effectiveness Ratio
IES	Income and Expenditure Survey
LMICs	Low- and Middle-Income Countries
MUP	Minimum Unit Price
NCD	Non-Communicable Disease
NICE	National Institute for Health and Care Excellence
NiDS	National Income Dynamics Study
OECD	Organisation for Economic Co-operation and Development
OOP	Out Of Pocket (costs)
PIF	Potential Impact Fraction
PRICELESS SA	Priority Cost-Effective Lessons for System Strengthening in South Africa
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
QALY	Quality Adjusted Life Year

RR	Relative Risk
SAAPA	South African Alcohol Policy Alliance
SADHS	South African Demographic and Health Survey
SAMRC	South African Medical Research Council
SAPM	Sheffield Alcohol Policy Model
SARG	Sheffield Alcohol Research Group
SAWIS	South Africa Wine Industry Information and Systems
SD	Standard Drink
SES	Socio-economic Status
SROI	Social Return on Investment
TB	Tuberculosis
USD	United States Dollars
VAT	Value Added Tax
WHO	World Health Organisation
ZAR	South African Rand

Outline of chapters

Chapter one

I begin this thesis by outlining the context of alcohol consumption, harm and policy in South Africa. I introduce evidence for the effectiveness of alcohol pricing policies as a policy response and the importance of health economic modelling for decision makers.

Chapter two

In chapter two I briefly outline my definition of equity for the purpose of this thesis and introduce some established methods for equity-informative economic evaluation. I then present a scoping review of the literature for examples applied to health policies in LMICs. I consider how the methods used could apply to modelling of alcohol pricing policies in South Africa.

Chapter three

Chapter three outlines my stakeholder engagement work which was undertaken at the beginning, middle and end of the modelling process. I undertook 12 scoping interviews and three workshops with South African experts in alcohol policy drawn from government, academia and civil society organisations.

Chapter four

Chapter four sets out the detailed mathematical methods used to build the model. This includes exploration of datasets, definition of key equations and processes used in the model.

Chapter five

Chapter five is the first of two results chapters and is included in publication format.
Title: *"Effects of minimum unit pricing for alcohol in South Africa across different drinker groups and wealth quintiles: a modelling study*".
Published in BMJ Open
Authors: Naomi Gibbs, Colin Angus, Simon Dixon, Charles Parry, Petra Meier
I completed all modelling, stakeholder engagement and writing, with supervision throughout and comments on the first draft provided by all four co-authors.

Chapter six

Chapter six is the second of the results chapters and is included in publication format. Title: *"An Extended Cost-Effectiveness Analysis of Minimum Unit Pricing in South Africa"*.

Authors: Naomi Gibbs, Colin Angus, Simon Dixon, Charles Parry, Petra Meier, Michael Boachie, Stephane Verguet

I applied an extended cost-effectiveness analysis methodology to my original model. I conceptualised the study. I completed the modelling under the supervision of Colin Angus and Stephane Verguet, University of Harvard, (the founder of the methodological approach). Micheal Boachie, University of Witswatersrand, provided data inputs for the model. I wrote the first draft, all authors revised it.

Chapter seven

Chapter seven provides a discussion of the unique scientific contribution this thesis has made by applying epidemiological modelling to the policy appraisal of MUP outside of a high-income country, employing distributional methods to explore a concern for equity and engaging stakeholders throughout the research. The chapter also outlines limitations and suggestions for further research.

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1. Introduction

In this chapter I outline what is known about alcohol consumption and harm in South Africa before outlining inequalities of income, health and healthcare access. Unrecorded alcohol, as an issue pertinent to the context, is explored before a brief summary of alcohol policy in South Africa is given. Finally, I present evidence for the effectiveness of alcohol pricing policies in reducing harm and how health economic modelling can support decision makers in setting such policies.

1.1 Alcohol consumption in South Africa

Alcohol consumption in South Africa is characterised by high levels of abstention and high volumes of consumption amongst drinkers. The World Health Organisation (WHO) use administrative and industry sources to estimate South African adult (15+) per capita annual consumption (in litres of pure alcohol, 2016 -2018) at 9.5, higher than the global average (6.4) and the average across the WHO Africa region (6.3) (World Health Organisation, 2020). In order to estimate abstention, self-reports from surveys are used. South Africa has high levels of reported abstention (80.8%/56.8% females/males) which results in an estimate of 30 litres of pure alcohol consumed per drinker per year, for comparison the UK estimate is 15.1 litres. This high level of consumption is accompanied by high levels of reported heavy episodic drinking (HED), particularly amongst men (33.7%/70.8% for females/males) (World Health Organisation, 2020). HED is defined here as 60 or more grams of pure alcohol on at least one occasion per month (60 equates to 5 standard drinks). For comparison, the same report estimates UK HED at 22.0%/55.1% for females/males.

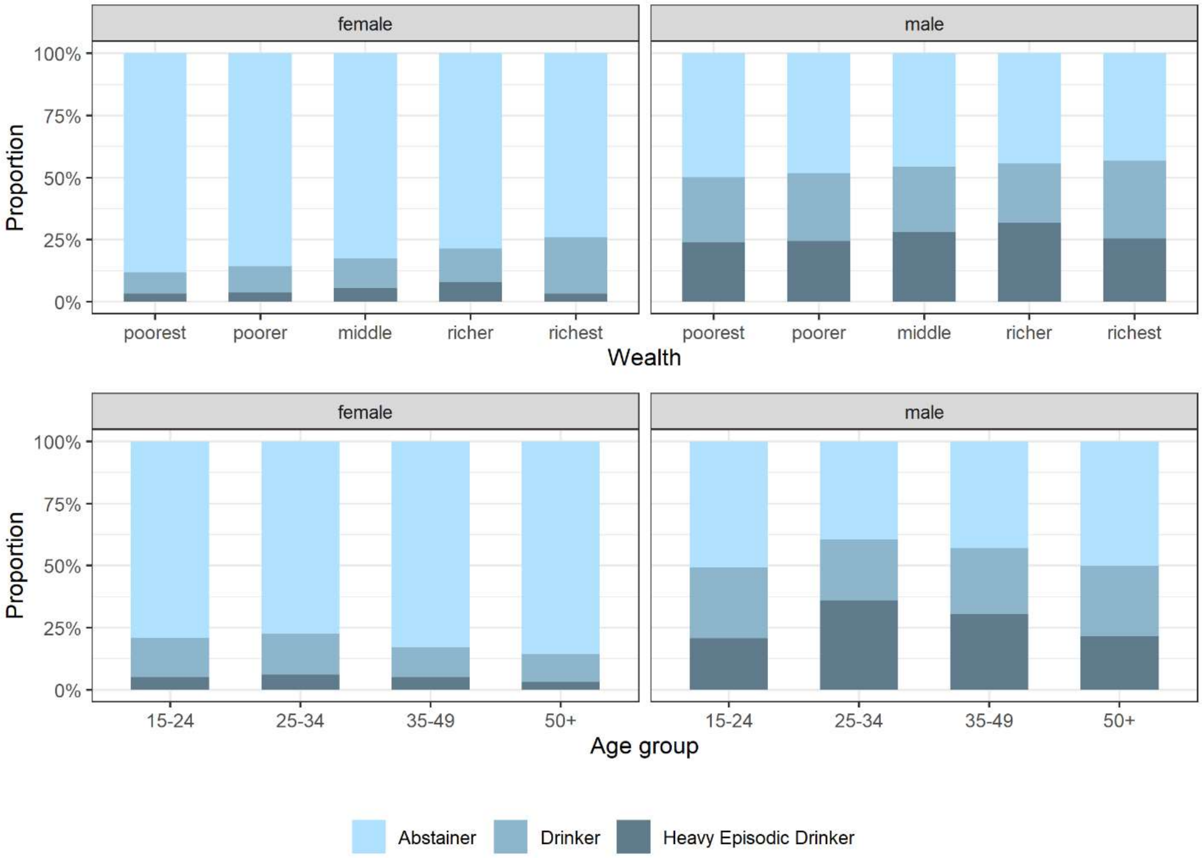
Alcohol consumption in South Africa, as with most countries, is highly socially patterned. Data from the South African Demographic and Health Survey (SADHS) indicates that as wealth increases so does the prevalence of drinking anything at all, the prevalence of heavy episodic drinking peaks in quintile four for both females and males (Figure 1.1). Drinking at all and heavy episodic drinking is highest amongst those age 25 – 34 (Figure 1.1), this is consistent with analysis of the National Income Dynamic Study (NiDS) (Vellios and Van Walbeek, 2018). The absolute level of consumption is much lower among women than men however the consumption patterns across wealth and age are similar for both women and men.

Figure 1.1: Drinking prevalence by wealth quintile and age, faceted for sex, created by author using data from 2016 SADHS

Drinker: someone who reports drinking any alcohol in the last 12 months

Heavy episodic drinker: someone who reports drinking five or more drinks on one occasion in the past month

Wealth: calculated using an asset index related to ownership of goods and household characteristics

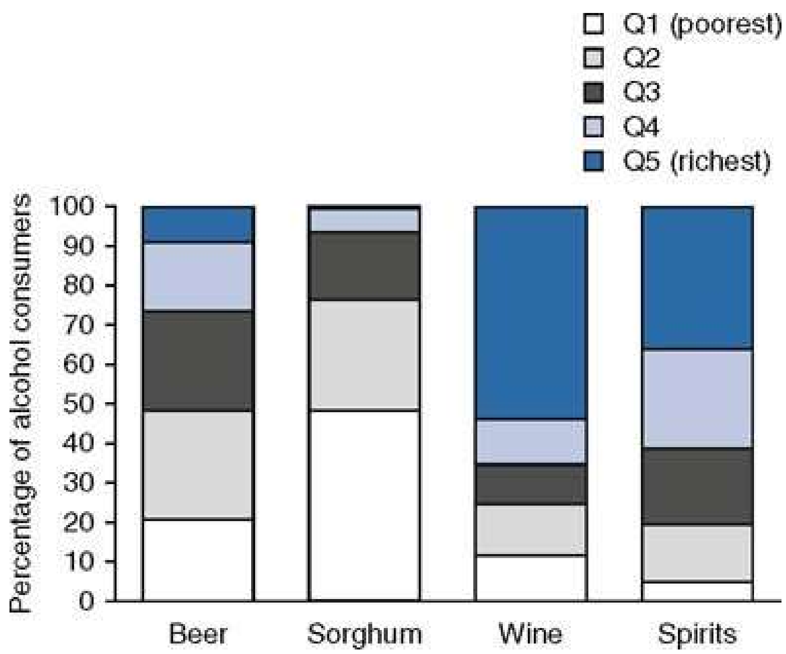


Ethnic group is another demographic variable of interest particularly in the context of South Africa. White people are far more likely to report drinking than Black Africans (National Department of Health (NHoH), 2019). However, Black Africans constitute the vast majority in South Africa (81%/9%/8%/2% - Black African/Coloured[2]/White/Indian (Rebublic of South Africa, 2019)) and race is highly correlated with wealth. Therefore, a focus on the difference between Black African and White ethnic groups would mainly serve to highlight the difference between the top quintile (which includes most of the White minority) and the bottom four quintiles.

[2] Coloured: The terms used here to describe ethnic groups are those published by Statistics South Africa. They are not in any way intended as a pejorative term but reflect the language used by the governmental agencies in the country studied.

The type of alcohol drunk, as well as levels of consumption, also differ by socioeconomic status. Data from the South African Income and Expenditure Survey (IES) indicates the poorest quintile are the largest consumer of Sorghum beer and the richest consume the largest proportion of wine (Figure 1.2). Sorghum is a grain used to produce beer; it can be bought as beer or as a powder, which is then used to produce homebrew. Sorghum is traditionally drunk more in poorer communities and is an inferior good; when income rises consumption of Sorghum will fall (South Africa, 2014). Evidence from a nationally representative expenditure survey indicated that between 2001 and 2012 the prevalence of drinking Sorghum beer has declined (Van Walbeek and Blecher, 2014). There appears to be growing popularity for mainstream branded alcohol as the alcohol industry looks to effectively market and expand in South Africa.

Figure 1.2: Alcohol consumed by quintile (Ataguba, 2012, p. 71 Figure 1)



1.2 Alcohol harm in South Africa

Heavy alcohol consumption over time causes most health harm, particularly for chronic harms. However, for some conditions it is heavy drinking in the occasion (HED leading to intoxication) that increases risk, particularly for acute harms such an intentional injury and road injury (Room et al., 2005). Chronic harms are most associated with long-term heavy drinking and acute harms are associated with intoxication. Figure 1.3 provides a simple causal model of alcohol use and mortality; this could easily be expanded to include morbidity as well as mortality.

Figure 1.3: Causal model of alcohol consumption, intermediate mechanisms and long-term consequences (Rehm et al., 2010a)

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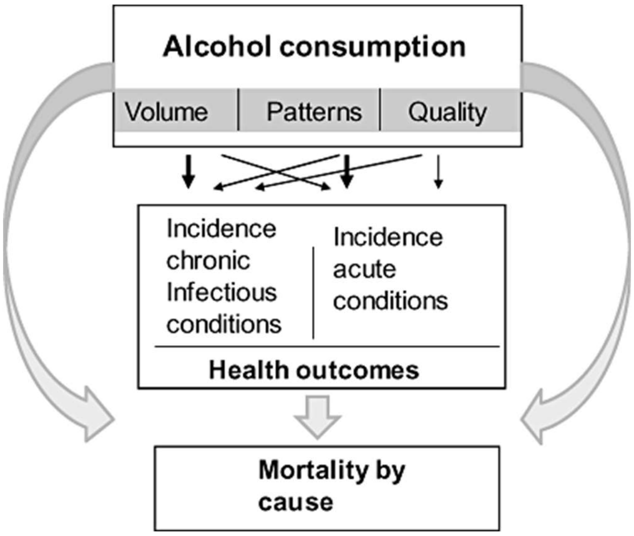


The high volume and risky pattern of alcohol consumption in South Africa results in a high burden of disease. In 2019 Disability Adjusted Life Years (DALYs[3]) attributable to alcohol use were estimated at 586.41 per 100,000 people for women and 3,717.27 per 100,000 people for men (Institute for Health Metrics and Evaluation, 2019); this represents the fourth highest in the WHO Africa region. Comparing the DALY burden with that of other risk factors in South Africa alcohol use is amongst the top three, following unsafe sex and high fasting plasma glucose (Institute for Health Metrics and Evaluation, 2019). The harm resulting from alcohol use is also diverse, contributing to a broad range of disease and injury conditions in South Africa (Table 1.1).

[3] DALYs represent a time-based measure of overall burden of disease for a given population. DALYs are the sum of years of life lost due to premature mortality as well as years of life lost due to time lived in less than full health World Health Organisation. (2018). *Global Information System on Alcohol and Health: World Health Organisation* [Online]. Geneva: WHO. Available from: http://apps.who.int/gho/data/node.gisah.GISAHhome?showonly=GISAH [Accessed 14/02/2019].

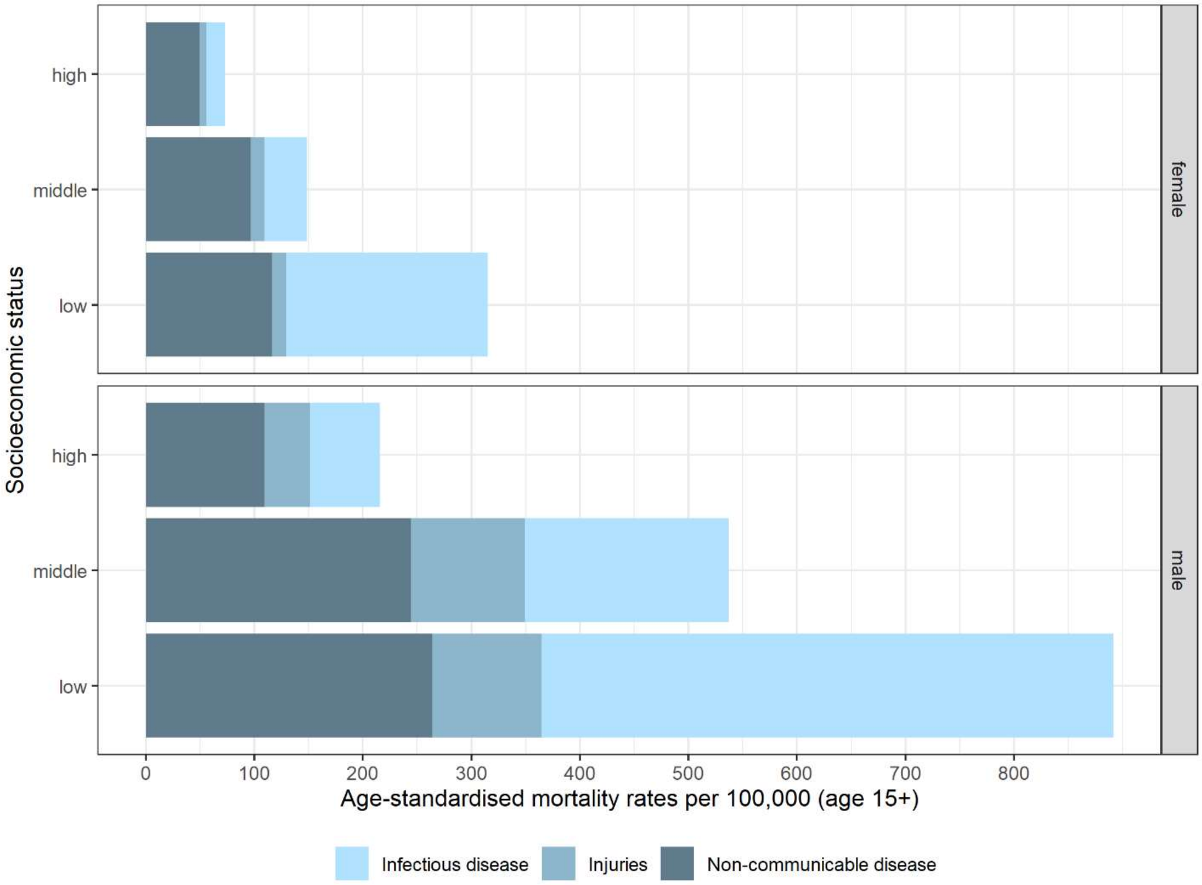
Table 1.1: Death rates attributable to alcohol use by cause in South Africa, 2017 (Institute for Health Metrics and Evaluation, 2019)

Cause of death	Deaths (per 100,000) attributable to alcohol use by cause, in 2017 (95% confidence intervals)
Respiratory infections and tuberculosis	25 (19 - 31)
Cardiovascular diseases	17 (11 - 22)
Self-harm and interpersonal violence	11 (6 - 16)
Neoplasms	8 (7 - 10)
Transport injuries	4 (2 - 6)
Digestive diseases	2 (1.8 – 2.4)
Diabetes and kidney diseases	2 (0 – 5)
Substance use disorders	1 (1 - 2)
Unintentional injuries	1 (0 - 2)
Neurological disorders	0.5 (0.3 - 0.7)

Two alcohol attributable diseases which have received specific attention in South Africa are foetal alcohol spectrum disorder (FASD) and HIV/AIDS. FASD in South Africa has around the highest known prevalence rates in the world, estimated between 29 and 290 per 1000 live births (Olivier et al., 2016). In South Africa alcohol use is also associated with gender-based violence and HIV, due to increased sexual risk taking and reduced antiretroviral therapy (ART) adherence (Fisher et al., 2007, Probst et al., 2018a, Bonner et al., 2019, Scott-Sheldon et al., 2014).

International research has revealed that lower socioeconomic groups experience higher levels of alcohol related harm (Mackenbach et al., 2015). In addition there is evidence of a phenomenon coined the alcohol harm paradox, in which lower socioeconomic groups experience higher levels of alcohol related harm despite drinking less or the same as higher socioeconomic groups (Bloomfield, 2020). In South Africa, there is evidence that harm is concentrated amongst the lower socioeconomic groups and prevalence of drinking does increase with wealth but it is not clear if total volume consumed amongst drinkers also increases with wealth. Probst et al. (2018a) examined the HIV/AIDS mortality attributable to alcohol use split by socioeconomic status in South Africa. Male age standardised HIV/AIDS mortality attributable to alcohol was 229.6 and 31 per 100,000 for low and high SES groups respectively, for females this was 75.5 and 10.8 per 100,000. Those of lower SES had a far higher HIV/AIDS alcohol attributable mortality (Probst et al., 2018a). Probst et al. (2018b) then developed their work to consider other forms of alcohol attributable harm. They estimated various age standardised alcohol attributable fractions (AAFs[4]) and alcohol attributable mortality rates by three socioeconomic status (SES) groups. Alcohol attributable mortality was highest in the lowest SES group, 727 per 100,000 deaths, compared with 163 deaths per 100,000 for the highest SES group. The largest cause of alcohol attributable deaths in the low SES group resulted from infectious disease as opposed to chronic disease in the high SES group (Figure 1.4). AAFs were highest in low and middle SES groups for men, partly linked to higher levels of consumption among drinkers.

Figure 1.4: Alcohol attributable mortality rate by sex and SES
created by author using data from supplementary appendix to Probst et al. (2018b)



[4] AAF: Alcohol attributable fractions indicate the proportion of a particular disease or injury condition that is attributable to alcohol compared with a scenario of no alcohol.
Rehm, J., Mathers, C., Popova, S., Thavorncharoensap, M., Teerawattananon, Y. & Patra, J., (2009). Global burden of disease and injury and economic cost attributable to alcohol use and alcohol-use disorders. *Lancet*. **373**(9682), 2223-2233.

Mukong et al. (2017) also evidenced the association between alcohol, infectious disease and socioeconomic status in South Africa. In a study relating smoking and alcohol use with income-related inequality in health, for those of lower SES, alcohol use contributed more highly to tuberculosis than to diabetes, stroke or cancer.

In addition to the increased burden of alcohol harm amongst lower SES groups research has highlighted the differential access to services by ethnic group. Myers and Parry (2005) have shown black South Africans are underrepresented in accessing substance abuse treatment services.

1.3 Broader inequalities in South Africa

1.3.1 Income

Due to the system of apartheid, in force until 1994, South Africa is a country divided between the rich and poor. An alcohol pricing policy seeking to improve population health, and have a positive equity impact, would do so in the context of significant income inequality and socioeconomic inequalities in health and healthcare. In 2015 the income inequality measured by the Gini coefficient[5] was 0.68, down from 0.72 in 2006 (Statistics South Africa, 2017). Despite the decline it remains the highest in the world (World Bank, 2019). Statistics South Africa (2017) also highlight the variation in absolute level and trend (from 2015 compared with 2006) between ethnic groups reflecting the shifts in society. Black Africans have the highest and increasing Gini coefficient of 0.65 up from 0.64, Whites 0.51 down from 0.56, Coloureds[6] 0.58 down from 0.6 and Indian/Asians, 0.56 at both time points.

1.3.2 Health

Booysen et al. (2018) used data from the 2012 South African National Health and Nutrition Examination Survey to demonstrate inequality in health by socioeconomic status. They calculate concentration indices where zero indicates perfect equality; negative values represent a pro-poor distribution and positive

[5] Gini coefficient lies between 0 and 1, 0 = perfect equality, 1 = perfect inequality. It is calculated as the area between the Lorenz curve and the diagonal. Morgan, J., (1962). The anatomy of income distribution. *The review of economics and statistics*. 270-283.

[6] Coloured: The terms used here to describe ethnic groups are those published by Statistics South Africa. They are not in any way intended as a pejorative term but reflect the language used by the governmental agencies in the country studied.

values pro-rich (bounded at -1 and +1). Across four different measures bad health was found to be concentrated amongst the poor, self-reported good health concentrated amongst the rich (Figure 1.5).

Figure 1.5: Concentration indices for health status by socioeconomic status (Booysen et al., 2018)
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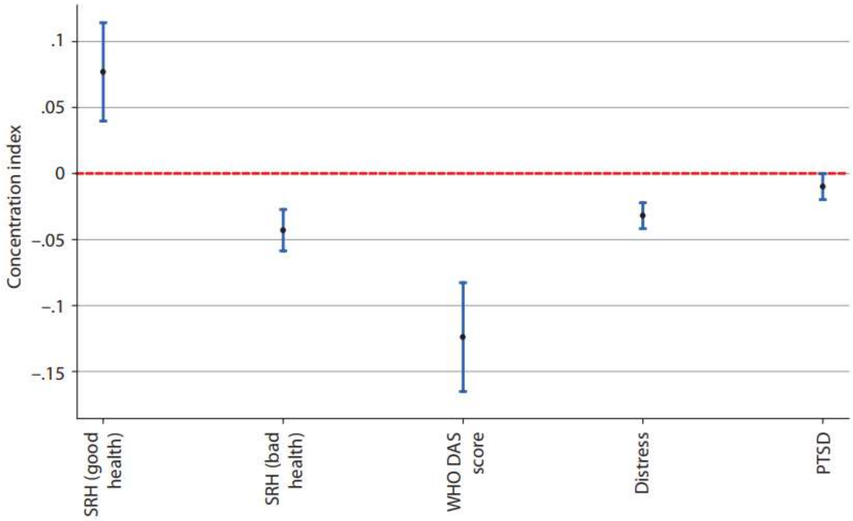

Note: SRH – self-reported health; WHO DAS – WHO Disability Assessment Schedule; Distress – Kessler Psychological Distress Scale (K10); PTSD – post-traumatic stress disorder

1.3.3 Healthcare access

In South Africa when those who are poorer experience ill health they are less able to meet their need for healthcare (Booysen et al., 2018). The concentration curve for unmet need is to the left of the 45-degree line illustrating unmet need is concentrated amongst those with less wealth (Figure 1.6). A previous study by Ataguba and McIntyre (2012) also found that the poorest quintile had the lowest access to healthcare and the worst self-reported health status.

Figure 1.6: Self-reported unmet need for healthcare. (Booysen et al., 2018)
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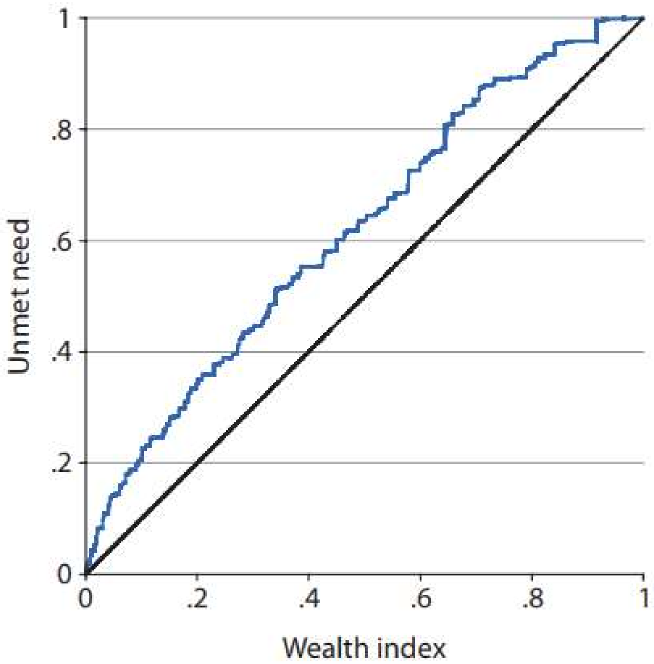
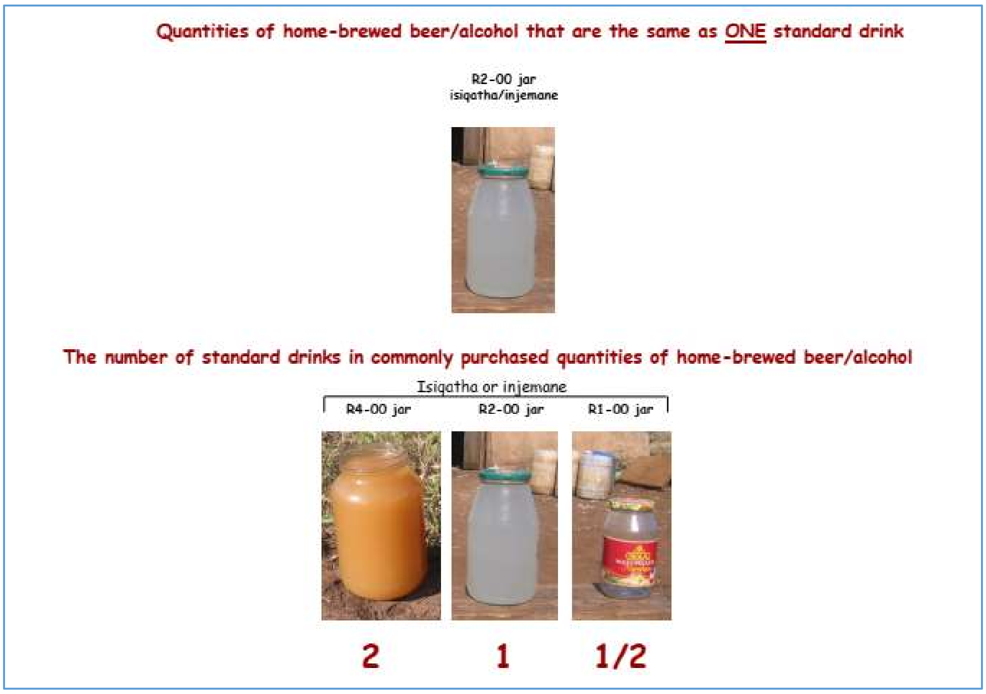


1.4 Unrecorded alcohol

Alcohol consumption estimates will often consist of both recorded and unrecorded consumption. Recorded consumption is that which is captured in official statistics such as data on alcohol taxation or sales. Unrecorded alcohol encompasses a broad array of sources, including; home brew, legal or illegally informally produced, smuggled, cross border shopping and alcohol which is intended for industrial or medical use (World Health Organisation, 2018). The WHO Global Information System on Alcohol and Health estimate unrecorded consumption at 24% of all alcohol consumed in South Africa (World Health Organisation, 2018). The team who produce these estimates (at the Centre for Addiction and Mental Health, Institute for Mental Health Policy Research, Toronto) confirmed (via email) that this estimate was obtained by gathering seven expert opinions. Van Walbeek and Blecher (2014) report estimates of unrecorded consumption in South Africa ranging from 26% of the market to 14%. They report that all studies agree that the major source of unrecorded alcohol in South Africa is home brew. Home brew is not only made for individual consumption at home but is also sold informally (Figure 1.7). There is a high level of uncertainty and variability in the estimates of homebrew consumption. Analysing the SADHS data reveals that 12% of male survey respondents had drunk at least one home brew in the last 7 days, this was 9% for female respondents. In the International Alcohol Control (IAC) [7] study covering the Tshwane Metro only 1.5% reported drinking home brew of which 0.6% drink it as their main drink (Trangenstein et al., 2018). For a small sample of 243 young adult drinkers in Khayelitsha (a large township) 2.5% reported that homebrew was something they would normally drink, they were permitted to choose more than one drink type (Ferrell, 2016).

Figure 1.7: Showcard for the SADHS for homebrew quantities and prices (South Africa, 2019)



Home-brew, along with other recorded forms of alcohol, is often purchased at unlicensed premises. In 1926 apartheid legislation prohibited African and Indian access to licensed premises or employment by licence holders. This meant that by the time the democratically elected government took power in 1994 they inherited a significant number of shebeens. Shebeens are unlicensed bars or pubs, found in the South African townships, often open late and with a reputation for violence and risky sexual behaviour. The political history has institutionalised heavy consumption, to intoxication, and associated behaviours which lead to acute alcohol harms.

[7] International Alcohol Control Study – provides internationally comparable (16 countries) detailed surveys of drinkers including drink types, prices and drinking locations. Countries also undertake an alcohol environment protocol that details the policy context of alcohol. www.iacstudy.org

1.5 Alcohol policy in South Africa

1.5.1 Overview

Alcohol policy in South Africa has developed in a piecemeal fashion since 1994. Four specific policy changes between 1994 and 2010 are highlighted by Parry (2010b). These are the requirement to add warning labels to alcohol products, restrictions on employment of people below 18 in the liquor trade, increased excise taxes and legislating on alcohol container size (Parry, 2010b). In 2010 an interministerial committee was established to design and implement interventions to reduce alcohol harm. They drafted The Control of Marketing of Alcohol Beverages Bill of 2013 intended to ban all alcohol advertising, amongst other measures. This was opposed by the alcohol industry who used diverse strategies such as commissioning impact assessments, focusing on economic arguments, lobbying and discrediting public health advocates in the media (Bertscher et al., 2018). The Bill was never made available for public comment, instead the 2017 Liquor Amendment Bill (South Africa, 2017a) was drafted which includes limited restrictions on advertising, restrictions on outlet location, raising the minimum drinking age from 18 to 21, and making manufacturers and suppliers of alcohol to unlicensed outlets liable for all damages caused by their products unlawful distribution. This bill has not been approved by the national legislature or signed into law. In March 2020 the national cabinet approved the 2020 Road Traffic Amendment Bill to effectively prohibit any level of drinking and driving, however it still needs to go to the national legislature for approval (Republic of South Africa, 2020). In September 2021 the President signed into law the 2016 Liquor Products Amendment Bill which brings traditional African beer produced for commercial purposes into the scope of regulation (South Africa, 2016).

South Africa has both state and provincial legislatures. Provincial governments may legislate on many areas, including; environment, health services, regional planning and development, trade and industrial promotion, urban and rural development and liquor licensing. The Western Cape government, for example, have been particularly active in considering provincial legislation to combat alcohol harm. The Western Cape alcohol harms reduction policy 2017 (South Africa, 2017b) outlines the extent and nature of alcohol harm in South Africa and potential policy approaches to combat this locally, including provincial taxation and MUP. This policy was approved as a White Paper in 2017 but never taken to the provincial legislature for approval or signed into law.

1.5.2 Taxation

The national government have used alcohol taxes to raise revenue and correct for the negative externalities related to alcohol consumption. Several historical and social influences have led to the inconsistent system of taxation between different alcoholic drinks. For example, prior to 1990 wine was not taxed at all due to its role in the economy (PRICELESS SA, 2017). African beer powder and African beer taxation is kept low, due to its popularity amongst lower socioeconomic groups. Since 2002 increases have been above inflation each year (except for Sorghum based products which have remained flat) to keep up with increases in retail prices. The tax rates for South Africa are published in the Full Budget Report each year (Treasury, 2020). For 2021 they are: R4.39 (£0.21 GBP) per litre for wine, R0.782 (£0.04 GBP) per litre for traditional African Beer, R106.56 (£5.21 GPB) per litre of absolute alcohol for malt beer/cider/alcoholic fruit beverages, R213.13 (£10.42 GBP) per litre of absolute alcohol for spirits. This taxation system results in wine and traditional beer benefiting from much lower rates of tax by volume of absolute alcohol.

1.6 Evidence for alcohol pricing policies

Alcohol pricing policies are consistently recommended as one of the most cost-effective policies governments can employ to reduce alcohol harm (World Health Organisation, 2010, Chisholm et al., 2018, World Health Organisation, 2019b). Governments have employed a variety of approaches; amongst them are general price increases via taxation, MUP and banning of discounting. There are also more unusual and innovative approaches such as the taxation system in Thailand. They use a combination of volumetric taxation (tax applied based on alcohol content) and differential ad valorem tax for different drink types in order to both increase the price of alcohol drunk by heavy drinkers and attempt to prevent drinking initiation amongst the young (Sornpaisarn et al., 2012).

Specific tax increases and/or floor prices can be set at a variety of levels and targeted at either the off-trade (supermarkets, off-licenses etc) or the on-trade (restaurants, pubs etc). Different approaches will be most suitable depending on the specific objectives of the government i.e. to curb youth drinking, to reduce overall consumption or to target heavy drinking whilst not penalising moderate drinkers (Purshouse et al., 2010).

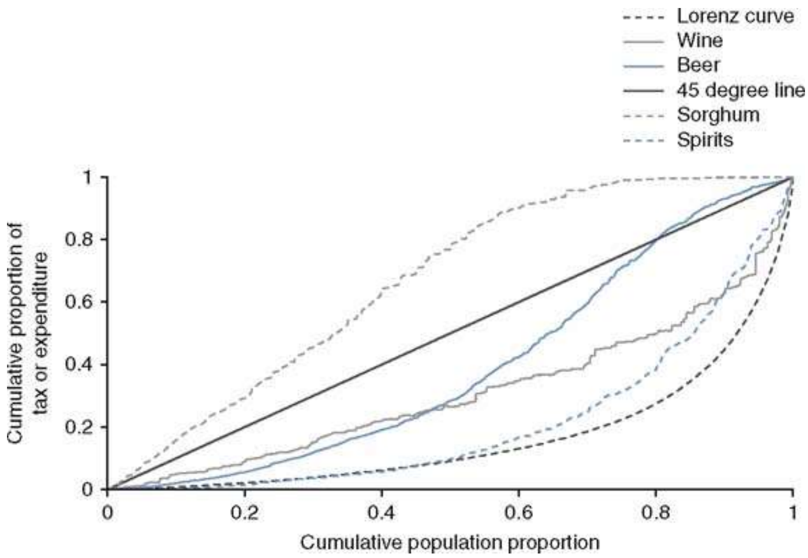
There is increasing evidence that MUP is highly cost-effective, although much of the evidence is drawn from high-income countries (O'Donnell et al., 2019, Robinson et al., 2020, Brennan et al., 2015). It is currently operational in Scotland, Wales and Australia's Northern Territory where it has been introduced in response to high levels of alcohol related harm. The rationale behind MUP is that heavy drinkers (who accrue the most harm) purchase the cheapest alcohol, therefore rather than increasing the price of alcohol across the price distribution as an excise tax would, MUP increases the price of the cheapest alcohol and thus reduces the consumption of those at highest risk.

A common concern relating to pricing policies is their equity impact. If the poor spend more proportionally on alcohol then this is seen as regressive and potentially problematic. The distribution of the accrued health benefits resulting from the policy then becomes even more relevant. Modelling evidence for Scotland suggested that the greatest health benefits will accrue to lowest socioeconomic groups as they purchase more of the cheapest alcohol (Angus et al., 2016). Due to their price elasticities they also realise a decrease in spending on alcohol (Holmes et al., 2014). This predicted disproportionate reduction in consumption for lower socioeconomic groups has so far borne out in the evidence that has emerged since the introduction of the policy (O'Donnell et al., 2019).

A review of the drinking patterns and socioeconomic inequality (which included studies from ten high-income countries) suggested that to address socioeconomic inequalities in mortality the policy focus should be on the reduction of heavy episodic drinking rather than alcohol use overall, as acute harms contribute more highly to the inequality (Probst et al., 2020). Therefore, if reducing socioeconomic health inequality is a central concern, pricing policies which target the alcohol drunk by heavy episodic drinkers may be preferred.

This concern relating to the distribution of policy impact is paramount in the context of South Africa. To date alcohol pricing research has focused on the proportion of alcohol tax paid by the poor compared with the rich relative to their income. Ataguba (2012) explored the concentration of alcohol tax by quintile across drink types (Figure 1.8).

Figure 1.8: Concentration curves by drink type and Lorenz curve (Ataguba, 2012, p. 73)



The concentration curve[8] for Sorghum, above the 45-degree line, indicates this tax is paid disproportionately by the poor. Taxation of wine and spirits are paid disproportionately by the rich. However, the Kakwani[9] indices indicated regressivity[10] across every drink type, driven by very high income inequality, as demonstrated by the Lorenz curve[11]. Further research has indicated that spending on alcohol has become less regressive between 1995 and 2011 mainly due to a reduction in income inequality (Marx et al., 2019). Parry et al. (2003) challenge the regressive framing of alcohol pricing policies as misplaced and “cynical”. The failure to take account of where and to whom the health benefits would fall, and also where tax revenue is spent, which Parry et al. (2003) state would almost certainly be progressive, prevents a fully informed debate.

[8] Concentration curve: A concentration curve can relate two dimensions, any variable of interest on the y axis such as a measure of health or cumulative tax, and cumulative population ranked by income on the x axis (Wagstaff, 2002).
[9] Kakwani: a measure combining income inequality and concentration indices. (Kakwani et al. 1997)
[10] Regressivity: Refers to the poor paying a larger percentage of their income than the rich.
[11] Lorenz curve: A measure of income inequality where cumulative income is plotted on the y axis against cumulative population ranked by income on the x axis. A Lorenz curve can be applied to health but only using one dimension (Lorenz, 1905).

1.7 Health economic modelling to support decision makers

Health economic modelling of alcohol pricing policies can contribute significant evidence to policy development. Stewart and Smith (2015) note that economic models often provide the ‘gold dust’ of quantitative evidence needed to win a policy debate. In the UK, the Sheffield Alcohol Policy Model (SAPM) (Brennan et al., 2015) was instrumental in the MUP debate and subsequent legislation passed in Scotland (Katikireddi et al., 2014). Research in South Africa has recently utilised health economic modelling to appraise alcohol pricing policy options. Modelling work includes linking national excise tax rises with all cause alcohol attributable mortality (Stacey et al., 2018, PRICELESS SA, 2017) and modelling alcohol consumption changes in the Western Cape resulting from a potential provincial excise tax or minimum unit price (Van Walbeek and Chelwa, 2018). Another example is modelling that was undertaken in relation to the introduction of a national Sugar Sweetened Beverage Tax in 2018 (Manyema et al., 2016). The model estimated a reduction in stroke cases and deaths over 20 years with resulting savings in healthcare costs.

Methods for modelling public health interventions are continuing to develop. Public health economic models cover a range of policies and outcomes and as such there are a variety of epidemiological model structures available (Briggs et al., 2016). Critical to the relevance of the modelling work and therefore its opportunity for impact is the timely involvement of relevant stakeholders (Squires et al., 2016). Public health economic evaluations can aid decision makers further by not only considering health maximisation but also incorporating a concern for equity, a common public health policy objective and of particular relevance to South Africa with its recent political history (United Nations, 2015, Marmot et al., 2012, Cookson et al., 2021). Methods are emerging to support this focus and provide decision makers with information about distributional impact (Asaria et al., 2016, Verguet et al., 2016a)

1.8 Conclusion

In this introduction I have briefly explored the significant burden of alcohol harm in South Africa and how pricing policies might work to address this. South Africa is unique in being characterised by high levels of abstinence coupled with high levels of mean drinking amongst drinkers. This drinking pattern coupled with the broader disease burden spanning non-communicable disease, infectious disease and injury, creates a very different alcohol harm profile than experienced in many high-income countries, such as the UK. Conditions including HIV, tuberculosis, foetal alcohol syndrome, intentional and road injury predominate the alcohol policy discussion. The relationship between alcohol harm and socioeconomic status indicates that the poor bear the largest burden of alcohol-related harm, particularly as a result of infectious disease.

Alcohol policy in South Africa has developed in a piecemeal fashion since 1994, with uncertainty surrounding the implementation of the 2017 Liquor Amendment Bill. There is an established precedent in South Africa for using taxation to simultaneously reduce consumption and raise revenue, although this has been inconsistently applied dependent on drink type due to the relationship with the wider economy or society. The excise tax system has benefited traditional African beer and wine, enabling very cheap prices. In South Africa there is also uncertainty as to the magnitude of unrecorded alcohol which includes homebrew.

There is strong evidence to suggest that pricing policies could alleviate some of the burden of alcohol harm. However currently alcohol taxation is regarded as regressive within policy debate in South Africa. This may be in part due to the sparsity of research focused solely on South Africa that directly presents improved distributional health outcomes alongside tax increases. Equity is a highly relevant topic in South Africa given the history of apartheid which institutionalised inequalities. Inequality of income, health and access to healthcare are the backdrop to policy interventions, it is vital to consider disadvantaged groups in any quantitative policy appraisal. My thesis will provide evidence to contribute to the policy debate around both effectiveness and equity.

The impact of alcohol pricing policies on population health in South Africa is an important public health question in light of the extent and nature of alcohol harm. Exploring the equity impact of these policies is essential and will need to be clearly defined and investigated.

2 Chapter two: Incorporating equity into economic evaluation of health policies: A scoping review

In this chapter I firstly explore what defines health equity, and how this might apply to alcohol related harm, before briefly describing a number of established methods for illustrating equity impact in economic evaluation. Following this my scoping review of economic evaluation of health policy in LMICs with a concern for equity is presented.

2.1 Defining health equity

Equity is an interdisciplinary normative concept much debated in the literature. Health equality and health equity are defined in various ways by academic and policy institutions and are often wrongly used interchangeably. I define health equality as parity of any health metric between individuals or groups, for example equality of life expectancy between different population groups. Not all health inequalities would necessarily raise an equity concern, additional dimensions need to be considered in order to evaluate equity. The World Health Organisation provides one commonly used definition of health equity (Box 2.1).

> ***"Equity is the absence of avoidable, unfair, or remediable differences among groups of people, whether those groups are defined socially, economically, demographically or geographically or by other means of stratification. "Health equity" or "equity in health" implies that ideally everyone should have a fair opportunity to attain their full health potential and that no one should be disadvantaged from achieving this potential."***

Box 2.1: WHO definition of equity (World health Organisation, 2019a)

Drawing on this and briefly exploring some key economic and public health literature, I argue that health inequity is the existence of a health inequality between socially determined subgroups where the cause is both avoidable and unfair. The argument starts with the importance of measuring health outcomes.

2.1.1 Health as the outcome measure of interest

Firstly, a concern for health equity requires the measurement of health outcomes. Health economists Culyer and Wagstaff (1993) explored several definitions of equity in relation to health and healthcare. Their key contribution was to broaden the focus from access to healthcare to health outcomes generally. Healthcare is only a means to an intermediate end (health) and health is a means to a further end (flourishing). They defined equity in health as the equalisation of overall lifetime health subject to the respect for individual choice and without levelling down. Levelling down would require deliberately reducing the health of the healthiest to achieve equality. Drawing on moral philosophy their argument developed from health as an outcome, providing direct utility, to health as a platform providing an opportunity to "flourish". This definition accords with Sen's view of health as a functioning (Sen, 1991). This established the position that to explore and quantify equity in health one must measure health outcomes, not simply access to healthcare.

2.1.2 Subgroups as central to the concern for equity

Measuring health outcomes between individuals, known as measuring pure health inequality in much the same way as income inequality, can only tell us about the unidimensional distribution of health in the population. It does not provide the decision maker with policy relevant information about which groups are worse off than others. It is more helpful to highlight the differences in health outcomes between policy relevant subgroups in order to understand whether already disadvantaged groups are also experiencing the poorest health and where and how to best direct resources. The groups must be socially/culturally defined in each context as those disadvantaged by the societal structure in which they live and this is best determined by the decision maker. Age, gender and race are characteristics commonly used to define subgroups. Wealth and geographical location may also be the focus whereas some subgroups, for example relating to health status such as HIV/AIDS, are highly policy and country specific.

2.1.3 Alcohol attributable harm as an equity concern

Health inequalities between subgroups of interest however, may not always constitute an inequity, there must also be consideration of the cause of the health inequality. Whitehead (1991), suggested the root cause of health differences must be both avoidable and unfair for the inequality to be considered an inequity. Fairness is linked to possession of fully informed free choice. Examples where fully informed free choice is limited include: *"health-damaging behaviour where the degree of choice of lifestyles is severely restricted; exposure to unhealthy, stressful living and working conditions; inadequate access to* *essential health and other public services; natural selection or health-related social mobility involving the tendency for sick people to move down the social scale" (Whitehead, 1991, p. 219).* Lower socioeconomic groups in South Africa, living in high population density townships with stressful living and working conditions and exposed to environments where beer and wine are cheaply and readily available might reasonably be considered as having their free choice regarding health-damaging behaviour (alcohol consumption) as limited. In addition in South Africa, as in most countries, lower socioeconomic groups also experience greater levels of alcohol harm at the same levels of consumption (Probst et al., 2018b) which raises a further equity concern.

2.1.4 Summary

My above argument can be summarised as follows: the measurement of health outcomes is central to understanding health inequity, these outcomes must be measured as health inequalities at the group rather than individual level, these groups must be socially determined, and finally, there must be a consideration of avoidability and fairness in the cause of the health inequality. This confirms differential alcohol attributable harm by socially defined subgroups in South Africa as an equity concern as well as alcohol attributable harm, where free choice is limited by social and environmental factors.

2.2 Methods for equity-informative health economic evaluation

An equity-informative health economic evaluation incorporates the above definition of equity and provides a framework with which to evaluate or appraise different policy options from an economic perspective. In particular it can enlighten the decision maker about the impact on socially defined subgroups of interest across both costs and consequences (Drummond et al., 2015). The consequences can be any measure which captures the health outcome/s of interest, for example life years saved, cases averted, or cancers detected. They may also include quality adjusted life years (QALYs) or disability adjusted life years (DALYs), derived by combining both morbidity and mortality impact via preferences and judgements associated with a particular health state (Drummond et al., 2015). Economic evaluations can also take different perspectives such as a healthcare perspective in which the only costs considered are those to the healthcare sector or a societal perspective in which broader public and private costs and consequences are considered. For the purpose of my review of existing literature in this area the term cost-effectiveness analysis will be used to encompass all forms of health economic evaluation including cost-benefit analysis and cost-utility analysis.

There have been various methods employed in the literature to develop equity-informative economic evaluations. Cookson et al. (2009) suggest four ways to highlight equity in public health policy evaluation. Firstly, a review of background information on equity (including existing patterns and causes of health inequality, stakeholder views and effects of interventions in other settings). This could be used on its own or as a useful preparatory stage for the following approaches. Secondly, health inequality impact assessment (generating quantitative evidence about the impact of a health intervention on health inequality). Thirdly, opportunity cost analysis which estimates health foregone between populations groups when making allocation decisions within a fixed budget. Fourthly, equity weighting analysis (applies different equity weights on the health gains of certain groups of people who are of an equity concern). Following growing interest and increasing publication of research in this area Cookson et al. (2017) went on to classify two streams of equity application: equity impact analysis (quantifying distribution of impact by equity relevant parameters) and equity trade-off analysis (quantifying trade-offs between total health and equity objectives). A tax or minimum price policy is not funded by a fixed budget as with healthcare services or other public health interventions, such as education programmes or vaccinations. Therefore, the equity impact analysis stream is likely to be most relevant to a population level fiscal policy such as alcohol pricing.

Within the equity impact analysis stream Cookson et al. (2017) highlight two leading methodological approaches, extended cost-effectiveness analysis (ECEA) and distributional cost-effectiveness analysis (DCEA). The DCEA is now often used as an umbrella term to describe any cost-effectiveness analysis that is concerned with differential impact, as such an ECEA would simply be a subset, but for the sake of this review I will define them separately. In preparation for the scoping review I provide a high level methodological overview of ECEA, DCEA and other common approaches.

2.2.1 Distributional cost-effectiveness analysis

DCEA is a method which has mostly been applied in England in the context of universal healthcare (Asaria et al., 2016). DCEA has two stages. Firstly, to model the social distribution of health associated with alternative interventions and secondly to evaluate the interventions by comparing total health gains (or losses) with reducing (or increasing) health inequality. The net health effect usually includes health opportunity cost, whereby the health loss from displacing other healthcare spending is estimated.

Griffin et al. (2019) conducted a DCEA on 134 National Institute for Health and Care Excellence (NICE) public health guidelines in England. Distributional impact was analysed across age, gender and index of multiple deprivation. For each intervention, they calculate the total QALY gain and the reduction in health inequality between the most and least healthy.

2.2.2 Extended cost-effectiveness analysis

An ECEA specifies the inclusion of four elements: health outcomes (no standardised metric required), private expenditures from seeking healthcare often referred to as out of pocket costs (OOP) (including direct medical care costs and indirect medical care costs such as transportation), financial risk protection and costs to the government/implementer (Verguet et al., 2016a). The framework also suggests an additional financial outcome, the inclusion of lost wages referred to as indirect costs. The guidance indicates that outcomes should be distributed across wealth/income quintiles. The inclusion of specific financial variables in ECEA provides an explicit link between health and poverty, particularly pertinent for countries without free universal healthcare. There are three commonly used financial risk protection measures (Table 2.1).

Table 2.1: Definition of financial risk protection measures (Verguet et al., 2016a).

Financial risk protection measure	Definition
Catastrophic health expenditure	Catastrophic health expenditure (CHE) consists of payments made by the patient to acquire essential health care, which exceeds a certain percentage of their income. If a high proportion of total expenditure is being diverted to healthcare this will be at the expense of other essential items and is therefore *catastrophic* to the household.
Poverty averted	Generally, this is calculated as the numbers who would fall below a national or international poverty line as a result of private expenditure on healthcare in the absence of the policy.
Value of insurance	The amount society would be willing to pay to avoid the risk of the private expenditure associated with the disease or illness. It requires the calculation of an individual's expected income (taking account of the magnitude and probability of the financial shock resulting from illness) as well as the individual's certainty equivalent income which is derived through an estimation of the risk function (using the Arrow-Pratt coefficient of relative risk aversion). Individuals are assumed to be risk averse and to value the protection provided by the insurance.

Watkins et al. (2016) conducted an ECEA for South Africa modelling the impact of salt consumption reduction on cardiovascular disease. They calculated reductions in CVD cases and savings in public and private sector costs. They measured financial risk protection using cases of catastrophic health expenditure averted and cases of poverty averted.

2.2.3 Other common approaches

Any cost-effectiveness analysis, which stratifies results by subgroups of interest, could potentially be used to explore equity. This differential impact can be quantified/illustrated using tables, bar charts or by constructing concentration curves or indices. The Lorenz curve is one type of concentration curve traditionally used in economics as a measure of income inequality (Lorenz, 1905). Cumulative income on the y-axis is plotted against cumulative population on the x-axis ordered by income (Figure 2.1). The 45-degree line indicates perfect equality. A curve below the 45-degree line indicates unequal distribution of income. The Gini coefficient is computed as A/(A+B) or 2A and lies between 0 and 1. Perfect equality would be zero, perfect inequality one. A health measure can be substituted for income to create the health Lorenz curve (Figure 2.2).

Figure 2.1: Gini coefficient and Lorenz curve (Wikipedia, 2018)

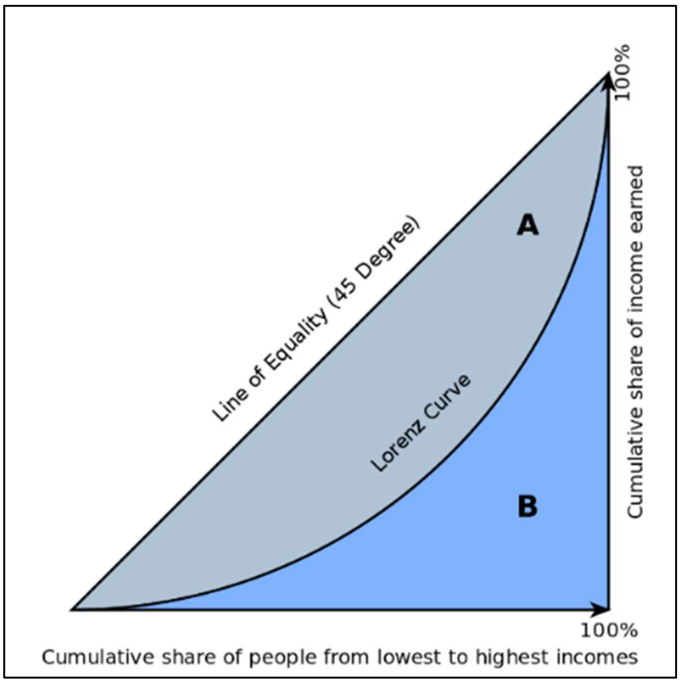


Figure 2.2: Health Lorenz curve (Regidor, 2004)

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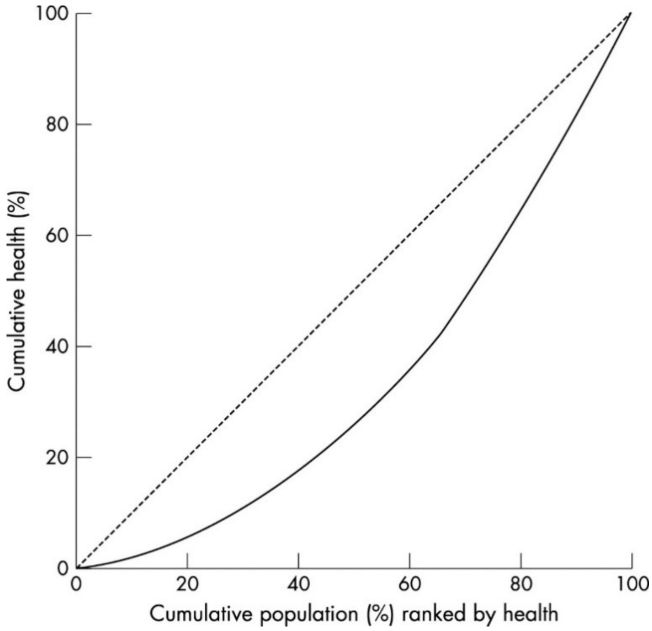

The health Lorenz curve illustrates pure health inequality but as mentioned above the definition of equity for my PhD requires consideration of subgroups. As such, pure health inequality measures are not useful. However, the approach can be extended to relate health outcomes with any continuous variable ranked by a measure that captures living standards, creating an ill health concentration curve (Figure 2.3). Ideally, this variable is measured at the individual level but it is possible to use subgroups, such as quintiles (O'Donnell et al., 2008). The ill health concentration curve can lie above or below the 45-degree line. When considering a negative health outcome which disproportionately affects the poor it will lie above the line (Figure 2.4).

Figure 2.3: Ill health concentration curve (Zere and McIntyre, 2003)

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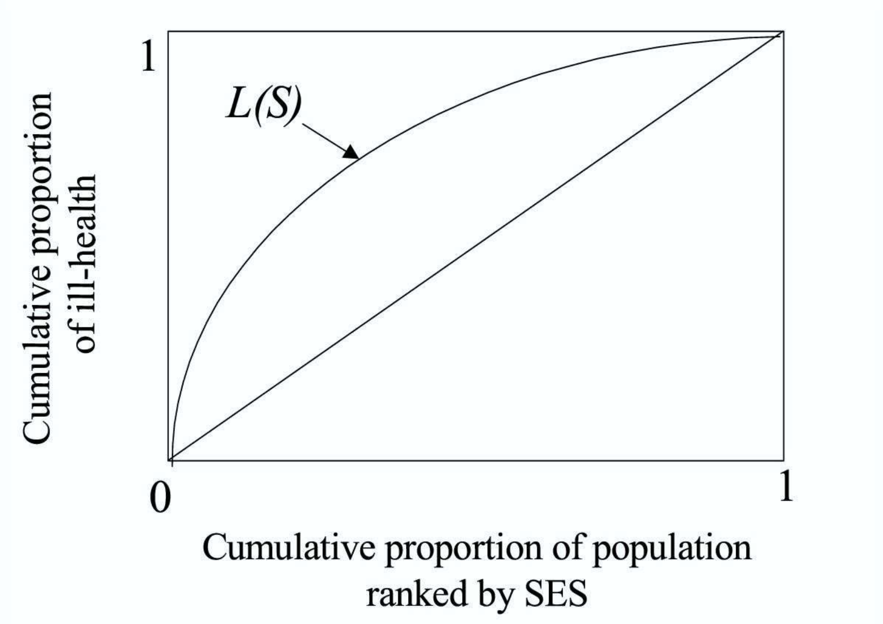

Figure 2.4 Concentration curve (Zere and McIntyre, 2003)

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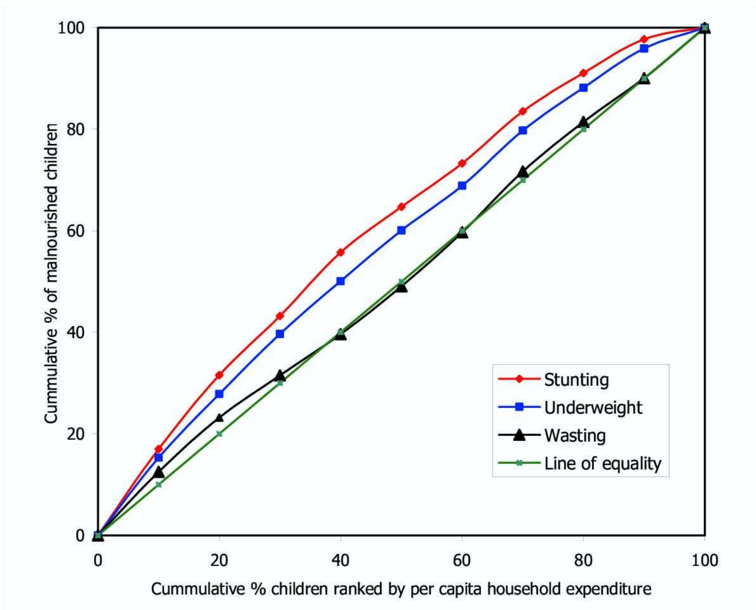


From the ill health concentration curve a concentration index can be calculated (Kakwani et al., 1997). The concentration index lies between -1 and +1. If there is no inequality the concentration index is zero. Negative values indicate the health variable of interest is concentrated amongst the poor, positive values amongst the rich. This method can be applied to any continuous variables with a ranking (such as income and age) that is of interest in the consideration of equity. It may also highlight the interaction between sex or ethnic groups with age or income. For example, comparing the separate concentration indices between ethnic groups or between men and women may be enlightening.

My literature review will scope which methods have been used for equity-informative economic evaluation of health policies in LMICs to date. This review focuses on the application of methods to provide empirical evidence to inform policy decisions and does not review methodological papers (Johri and Norheim, 2012, Lal et al., 2018, Sassi et al., 2001). This will better highlight the potential strengths and limitations of applying these approaches to a real policy question in a LMIC, and crucially to alcohol pricing policies in South Africa.

2.3 Scoping review

2.3.1 Aims

There are two aims. Firstly, to explore the scope of economic evaluation of health policies applied in LMIC/s with an explicit focus on equity. Secondly, to identify potential approaches applicable to the evaluation of equity impact of alcohol pricing policies in South Africa.

2.3.2 Research question

How has a concern for equity been incorporated into economic evaluation of health policy in LMICs?

2.3.3 Methods

A scoping review method was chosen as it represents a systematic, transparent and replicable search strategy whilst not requiring the formal process of quality assessment commonly found in systematic reviews (Grant and Booth, 2009). This method matches the requirements needed to meet the aims; facilitating the inclusion and analysis of papers which are wide ranging in both topic and methods and which would be unsuitable to be judged against a quality criteria that could be completed for some though not all of the papers. The purpose being to explore methods and consider their application to South Africa rather than extract a comparable treatment effect for analysis.

2.3.4 Identifying relevant studies on the basis of titles and abstracts

I chose Web of Science, Scopus, Medline and Embase databases to cover literature from both health and social sciences as my topic of interest spans more than one academic discipline and I wanted to capture the breadth of work that is used to inform health policy. I created bespoke search strategies appropriate to each database. I performed free text searches on title, abstract and keywords with additional MESH and Emtree subject headings included for Medline and Embase respectively. I intersected five key search areas to identify papers which met the inclusion criteria: geography, equity concern, health economic evaluation, health policy, and decision/policy-making (Table 2.2). An English language filter was applied to all search results; no filter was applied for year of publication. The search strategy for LMICs was taken from the Cochrane Central Register of Controlled Trials (Cochrane, 2012) and updated using the World Bank list of country classifications as of February 2021 (World Bank, 2020). Whilst scoping search strategies I performed quality assurance of the searches by checking for inclusion of three papers which I knew met all inclusion criteria and thus should be picked up (Watkins et al., 2014, Rheingans et al., 2012, Arnold et al., 2020). My search strategy was refined via consultation with all supervisors who collectively provide expertise in alcohol, health inequalities, economic evaluation and LMICs. An information specialist at ScHARR with experience of literature searching for economic modelling was also consulted. The free text search strategy for Scopus is shown as an example (Table 2.3), all others are in Appendix 1.1.

Table 2.2: Inclusion criteria

Inclusion criteria	
Geography	The policy evaluated must be applied in a LMIC, defined by World Bank classifications as of February 2021. South Africa is an upper-middle income country, restricting it to South Africa would produce too few papers. Health policy evaluation incorporating equity in South Africa is likely to have more in common with other LMICs than with HICs due to limited provision of health care and data challenges.

Equity concern	The research question must incorporate differential policy impact on health outcomes by subgroups of interest in accordance with the above definition of equity (Section 2.1.4). It is insufficient for the paper to disaggregate results without highlighting this as an equity concern. It is not vulnerable subgroups per se that are of interest but the focus on differential impact between subgroups. Policies aimed exclusively at equity relevant subgroups are not of interest, for example: an immunisation programme targeted at people living in South African townships. Socioeconomic and poverty have been specifically included as search terms due to their popularity in the literature as equity relevant subgroups. They are also measurable using continuous variables and therefore likely to be amenable to interesting methods such as concentration curves. It was not possible to search specifically for every other potential equity relevant subgroup but methods should be transferable.
Health economic evaluation/modelling	An evaluation of costs and consequences (including at least health) of alternative policy options. The perspective of the evaluation can be healthcare or societal. Costs and consequences might accrue to government, industry or private individuals. In the case of pricing policy of unhealthy goods, the costs may be borne by the consumer. Tax revenue for the government will be considered a negative cost. The research must simulate hypothetical policy options. As a result, all of the economic evaluations I am interested in will include modelling. There are many terms used interchangeably in the literature depending on researcher discipline. Model and simulation are two known examples.

Health policy	The health policy can be any public health or healthcare intervention. Examples of policies include: the provision of healthcare services such as drug treatment or surgery; public health programmes such as vaccinations and screening; and public health measures such as taxation of unhealthy goods or the provision of clean water and sanitation. Policy could be at a local, national or global level.
Decision/policy-making	The economic evaluation must be intended to inform decision making/policy around health. It should provide realistic policy options and consequences of said options so that decision makers can see the impact on health and how that impact is distributed throughout the population.

Table 2.3: Search strategy for Scopus (all others in appendix 1.1)

Database: Scopus Strategy: Keyword search in title, abstract and keywords (includes both author keywords and indexed keywords)
1. Geography TITLE-ABS-KEY(“low-resource setting*” or “resource-constrained setting*” or “resource-poor setting*” or “limited-resource setting*” or “resource-limited setting*” or Africa* or (Asia* W/2 south) or (Asia W/2 east) or “latin America*” or “central America*” or “south america*” or caribbean or “west indies” or “middle east”) OR TITLE-ABS-KEY((countr* or nation* or population* or world) W/0 (developing or “less* developed” or “under developed” or “least-developed” or underdeveloped or “middle income” or “middle-income” or “low-income” or “low* income” or underserved or “under served” or deprived or poor*)) OR TITLE-ABS-KEY(econom* W/0 (developing or “less* developed” or “under developed” or underdeveloped or “middle income” or middle-income or “low* income” or low-income)) OR TITLE-ABS-KEY(low* W/0 (gdp or gnp or “gross domestic” or “gross national”)) OR TITLE-ABS-KEY(lmic* or “third world” or “lami countr*” or “transitional countr*”) OR TITLE-ABS-KEY(all LMIC country names listed out)
2. Health TITLE-ABS-KEY("global health" or "health equity" or "public health" or mortality or morbidity or death or disease or conditions or illnesses or "quality adjusted life year" or "disability adjusted life year") OR AFFIL(health or hlth)
3. Equity TITLE-ABS-KEY(equit* or equality or fair* or inequalit* or inequit* or distibution* or stratified or "financial risk protection" or socioeconomic or Gini or Lorenz or “social justice” or poverty or “health disparit*”)
4. Economic evaluation TITLE-ABS-KEY("extended cost-effectiveness" or "distributional cost-effectiveness" or "equity-effectiveness model" or "cost-effectiveness" or "cost utility" or "cost benefit" or "economic model*" or "return on investment" or “simulation model*”)

5. Decision/policy-making TITLE-ABS-KEY(polic* or decision-mak* or decision-support or decision-process or decision-aid* or implement* or impact or priorit* or "health-facility strengthening" or appraisal or evaluation) or AFFIL(policy)
1 AND 2 AND 3 AND 4 AND 5 Limit to English language

An initial review was undertaken in 2019 for the confirmation review and was updated in February 2021. Here I describe the methods and combined results. Results from all four databases were downloaded to endnote before removing duplicates (Figure 2.5). A title screen was undertaken to eliminate papers which were clearly irrelevant. Examples include cost-of-illness studies, medical trials, willingness to pay, discrete choice experiments, epidemiological studies, elicitation of health utilities and study protocols for randomised control trials. The title sift strictly did not consult abstracts, in the case of ambiguity articles were kept in. There were 961 articles at the end of this stage.

The next stage was an abstract sift. The following exclusion criteria applied: not a LMIC; no simulation of a hypothetical policy; and no explicit focus on equity. Several papers quantified the differential impact of a disease on socioeconomic groups and concluded that policy action was needed, but if there were no policy options simulated these papers were excluded. Papers which evaluated the cost-effectiveness of programmes targeted only at disadvantaged groups were also excluded as they did not report the impact on population-level inequality only the overall impact on the target population. Literature reviews were also removed. After the abstract sift 168 papers remained.

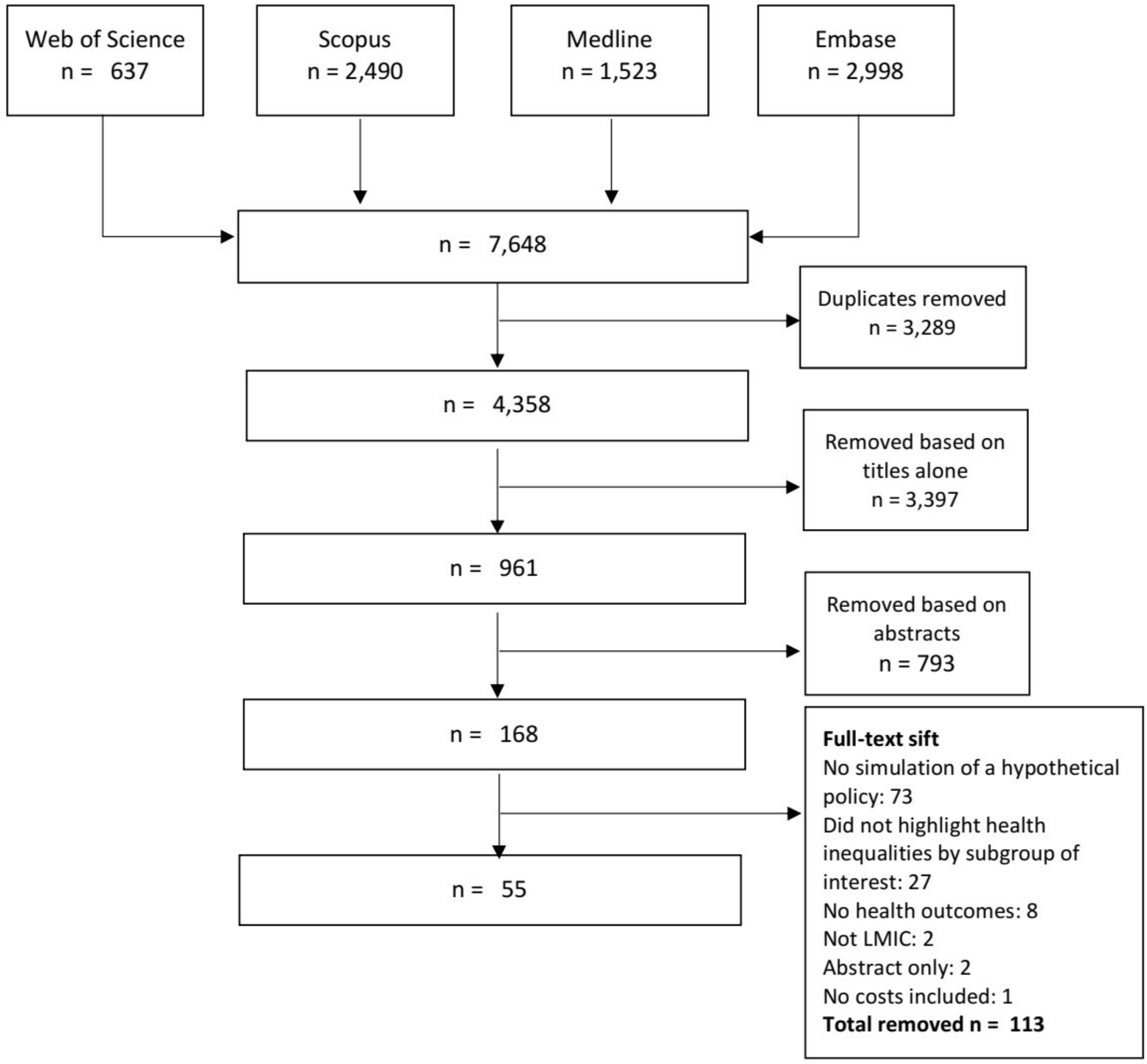
2.3.5 Study selection

A full text sift was completed on the remaining papers using the following exclusion criteria: no simulation of a hypothetical policy; did not highlight health inequalities by subgroup of interest; no health outcomes included; not LMIC; abstract only; no costs included. Reasons for rejection were recorded (Figure 2.5). The most common reason for exclusion was the requirement for simulation of a hypothetical policy, 73 papers. The majority of these papers related to the analysis of retrospective data with no attempt to model scenarios. These included: assessing associations between health insurance and financial protection; identifying prevalence of illness across socioeconomic groups; and cost-effectiveness of healthcare interventions from trials using only retrospective data and therefore including no element of modelling to simulate hypothetical policy options as outlined in my inclusion criteria.

The second most populous exclusion category was that the paper did not focus on health inequalities between subgroups of interest. Although the papers did simulate hypothetical policies they did not account for differences between subgroups, or if they did it did not appear in the discussion. A number of these papers listed equity as a clear focus but it had been conceptualised in a different way, for example, by considering pure health inequality or inequality of access to healthcare services. Robberstad and Norheim (2011) evaluated two competing public health programmes in Tanzania (hypertension in adults versus a childhood vaccine). They used Gini coefficients and achievement indices to incorporate concern for pure health inequality. The same methods are applied by Ngalesoni et al. (2016) completing an equity impact analysis of cardiovascular disease in Tanzania. A further group of papers defined equity as all people receiving the same treatment, for example a study of cervical cancer screening in Uganda, examining the trade-off between increased coverage and frequency (Campos et al., 2017). The trade-off in this case was between equity (defined as all people receiving the same treatment) and efficiency (maximising health benefit in years of life saved). Another example concerns ART as a treatment for HIV in South Africa which compared universal coverage with intensity of treatment (Cleary et al., 2010). These papers do not meet my definition of equity as they do not compare outcomes between subgroups of interest.

Of the final papers excluded eight reported utilisation or access outcomes rather than health outcomes. Two were not based in a LMIC and two were abstracts. One paper estimated the effectiveness of a community-based drug service on post-partum haemorrhage but did not estimate any costs (Pagel et al., 2009). At the end of this stage 55 papers remained.

Figure 2.5: PRISMA flow diagram. All results downloaded 1st February 2021



2.3.6 Data extraction

In order to explore the scope of health economic evaluation of health policies applied in LMICs with an explicit focus on equity the following data was extracted: publication year, country or region of focus, income classification of the country or countries of focus, income classification of the location of the institution of the first author (as an indication of research leadership), funding source, health problem, policy intervention, analytical framework, method details, approach to conceptualising and quantifying equity.

2.3.7 Collating, summarising and reporting results

The results are presented in two ways. Firstly, summary information is provided covering: countries, health problems, policy areas, publication years, authorship and funding. This provides an overview of the size and scope of the evidence base. Secondly, the studies are organised thematically according to an analytical framework. The analytical framework gives an indication of which costs and consequences have been included in the study, which is often, though not always, interrelated with their approach to illustrating a concern for equity. This provides a useful categorisation of the methods that have been applied thus far to highlight equity within health economic evaluation in LMICs. Following this, a discussion of the strengths and weaknesses of the approaches will be discussed in relation to their potential application to alcohol pricing policy evaluation in South Africa.

2.3.8 Summary results

A summary of the countries, health policies and health conditions is given (Table 2.4). The papers covered 18 countries in the single country studies with at least a further 17 countries in the multiple country studies. Ten papers covered India, ten Ethiopia, five China, three South Africa, three Vietnam and all those remaining just one or two. The countries have been classified by income type using the World Bank income classifications (World Bank, 2020), the seven studies covering more than one country are categorised as multi-country study. The most populous categories of policy interventions evaluated were healthcare provision (17), pricing policies (14) and vaccination programmes (14). The healthcare provision and vaccination policy evaluations covered all income classifications although tended towards the low- and lower middle-income countries whereas the 14 pricing policy evaluations did not include any low-income countries. A range of health conditions are covered in the 55 papers, including nine papers on rotavirus, eight tobacco related mortality, four infant malnutrition, four pneumonia and four cancer.

Despite not applying any filter for date of publication no papers were published before the year 2000, 50 out of the 55 (91%) were from 2015 onwards, indicating a relatively new field of research. A total of 35 out of 55 papers (64%) included at least one author affiliated with an institution in the country studied. 47 out of 55 papers (85%) listed both first and last authors affiliated with HIC institutions (although authors may have had more than one affiliation listed). There appears to be collaboration between international partners however the leadership lies with the high-income partner.

The Bill and Melinda Gates Foundation funded or part funded 22 of the studies. Other named funders (excluding universities) include the World Bank, the World Health Organisation, PATH (a global health organisation with a focus on vaccines), GAVI (a public-private global vaccine alliance), the National Cancer Institute, UNICEF (The United Nations Children's Fund), National Institute for Health Research, Wellcome Trust and the Health Systems Trust. Three of the papers received private sector funding, two by the Nestle Research Centre and one by a pharmaceutical company.

Table 2.4: Summary data of the 55 included papers

	Food fortification or legislation	**Healthcare provision**	**Vaccination**	**Vaccination and healthcare provision**	**Increasing female educational level**	**Pricing policies**	**Road safety policy**	**Screening**	**Improving living conditions**	**Total**
LIC*		**6**	**4**	**3**						**13**
Ethiopia		3	4	3						10
Malawi		2								2
Uganda		1								1
LMIC*	**1**	**6**	**4**			**5**	**1**		**2**	**19**
Bangladesh		1								1
India		4	2			2			**2**	10
Lao			1							1
Nigeria			1							1
Pakistan						1				1
Philippines	1					1				2
Vietnam		1				1	1			3
UMIC*	**1**	**3**	**3**			**8**		**1**		**16**
Armenia						1				1
Brazil		2								2
China			2			2		1		5
Columbia						2				2
Ecuador						1				1
Lebanon						1				1
Malaysia			1							1
South Africa	1	1				1				3

	Food fortification or legislation	**Healthcare provision**	**Vaccination**	**Vaccination and healthcare provision**	**Increasing female educational level**	**Pricing policies**	**Road safety policy**	**Screening**	**Improving living conditions**	**Total**
Multi-country studies**		**2**	**3**		**1**	**1**				**7**
Total	**2**	**17**	**14**	**3**	**1**	**14**	**1**	**1**	**2**	**55**
health problem *(number of papers)*	infant malnutrition *(1)*, cardiovascular disease *(1)*	cancer (1), CVD (1), cataracts (1), epilepsy (1), hypertension (1), infant malnutrition (1), mental ill health (2), neonatal complications (2), pneumonia (2), tuberculosis (1), multiple health conditions (4)	cancer *(2),* measles *(1),multiple health conditions (1)* pneumonia *(2),* rotavirus *(8)*	malaria (1), multiple health conditions *(1),* rotavirus *(1)*	postnatal complication *(1)*	cancer *(1),* infant malnutrition *(2), multiple health conditions (1),* obesity *(2),* tobacco related mortality *(7), diabetes (1)*	road traffic injury *(1)*	neonatal complications *(1)*	diarrhoea (1), multiple health conditions (1)	

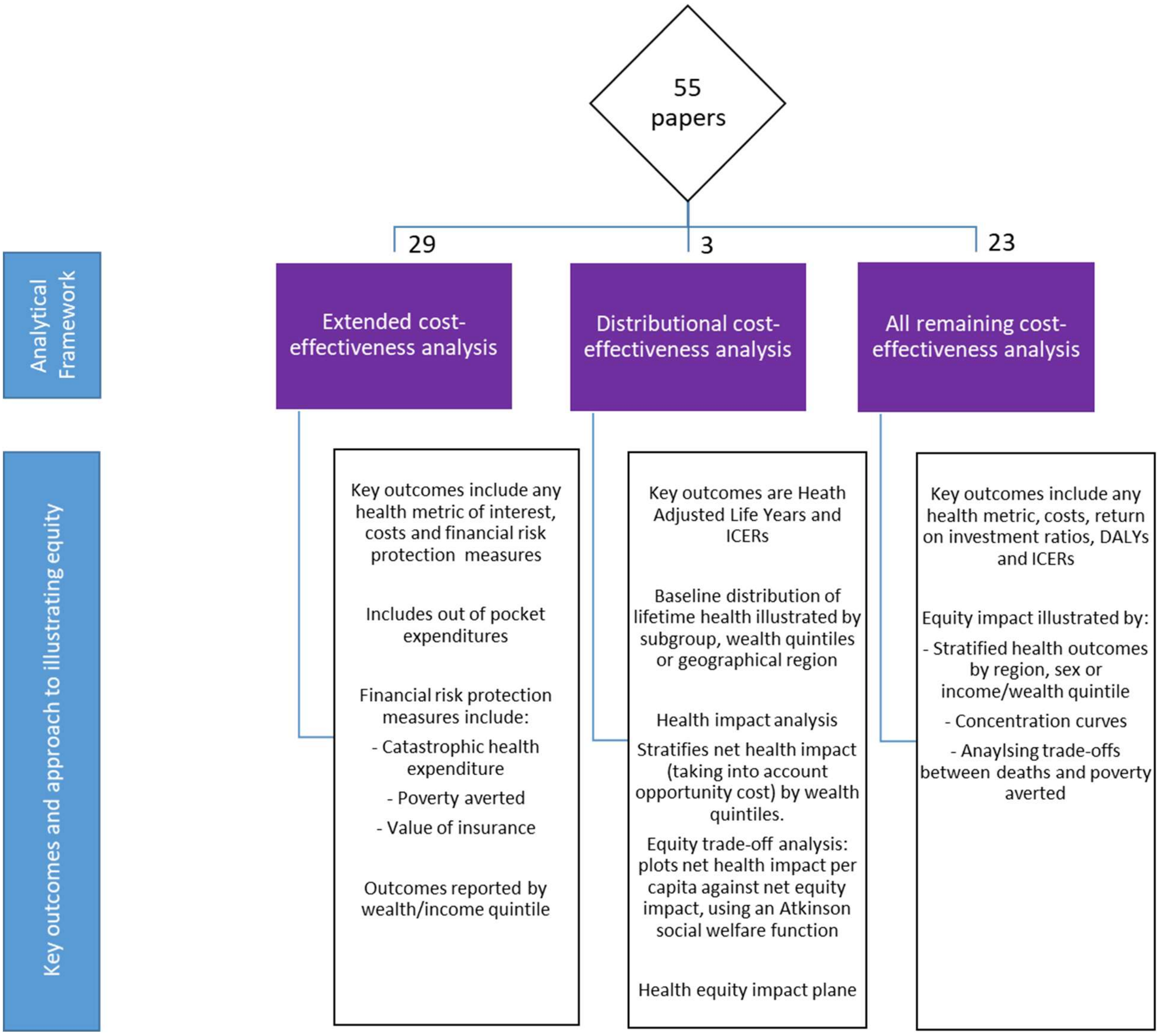
***LIC: Low-income country, LMIC: Lower-middle income country, UMIC: Upper-middle income country**

****Democratic Republic of Congo (DRC), Kenya, Zambia, Zimbabwe; 26 countries (with a focus on: Bangladesh, DR Congo, Ethiopia, India, Kenya, Niger, Nigeria, Uganda); Ethiopia, Mali, Niger, Rwanda, Uganda, Benin, Ghana, Kenya, Nigeria, South Africa, Zimbabwe, Bangladesh, (Punjab) Pakistan, Philippines, Vietnam; India and Ethiopia; India, Indonesia, Bangladesh, Philippines, Vietnam, Armenia, China, Mexico, Turkey, Brazil, Columbia, Thailand, Chile; Niger and India; Nigeria, Egypt, Bangladesh, Cambodia and Peru**

2.3.9 Thematic results - Analytical framework

I categorised all papers into a analytical framework according to which costs and consequences were included (Figure 2.6). The approach to illustrating a concern for equity is then explored.

Figure 2.6: Classification of papers by analytical framework and approach to equity



2.3.9.1 Extended cost-effectiveness analysis

As a reminder, ECEAs must include stratification by wealth/income quintiles, private healthcare expenditure averted and at least one measure of financial risk protection. Five papers which purported to be ECEAs are not included in the 29. One did not disaggregate the results by wealth/income quintile (Verguet et al., 2015c), and four did not include financial risk protection measures (Levin et al., 2015, Pecenka et al., 2015, James et al., 2018, Postolovska et al., 2018). All five are included in the "all remaining cost-effectiveness analyses" category. One paper did not identify as an ECEA but satisfies the criteria so is included (Shrime et al., 2019).

Results for two papers are provided for illustration (Table 2.5). They are purposely chosen to include a South African pricing paper and a study that formed the basis for one of the following DCEA studies. All remaining ECEA papers are listed in Appendix 1.2 Panel A.

Table 2.5: Results from two ECEA papers.

Author and year	Health problem	Policy	Country	Outcomes	Results
Saxena et al. (2019b)	Type two diabetes mellitus	10% tax on sugar sweetened beverages	South Africa	Deaths averted, taxation, government healthcare savings, OOP payments, catastrophic health expenditure cases averted, poverty cases averted	A 10% SSB tax increase would avert an estimated 8,000 T2DM-related premature deaths over 20 years, with most deaths averted among the third and fourth income quintiles. The bottom two income quintiles would also have the lowest savings in OOP payments due to significant subsidisation provided by government healthcare. An estimated 32,000 T2DM-related cases of catastrophic expenditures and 12,000 cases of poverty would be averted.
Verguet et al. (2013)	Rotavirus	Rotavirus vaccination	India and Ethiopia	Deaths averted, household expenditure averted, value of insurance	The programme would lead to a substantial decrease in rotavirus deaths, mainly among the poorer; it would reduce household expenditures across all income groups and it would effectively provide financial risk protection, mostly concentrated among the poorest.

2.3.9.1.1 Out of pocket costs (OOP)

ECEA studies include direct medical care costs associated with the disease(s). The amount payable by the patient OOP is dependent upon the healthcare system of that particular country. In a Malaysian study, where theoretically access to health care is provided regardless of income, healthcare costs incurred included consultation and medication charges (Loganathan et al., 2016). Three Ethiopian studies assume individuals pay 34% of any treatment costs with government paying the remainder (Johansson et al., 2015, Johansson et al., 2017, Assebe et al., 2020). Two papers studying the impact of tobacco policy only include treatment costs associated with a selective group of tobacco related diseases, namely: Chronic Obstructive Pulmonary Disease (COPD), stroke, health disease and lung cancer (Verguet et al., 2015a, Verguet et al., 2017b). Nine of the papers explicitly mentioned transportation costs. In one paper the OOP cost of care seeking was expanded beyond transportation to also include food and lodging (Shrime et al., 2016b). In a paper on rotavirus vaccination non-medical costs associated with the illness were included such as nappy and food costs (Loganathan et al., 2016).

2.3.9.1.2 Financial risk protection

The ECEA framework explicitly requires at least one measure of financial risk protection (defined earlier in Table 2.1). All three measures were present across the papers (Table 2.6).

Table 2.6: Financial risk protection measures used in the 29 papers

Financial risk protection measure	Number of papers
Catastrophic health expenditure	3
Poverty averted	3
Catastrophic health expenditure *and* poverty averted	12
Value of insurance	11

2.3.9.1.2.1 Catastrophic health expenditure

Catastrophic health expenditure consists of OOP payments made by the patient to acquire essential health care, which exceeds a certain percentage of their income, 15 papers included catastrophic health expenditure. All but two of these papers used a threshold of 10% of an individual's annual income. One paper evaluating the impact of motorbike helmet legislation in Vietnam used 25% (Olson et al., 2016) and one study on access to surgery in Ethiopia used 40% (Shrime et al., 2016b).

2.3.9.1.2.2 Poverty averted

Poverty averted is calculated as the numbers who would fall below a national or international poverty line, due to OOP costs, in the absence of the policy. It is included in fifteen papers. The papers either used international absolute poverty lines or more commonly national ones, the South African paper used a poverty line reported by Statistics South Africa of US$78 per month (Watkins et al., 2016).

2.3.9.1.2.3 Value of insurance

The value of insurance is the amount society would be willing to pay to avoid the risk of the OOP costs associated with the disease or illness. There are 11 papers which include the value of insurance: nine papers examining the impact of some form of public provision of healthcare service (including vaccinations) (Johansson et al., 2015, Johansson et al., 2017, Megiddo et al., 2018, Megiddo et al., 2016, Nandi et al., 2016, Verguet et al., 2015a, Verguet et al., 2013, Raykar et al., 2016, Verguet et al., 2016b), one paper on the impact of a tobacco price increase (Verguet et al., 2015a) and one on improved access to clean drinking water and sanitation (Nandi et al., 2017).

2.3.9.1.3 Indirect costs

The ECEA framework defines indirect costs as loss of income from waiting for or receiving treatment or being unable to work due to illness. There were two studies which included this outcome (Johansson et al., 2017, Olson et al., 2016).

2.3.9.1.4 Distributional impact

A defining requirement for ECEA is for outcomes to be disaggregated according to wealth/income quintiles. This was generally reported using tables and graphs, Figure 2.7 provides an example.

Figure 2.7: Impact of rotavirus vaccination in India and Ethiopia by income quintiles, poorest to richest. (Verguet et al., 2013)

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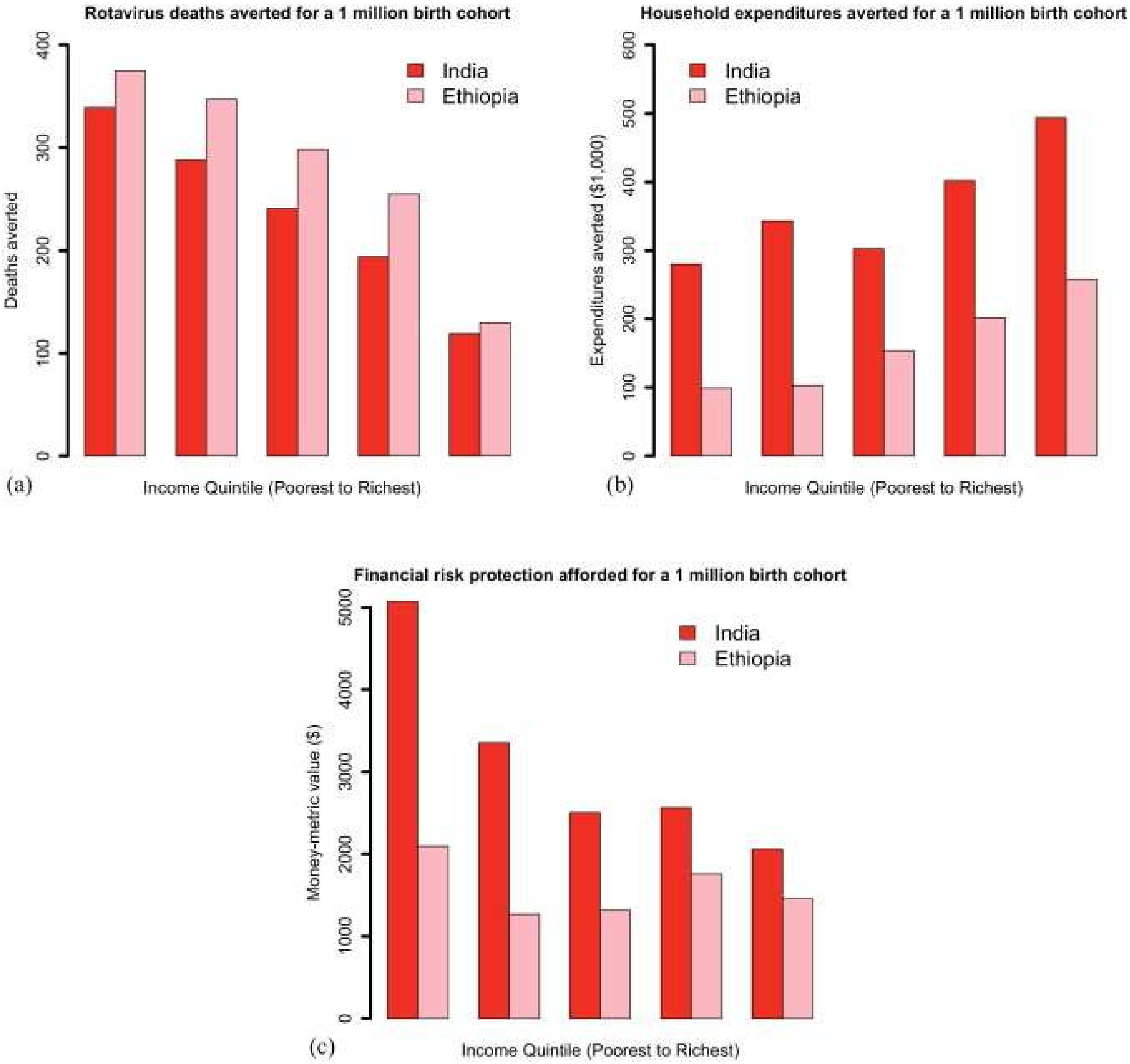

The approach taken to defining the quintiles depends on the context of the study and the data available. Often income quintiles are calculated from data on household income per capita (Figure 2.7). Where income measures are not available, or appropriate, wealth quintiles are used. Wealth quintiles are based on a domestic asset index score taking account of ownership of certain goods (television, fridge etc) and access to amenities (clean drinking water and sanitation); the Ethiopian study of pneumococcal vaccination used asset indexes to construct wealth quintiles (Johansson et al., 2015). A number of the ECEA papers provided detail of how inputs, as well as outputs are disaggregated by income. These include: all health related inputs in the South African salt reduction paper (Watkins et al., 2016); direct non-medical costs in the Malaysian study on rotavirus vaccine

(Loganathan et al., 2016); and healthcare utilisation in the paper on tobacco taxation in China and the paper on taxation of sugary drinks in South Africa (Verguet et al., 2015a, Saxena et al., 2019b).

2.3.9.2 Distributional cost-effectiveness analysis

Three DCEA studies are included in the review (Table 2.7). The first compares the interventions funded under the essential health package in Malawi with alternative combinations of interventions (Arnold et al., 2020). The second builds on a paper by Verguet et al. (2013) included above which simulated the impact of a hypothetical rotavirus vaccination in Ethiopia and India. Focusing on Ethiopia Dawkins et al. (2018) update the model to reflect the actual levels of vaccination coverage achieved from 2012 to 2016. They then compare this with a hypothetical programme focused on rural communities. The final paper analyses the funding of a community based primary healthcare programme in Brazil (Love-Koh et al., 2020). All three papers include authors from the University of York and were published in *Health Policy and Planning*.

Table 2.7: Results from DCEA

Author and year	Health problem	Policy	Country	Outcomes	Results
Arnold et al. (2020)	Multiple health conditions	Funding a large number of health services under the essential health package	Malawi	DALYs, Health Adjusted Life Expectancy	They find that a similar set of interventions would be prioritized when impact on health inequality is incorporated alongside impact on overall population health. Their results suggest that efforts to improve access to the Essential Health Package could be targeted to specific interventions to improve the health of the poorest fastest but that identifying these interventions is uncertain.

Dawkins et al. (2018)	Rotavirus	A rotavirus vaccination programme, which invests additional resources into vaccine delivery in rural areas compared with the standard programme currently implemented in Ethiopia.	Ethiopia	Health Adjusted Life Years, Costs, Incremental Cost-effectiveness Ratios (ICERs)	Compared with the standard vaccination programme the pro poor programme provides greater gains to the lowest wealth quintile groups at the expense of the highest quintile groups.
Love-Koh et al. (2020)	Multiple health conditions	Funding a community based primary healthcare system	Brazil	DALYs, cost per DALY	They estimate a cost-per-disability-adjusted life years of funding the healthcare system of $2640. Social welfare analysis indicates that, compared to gains in average health, changes in health inequalities accounted for a small proportion of the total welfare improvement, even at high levels of social inequality aversion.

The three papers vary slightly in their methods but encompass the same principles of considering the underlying distribution of health, considering opportunity cost through the calculation of net health benefit and quantifying the equity impact, often illustrating this on an equity plane. For the purpose of illustration I will focus on the steps taken by Dawkins et al. (2018). The paper is split into three parts: estimating the baseline distribution of lifetime health; equity impact analysis; and equity trade-off analysis.

2.3.9.2.1 The baseline distribution of lifetime health

A defining feature of DCEA is to start by illustrating the baseline distribution of health amongst the population by subgroup of interest, in this case wealth quintiles (Figure 2.8). The measure used is Health Adjusted Life Years (HALYs) which combine morbidity and mortality (very similar to QALYs). This baseline distribution includes the entire population, not just those who are the target of the intervention, as any health opportunity cost (health lost by disinvestment elsewhere in the system) is assumed to fall across the entire population.

Figure 2.8: Population distribution of health in Ethiopia: Health Adjusted Life Expectancy at birth compared with life expectancy (Dawkins et al., 2018)

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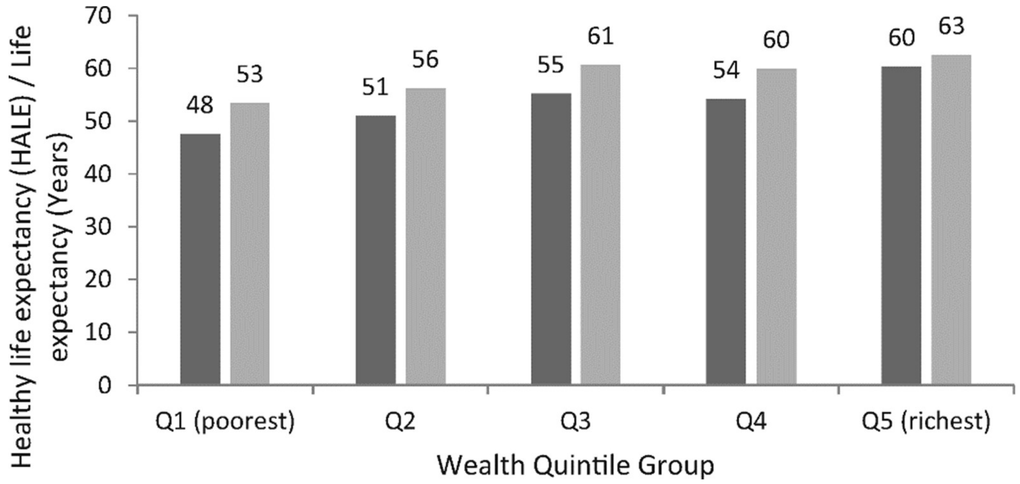

2.3.9.2.2 Equity impact analysis

The next step is to illustrate the net health benefit of the policy by subgroup (Figure 2.9). This shows a net health gain to the population overall for both vaccination programmes, compared with do nothing. Looking at the impact across quintiles it is clear the pro-poor vaccine benefits the poorest most at the expense of the richest.

Figure 2.9: Net health effect of each programme compared with no vaccination (Dawkins et al., 2018)

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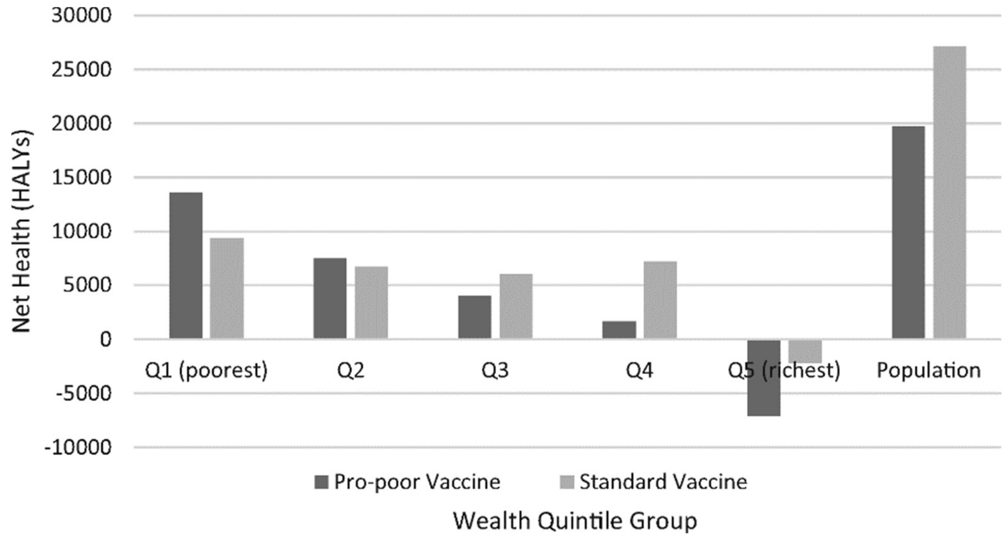

2.3.9.2.3 Equity trade-off analysis

The authors explored the trade-off between total health gains and reducing inequalities in health by plotting the pro-poor vaccine against the standard vaccine on a health equity impact plane (Figure 2.10). Net health impact is plotted against net health equity impact measured using an Atkinson social welfare function. The Atkinson social welfare function combines the aims of maximising total health and minimising inequality in the distribution of health (Asaria et al., 2016). The health equity impact plane indicates that, at cost-effectiveness thresholds of $10 and $50, there is actually a negative net health effect despite a positive health equity effect; decision makers have to decide how to balance these two priorities.

Figure 2.10: Cost-effectiveness plane and health equity impact plane (Dawkins et al., 2018)

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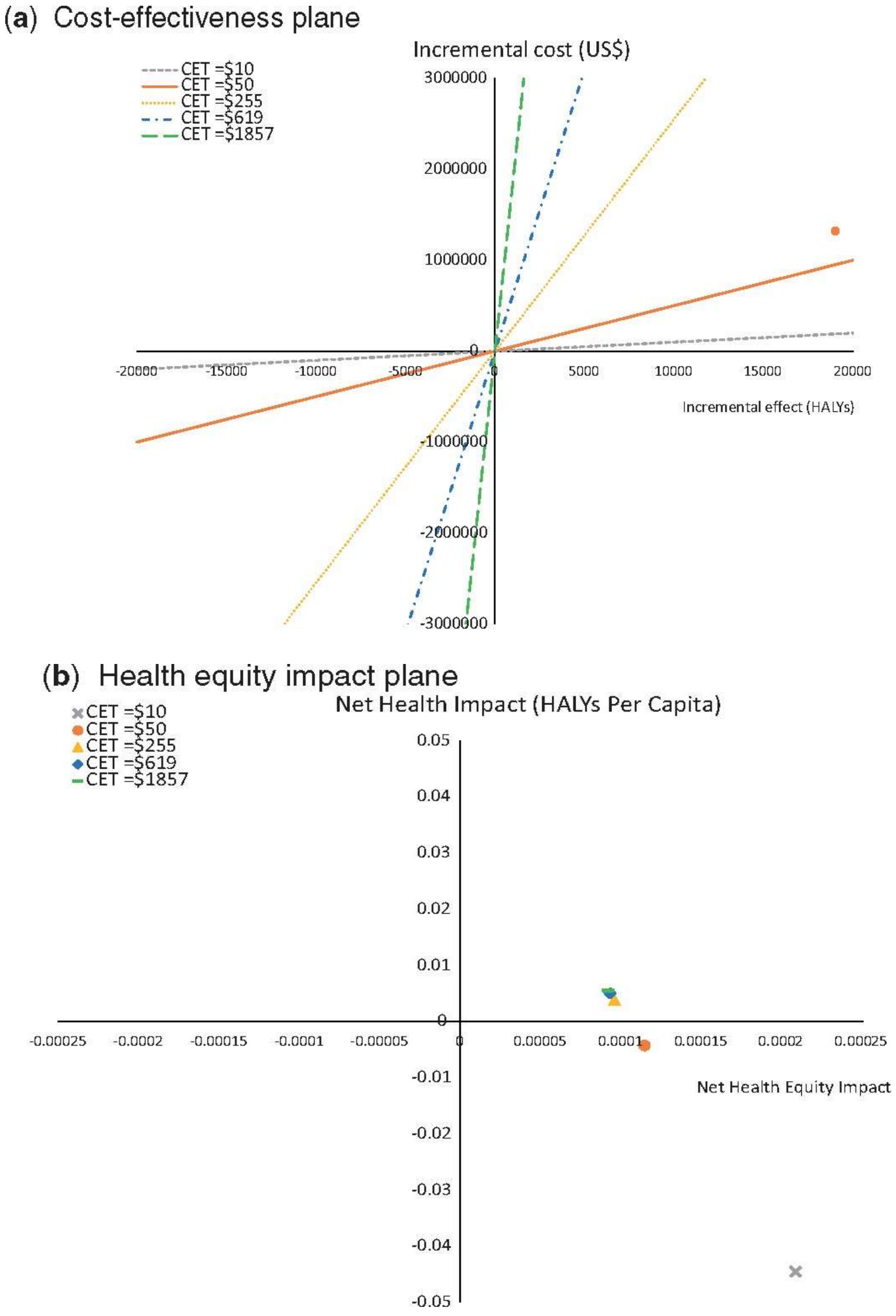

2.3.9.3 All remaining cost-effectiveness analysis

There are 23 cost-effectiveness analyses that do not fit into one of the previous subsets. I explore a selection below, the full list can be found in Appendix 1.2 Panel B. Whilst ECEA and DCEA are widely recognised as encompassing a methodological approach, no classification exists for other forms of CEA that incorporate distribution considerations. However, in order to draw out important differences, I have grouped studies by the approach taken to illustrate equity; stratification of results, concentration measures and consideration of trade-offs.

2.3.9.3.1 Stratification of results

Nineteen of the papers illustrated a concern for equity by presenting, and discussing, disaggregated results by region and/or a measure of income/wealth. Results from two of the papers are provided for illustrative purposes (Table 2.8).

Table 2.8: Results from two cost-effectiveness papers

Author and year	Health problem	Policy	Country	Outcomes	Results
James et al. (2018)	Tobacco related mortality	70% relative price increase in a packet of cigarettes, achieved via taxation	Columbia	Years of life gained, tax revenues	Over 20 years, the tax increase would lead to an estimated 191,000 years of life gained among Colombia's urban population, largest gains accrue to the bottom two income quintiles. The additional annual tax revenues amount to 2%–4% of Colombia's annual government health expenditure. The poorest quintiles bearing the smallest tax burden increase.
Fiedler and Afidra (2010)	Infant malnutrition	Wheat flour fortification programme versus the national vitamin A supplementation programme.	Philippines	Costs, number of children who still have inadequate vitamin A intake IVAI	Maintaining a universal supplementation program in urban areas and, in rural areas, introducing a targeted program to only the poorest municipalities (where the prevalence of vitamin A deficiency is the highest) will be most cost effective. Such a policy will reduce incremental direct Government expenditures on vitamin A programs by nearly 20% and will reduce the number of children with IVAI to 900,000 (12%) Filipino children.

Another of the 19 papers disaggregating results by subgroups was a return on investment evaluating a national hypertension treatment programme in Bangladesh (Table 2.9). The paper estimates the return on investment ratio which is the monetary value of benefits divided by the monetary value of costs. The benefits are measured as DALYs and then converted to a money metric using the Bangladeshi Gross Domestic Product (GDP) per capita. Return on investment ratios are stratified by gender and income quintiles; model inputs were also stratified by these variables.

Table 2.9: Results from SROI

Author and year	Health problem	Policy	Country	Outcomes	Results
Nugent et al. (2017)	Hypertension	Increasing coverage of blood pressure lowering drugs to 60% of hypertensive adults	Bangladesh	ROI ratio, costs, health outcomes (measured in DALYs)	Increasing coverage to 60% yields a 12.7: 1 annual return on investment by 2021. The return on investment is higher for providing medication for women than for men. Larger benefits accrue to the highest wealth quintile.

2.3.9.3.2 Concentration curves and indices

Three papers used some form of concentration measures, as well as stratification of results, to illustrate social group inequality (Table 2.10).

Table 2.10: Results from paper utilising concentration curves

Author and year	Health problem	Policy	Country	Outcomes	Results
Olsen et al. (2021)	Pneumonia	Healthcare provision	Ethiopia	Deaths averted, cost per life year saved, concentration coefficients	The regional incremental-cost effectiveness ratio (ICER) of scaling up the intervention coverage varied from 26 USD per life year to 199 USD per life year gained. In scenario analysis, they found prioritizing regions with high under five mortality rates is effective in reducing geographical inequalities, although at the cost of fewer lives saved as compared to the health maximising strategy.
Rasella et al. (2018)	Multiple health conditions	Healthcare provision	Brazil	Under five mortality rates, deaths averted, changes in mortality rate inequalities over time across municipalities	Under five mortality rates from diarrhoea, malnutrition, and lower respiratory tract infections are projected to be 39.3% (95% CI: 36.9%–41.8%), 35.8% (95% CI: 31.5%–39.9%), and 8.5% (95% CI: 4.1%–12.0%) lower, respectively, in 2030 under the maintenance of healthcare coverage as opposed to austerity, with 123,549 fewer under-five hospitalisations from all causes over the study period.
Rheingans et al. (2012)	Rotavirus	Rotavirus vaccine	26 countries (focus on 8: Bangladesh, DR Congo, Ethiopia, India, Kenya, Niger, Nigeria, Uganda)	Deaths averted, DALYs, costs, cost-effectiveness ratios, concentration indices	In all countries examined, the cost-effectiveness ratio for vaccination ($/Disability-Adjusted Life Year averted, DALY) is substantially greater in the higher quintiles (ranging from 2–10 times higher). In all countries, the greatest potential benefit of vaccination was in the poorest quintiles. However, due to reduced vaccination coverage, projected benefits for these quintiles were often lower. Equitable coverage was estimated to result in an 89% increase in mortality reduction for the poorest quintile and a 38% increase overall.

Rheingans et al. (2012) evaluated rotavirus vaccination across 25 countries reporting DALYs and cost-effectiveness ratios, split by wealth quintiles. They used wealth quintiles as one variable to calculate a number of bivariate concentration indices. Figure 2.11 contains four concentration indices. Firstly, the shading of the dots represents the concentration index for vaccination mortality reduction, darker circles indicate that vaccine mortality reduction is more concentrated amongst the poorest. Secondly, the size of the circles represents vaccine coverage, all the options are positive and so without exception we can see that coverage is concentrated amongst the wealthy, the bigger the circle the greater this is. Thirdly, the x-axis gives the concentration index for pre-vaccination rotavirus mortality, they are all less than zero and so you can see it is concentrated amongst the poor. Lastly, the y axis plots the concentration index for post-vaccination rotavirus mortality, again the axis is completely negative. The dashed line is the 45-degree line, points on this line have the same concentration index for pre and post vaccination mortality. It is clear that the vaccination programme has made the rotavirus mortality differential between rich and poor worse.

Figure 2.11: Concentration index for pre and post vaccination (Rheingans et al., 2012)

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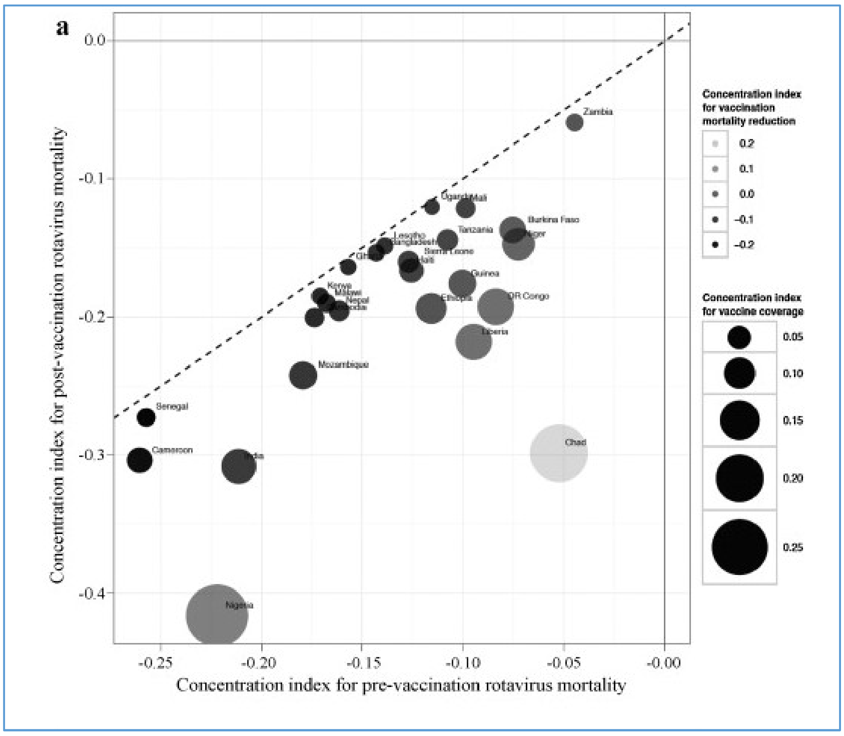


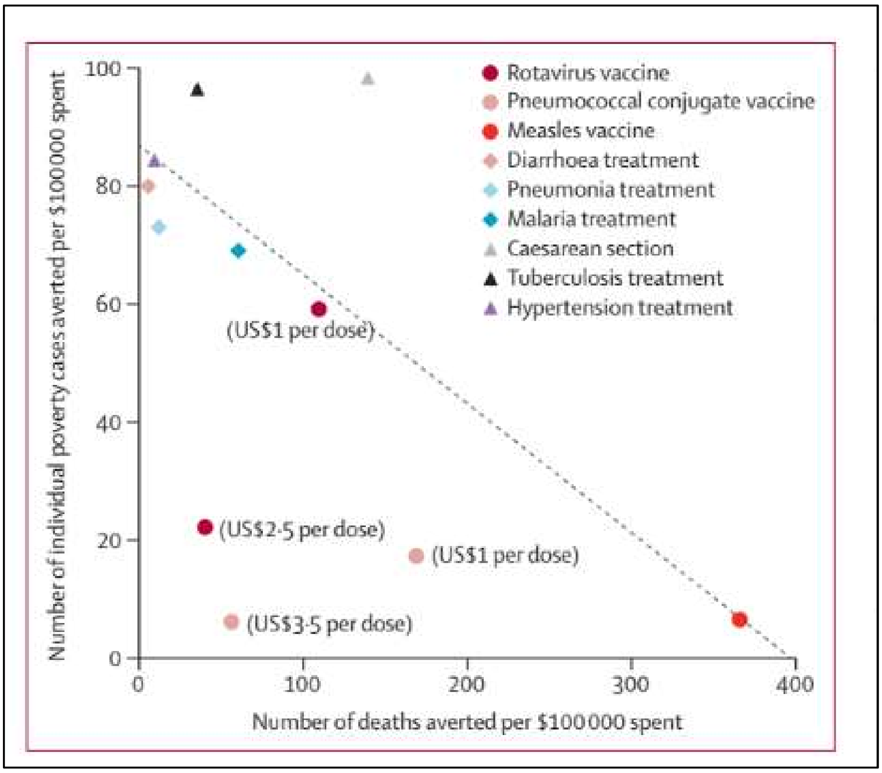
2.3.9.3.3 Trade-offs

The final paper claims to be an ECEA but was excluded for failure to explicitly disaggregate outcomes by wealth/income quintiles (Verguet et al., 2015c). The study evaluates public provision of a selection of health care services in Ethiopia (for example: measles vaccination, malaria treatment and hypertension treatment) (Table 2.11). Outcomes include death and poverty averted. Figure 2.12 shows death and poverty averted per $100,000 spent for each intervention. The direction of preference would be towards the north east, more deaths averted, and more poverty cases averted. A decision maker could see that choosing to provide hypertensive treatment would result in one of the best poverty cases averted results but would prevent fewer deaths compared to, for example, providing measles vaccination. This trade-off is not quantified in any way.

Table 2.11: Results from paper concerning trade-offs

Author and year	Health problem	Policy	Country	Outcomes	Results
Verguet et al. (2015c)	measles, rotavirus, diarrhoea, malaria, pneumonia, complicactions in childbirth, hypertension treatment, tuberculosis.	Public financing of nine interventions: measles vaccination, rotavirus vaccination, pneumococcal conjugate vaccination, diarrhoea treatment, malaria treatment, pneumonia treatment, caesarean section surgery, hypertension treatment, and tuberculosis treatment.	Ethiopia	Government intervention costs, household expenditures averted, deaths averted, poverty averted.	Per $100,000, the interventions that avert the most deaths are measles vaccination (367 deaths) pneumococcal conjugate vaccination (170 deaths), and caesarean section surgery (141 deaths). The interventions that avert the most cases of poverty per $100,000 are caesarean section surgery (98 cases), tuberculosis treatment (96 cases), and hypertension treatment (84 cases).

Figure 2.12: Financial risk protection afforded (poverty cases averted) versus health gains (deaths averted), per US$100 000 spent (in 2011 US$), for each of the nine interventions provided through universal public finance in Ethiopia, the dashed line represents a trend line (Verguet et al., 2015c)



2.3.10 Discussion

The results above have provided a scope of the literature that incorporates equity into economic evaluation of health policies in LMICs. Two distinct approaches have emerged. The DCEA approach which has been developed primarily at the Centre for Health Economics at York University. These methods take an academic health economist lens and include concepts such as social welfare functions and opportunity costs. The methods have been developed in high-income countries where well-established cost-effectiveness methods already directly influence healthcare decision making on a health maximisation basis. The DCEA methods appear to be a response to decision maker’s increasing concern for health inequality. The second approach, ECEA, is rooted in the public health discipline and appears to have emerged from the USA with support from the Harvard School of Public Health, the WHO and the Bill and Melinda Gates Foundation. It is simpler methodologically and has been developed specifically for LMICs who do not offer universal health care and who may be more concerned with poverty.

The second aim of this review was to identify which methods might be applicable to the economic evaluation of alcohol pricing policies in South Africa. ECEAs are now well established and have been applied to a broad range of health problems and interventions, which include pricing policies. Indeed the review provided two examples of ECEAs applied to South Africa one of which was a pricing policy (Saxena et al., 2019b, Watkins et al., 2014). The disaggregation of policy impact by wealth/income quintile is simple for the reader and easily communicated to a broad range of stakeholders, increasing the potential for impact. As income/wealth is associated with alcohol harm in South Africa the focus on income quintiles also appears appropriate to the research question. However, it may not be the best or only way to engage with socioeconomic inequalities. There are often a number of measures used to explore socioeconomic status within surveys with different strengths of association (Beard et al., 2019). Where data permits an initial exploration of the chosen dataset to explore relationships between socioeconomic indicators and alcohol harm would be ideal to inform the chosen measure, combined with consideration of what is credible and acceptable to stakeholders.

The inclusion of specific financial variables in ECEAs is an advantage of this method as they clearly link health and poverty; particularly relevant in countries without universal healthcare such as South Africa. South Africa has plans to introduce universal healthcare but the package is likely to be limited and will take time (Rispel, 2018). Even in the event of comprehensive universal healthcare the cost savings would remain relevant, although they would transfer from private individuals to the government. The choice of health outcome is unspecified in ECEA, as such broad measures (for example, all cause alcohol attributable mortality) could be chosen, or specific alcohol related diseases. One disadvantage of following a strict ECEA methodology is the risk it may crowd out the inclusion of other interesting outcomes such as productivity, crime or broader economic impacts. The ECEA also does not take specify any focus on the initial distribution of health by equity relevant subgroup, looking purely at the policy impact, however this could easily be added in and does not represent an inherent problem with the method. The methods for measuring financial risk protection are also being challenged in the literature which adds complexity and a potential reduction in credibility (Wagstaff, 2019).

The DCEA methodology provides an alternative. A key strength of DCEA, over ECEA, is its stipulation of presenting baseline health distributions by subgroup of interest. This is followed by the calculation of net health benefit in overall lifetime health resulting from the policy, providing a better understanding of the underlying general health inequality as well as the impact of the policy. The inclusion of health opportunity cost within DCEA is a strength but is unlikely to be relevant in the context of alcohol pricing policy. The imposition of a tax or minimum unit price does not deplete a fixed healthcare budget, displacing other spending and therefore health. In the case of taxation, it is likely that the government would see a net increase in revenue. In the case of minimum unit pricing there would be costs associated with implementation and enforcement, but it is unclear what spending this replaces and the consequential health opportunity cost. Any calculation of health opportunity costs would likely be prohibitively complex for a public health intervention such as alcohol pricing (Cookson, 2013). DCEA can also provide an illustration of equity trade-offs using equity impact planes and in the case of Dawkins et al. (2018) quantifying the level of health inequality aversion required by the government to prefer one policy to another using Atkinson's relative social welfare function (although other social welfare functions such as Kolm's absolute measure could be used). DCEA methodology, and particularly the equity impact plane, have been developed and applied to policy choices within a fixed healthcare budget thus far in the literature. In this context decision makers are making implicit trade-offs all the time, DCEA seeks to make that trade-off explicit. This is an important research question particularly in countries where resources are even more scarce however, an alcohol pricing policy does not fall within this framework. Nevertheless, the principle of highlighting the baseline distribution of health by equity relevant subgroups as a first step in the analysis may be a useful contribution. A DCEA may also provide a potential avenue for further research.

The remaining cost-effectiveness analysis used stratification, concentration measures and trade-offs. Stratification is the foundation of all the methods covered. Careful attention should be paid to the stratification of inputs as well as outputs in order to get as close as possible to the true subgroup impact of a policy. In pricing policies, elasticities would be a key input to stratify by subgroup of interest, if possible, as a key driver of the policy impact (Vecino-Ortiz and Arroyo-Ariza, 2018).

Using a return on investment methodology, thus supplying a monetary valuation of the ratio between costs and benefits, may appeal to decision makers more familiar with considering monetary outcomes and public sector wide impact. The return on investment in this review however considered only healthcare costs and health outcomes (DALYs were then converted to a monetary valuation using a threshold) (Nugent et al., 2017). A return on investment that takes a societal perspective, taking into account all costs and benefits resulting from the policy and providing a monetary ratio, could be applied to a pricing policy in South Africa. This would likely require a significant number of assumptions if including *all* costs and benefits to society which would need to be well researched and validated with stakeholders to ensure credibility. This could be stratified by subgroup of interest to highlight differential impact, as in Nugent et al. (2017).

The use of concentration measures is another method for demonstrating differential impact. This method could be particularly useful if comparing different taxation or minimum unit price scenarios using a single metric. Although concentration measures will be limited to only the ordinal variables (age and income), comparing concentration measures between ethnic groups or sex, for example, may begin to uncover important intersectionality (for example alcohol harm may be related to SES for black women but less so for white men). This may be important as the experience of an individual within society can be shaped by the interaction between belonging to multiple sociodemographic categories and by the issue being addressed, in this case alcohol in South Africa (Gkiouleka et al., 2018) although there are likely to be data constraints which may limit this approach. The final consideration is trade-offs, policies could be compared for their health versus poverty impact, as in Figure 2.12. This will enable analysis of which policies improve population health as well as reducing poverty (for example), or if they all do, to what extent.

Whilst not the focus of the scoping review, the identified studies also highlighted other practical and analytical issues that are of note. Data availability was commonly listed as a key limitation. This related to all inputs including cost and epidemiological data, in particular the lack of data disaggregated by equity relevant subgroups prevented or inhibited the exploration of differential impact (Dawkins et al., 2018, Watkins et al., 2016). Another limitation highlighted by the pricing policy evaluations were the assumptions relating changes in consumption to changes in price (Verguet et al., 2017b, Salti et al., 2016, Vecino-Ortiz and Arroyo-Ariza, 2018). This was not only in estimating, or borrowing, price elasticities but also in modelling behaviour, for example Verguet et al. (2017b) did not attempt to include background quitting or consumption reduction and assumed all behaviour occurs at once and lasts for the lifetime of the individual. These limitations are likely to be pertinent to economic evaluation of pricing in South Africa. A number of areas of further research were highlighted in the papers, this included the desire to better disaggregate inputs by population subgroups, for example including differential policy effectiveness in the evaluation. Watkins et al. (2016) also highlighted the importance of looking into broader economic effects beyond health. One gap in the 55 papers selected relates to the focus primarily on socioeconomic groups (although this is at least in part a product of the search strategy). More could be done to address other equity relevant subgroups or look in more depth at the intersection between subgroups in the context of the health problem and the policy intervention.

In summary, in order to complete an economic evaluation of pricing policy in South Africa with an equity focus three broad issues need to be resolved, in collaboration with stakeholders and with regard to data availability.

- Firstly, the selection of outcomes (health outcomes, financial risk protection measures, broader economic outcomes, return on investment ratios).
- Secondly, the choice of equity relevant subgroups of interest (SES, ethnicity, gender, age, rural, an intersection of these categories or any other).

- Finally, the method for illustrating equity impact (ECEA, part of DCEA, CEA using simple stratification, concentration measures, trade-offs).

2.3.11 Strengths and limitations

My search utilised four databases (Web of Science, Medline, Embase and Scopus) which enabled me to cover a broad range of topics and methods, however, papers exclusively from other databases and grey literature will have been missed. I also used an English language filter which means research conducted in non-English speaking regions (often in Spanish and French journals) were excluded. The search process was systematic and transparent and the breadth of methods and topics indicates that sufficient papers were captured to meet the objectives of the review, however, there was no second reviewer and so potentially useful studies may have been missed. The search included terms to cover inequalities and disparities but did not explicitly include every sub-group of interest, beyond socioeconomic status and poverty. This will introduce bias towards studies which include income/socioeconomic status as the subgroups, however the methods applied to socioeconomic subgroups are transferable to other groups and therefore does not limit the lessons which the review. The topic is interdisciplinary including at least: public health, epidemiology and economics which can lead to a variety of terms applied to the same concept some of which I may have missed, however, I included a broad range of terms in particular in relation to terms used for economic evaluation. The limitation to LMICs will have excluded a number of papers outlining studies in HICs some of which may have provided alternative approaches to incorporating equity. However, the scoping review results demonstrated that the leading methods have been applied to research questions in LMIC.

2.3.12 Conclusion

I started by defining equity as a concern for avoidable, unfair differences in health between subgroups of interest. I have briefly outlined key methodological approaches to incorporating equity in economic evaluations of health policy before scoping the literature for examples in LMICs. 55 papers provided examples across a range of health problems, policy interventions and LMICs. I stratified the papers into three subsets; each subset was then examined for its approach to illustrating equity. I have considered and discussed the strengths and weaknesses of applying different approaches to alcohol pricing policies in South Africa. I took forward three core questions to stakeholders: which outcomes to choose, which subgroups to choose and which methods to apply.

3 The role of stakeholder engagement in the appraisal of Minimum Unit Pricing of Alcohol in South Africa

In this chapter I outline the stakeholder engagement activities I undertook alongside building the mathematical policy model. Each stakeholder activity is outlined with the resulting outputs. At the end I review the contribution of the stakeholder engagement to the research project highlighting strengths and limitations before providing some personal reflections.

3.1 Background

3.1.1 Overview

The purpose of my stakeholder engagement was twofold: to shape the direction of the research using expert local knowledge (including understanding the problem, guiding model development and ensuring face validity); and to provide channels for future communication vital for increasing the potential for impact (Squires et al., 2016, Roberts et al., 2012, Howick et al., 2008).

The stakeholder engagement started with 12 semi-structured interviews, online or in person, with local alcohol experts in South Africa. This was followed by three face-to-face workshops at the beginning, middle and end of the economic evaluation modelling process, the first in person in Cape Town and the second two online.

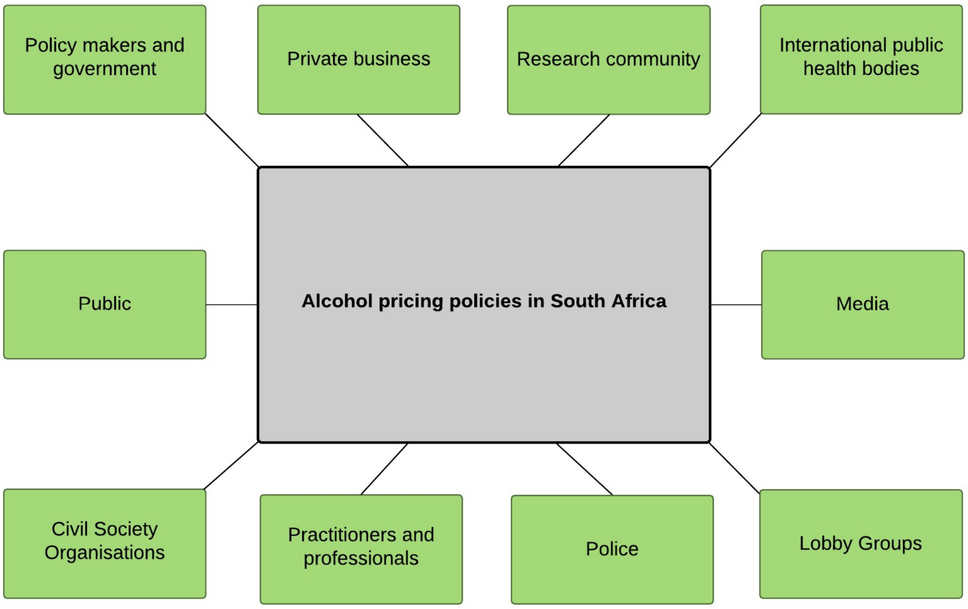
All stakeholder engagement plans received ethical approval at both the University of Sheffield and the South African Medical Research Council. Due to Covid-19 I submitted amendments in March 2020 centred on converting the workshops from in-person to online events (Appendix 2.1).

3.1.2 Identifying relevant stakeholders

As I am UK based it was vital I had a strong working relationship with a South African based researcher (Bradley et al., 2017). This ensured my research did not replicate work that was being carried out locally, made it relevant to the national policy debate and provided a level of legitimacy when engaging stakeholders. Professor Parry, the Director of the Alcohol, Tobacco & Other Drug Research Unit at the South African Medical Research Council (a parastatal organisation) agreed to co-supervise my PhD. Professor Parry, a member of the WHO Expert Panel on Drug Dependence and Alcohol Problems, also had extensive contacts in academia and policy both in South Africa and globally. His focus was on enabling my stakeholder engagement and supporting the scientific and ethical review process required by the South African Medical Research Council (SAMRC).

Initial conversations also took place with Dr Chelwa at the University of Cape Town and Professor Hofman at University of Witwatersrand whilst scoping the context of South Africa and alcohol. Identifying relevant stakeholders began with a stakeholder mapping exercise (Schiller et al., 2013) using papers and grey literature provided by Professor Parry (Bertscher et al., 2018, Parry, 2010a, Genisus Analytics, 2017) and consultation with three experts from three different South African academic institutions (Professor Parry, Dr Chelwa and Professor Hofman). This mapping exercise provided familiarisation with high profile organisations in the field; it also provided a useful list of places for research dissemination. The list of stakeholder categories and the organisation belonging to them were reviewed separately by Professor Parry and Professor Morojele both of the South African Medical Research Council (Figure 3.1 & Appendix 2.2).

Figure 3.1: Categories of stakeholders with an interest in alcohol pricing policies in South Africa



Following this exercise, a shortlist of experts working in alcohol policy in South Africa in either policy, academia or civil society organisations was drawn up. These three stakeholder categories were chosen as they all have an interest in policies that reduce alcohol harm but will each view the research with a different lens, drawing on diverse backgrounds and networks. This will support the tailoring of communication and outputs to more diverse audiences which will increase the potential for impact (Squires et al., 2016). The list of stakeholders has been checked by researchers external to SAMRC with expertise in alcohol in South Africa (Dr. Probst, Professor Hofman and Dr. Stacey) as part of providing scientific review of the research protocol during the SAMRC ethical review process. Dr.

Stacey and Professor Hofman made recommendations to add more policy professionals, this was incorporated into the plan.

3.2 Stakeholder interviews

3.2.1 Methods

Twelve face to face semi-structured interviews were carried out. The aim was to increase knowledge of the problem of alcohol in South Africa, identify areas of unconscious ignorance and build contacts. The data from the interviews helped to shape workshop content and reduce the chance of being blindsided by unfamiliar issues important to South Africans. Semi-structured interviews provide a starting point whilst allowing the conversation to flow to areas of importance to the interviewee. The questions focused on three areas: alcohol harm in South Africa, pricing policies and equity (Appendix 2.3). The conceptualisation of equity was kept broad to provide examples of how the term is understood rather than to answer specific modelling questions which arose from the scoping review (more suited to the workshops). To limit participant burden all interviews lasted between 30 and 60 minutes.

All interviews were carried out between June and September 2019. The first interview was piloted with Professor Parry before going into the field. In the majority of cases, where a pre-existing working relationship existed, introductions were provided to potential interviewees via email by Professor Parry. On receipt of positive interest, the interview questions, information sheet and consent form were emailed.

Amongst the 12 interviewees there were three from a policy context (National Treasury, Department of Health, Western Cape Liquor Authority), five represented civil society organisations (DG Murray Trust (2), South African Alcohol Policy Alliance, Khayelitsha Health Forum, Violence Prevention through Urban Upgrading) and four academics directly involved in alcohol policy and research (University of Cape Town and South African Medical Research Council). The 12 interviews were carried out face to face, six of these via skype or WhatsApp and six in person in Cape Town. The interviews were recorded on an encrypted recording device before being uploaded to a password protected folder on the University of Sheffield's system and deleted from the device. I was accompanied by my South African supervisor Professor Parry for three of the interviews as he was keen to refresh his working relationship with those particular stakeholders (one policy professional and two civil society). The recordings were all listened to in full and key points extracted into a MS word document.

3.2.2 Results

3.2.2.1 Alcohol harm and policy in South Africa

When asked about alcohol harm in South Africa a number of participants mentioned the same harms; HIV and risky sexual behaviour (n=7), gender based violence (n=6), road traffic injuries (n=6) and foetal alcohol syndrome (n=3). Other harms mentioned included tuberculosis (TB), non-communicable diseases, child neglect, injuries, heart disease, cancers, crime, violence, liver disease, unemployment and school absence. When asked about high profile policy issues most people (n=9) mentioned restrictions on advertising. There was awareness of the Western Cape White Paper on alcohol harm (n=5). Other policies mentioned were labelling, limits to the blood alcohol level when driving, raising the drinking age, restricting outlets or opening hours and licensing. All of the information confirmed previous research carried out, in particular the profile of HIV, gender based violence and road traffic injuries as harms at the forefront of people's consciousness in South Africa. One interviewee also talked about the health burden in South Africa in comparison with similar African countries.

3.2.2.2 Taxation and Minimum Unit Pricing

The questions in this part of the interview broadly aimed to discover how much participants knew about the current tax system, whether they thought it was effective in reducing alcohol harm, what they knew about MUP and whether or not they supported it. In general people's understanding of the current tax system was low. A theme, which arose unexpectedly, was hypothecated tax. The recent sugar tax in South Africa was ring fenced for health promotion however there was disappointment that this did not appear to have been spent. The idea of using alcohol taxation revenue for something related to alcohol harm reduction was mentioned by three interviewees. Interviewees felt that taxation was one of the best ways to reduce alcohol harm but inconsistencies with the way tax is levied were mentioned with special protection for wine due to its role in the economy and sorghum beer, for its cultural significance. Two interviewees mentioned the important role of beer in cultural events and rituals such as to celebrate the birth of a new child or at funerals.

Those that mentioned MUP labelled it as a "new" idea. Scotland was mentioned by seven of the interviewees, as well as Russia (n=3) and Canada (n=1). A number of interviewees thought it "might" or "could" work and that further evidence would be helpful. One strength mentioned for MUP was that it provided a signalling function by the government to industry although what was being signalled was not clarified. There was some confusion over whether MUP would replace the taxation system. In terms of feasibility of MUP one civil society organisation was taking legal advice on the constitutionality of introducing MUP and was interested in getting international input from those countries who have already implemented it. One respondent likened MUP to the South African carbon tax or sugar tax suggesting a strategic approach would be to introduce it at a low rate to ensure public support and then raise it over time.

A particular concern relating to MUP was the substitution effect to other, potentially more harmful, drinks such as homebrew, the inclusion of this in the modelling was suggested as important. There was also a concern that a bigger proportion of income amongst the poor would go on alcohol and as such women and children would suffer. One interviewee highlighted the lack of capacity for enforcement of a MUP. Much of the cheapest alcohol is sold in unlicensed shebeens which are unregulated. Related to this one interviewee talked about witnessing bribery of police to allow shebeen owners to trade outside of their hours highlighting the inconsistent enforcement of the law. Another was concerned that MUP would mean companies get richer as the money goes to industry and not to government. Coupled with this is the need for the government to raise more revenue, one policy professional stressed how there is a major fiscal crisis in the country and that "people are really panicking".

A number of interviewees mentioned the need for pricing policy to be part of a package of reform including, for example, meeting housing needs, regulating the alcohol supply chain, and licensing of outlets in informal settlements.

One interviewee spent some time outlining the distribution network of alcohol in South Africa and how this is controlled by the big beer companies. The large beer producers incentivise liquor shops/hotels/pubs to not only sell to the public (which is what their license is for) but to also become distributers to shebeens by offering bulk-buying discounts. The large beer companies provide them with the infrastructure to do this, for example large fridges. This way the beer companies get to supply to all the illegal shebeens (a substantial market) without doing it directly. If MUP came in, in theory, these bulk discounts would not be allowed, however, there appears to be an issue in enforcement and policing at this intermediate level of the supply chain. The national government deals with the producers and high-level legislation and the provincial with licensing. However, the police enforcement only appears to be at the level of shebeens (raiding and closing down unlicensed shebeens).

3.2.2.3 Equity

When asked "how is equity conceptualised in South Africa" six of the twelve interviewees laughed. Race and/or the previous system of apartheid was mentioned in five of the interviews. The topic of black economic empowerment arose a number of times. It appears that this is an argument often used by industry to promote the role of alcohol in society. For example the truck drivers who distribute alcohol are Black African. However, the industry have required the drivers to be self-employed, thus accepting all liability associated with the alcohol they deliver. Most Shebeen owners live in informal settlements and are thus Black Africans and so any restrictions can be seen as restricting economic opportunity. One civil society member saw equity as lots of people being able to get licenses to sell alcohol, resulting in many smaller shebeens rather than few larger ones. Another interviewee saw MUP as not equitable as the poor have to spend a larger proportion of their income on alcohol. The poor or economically disadvantaged were mentioned a number of times. Another interviewee saw equity as dependent on the topic of focus, providing examples of equity as people needing to use an equal proportion of their income to buy alcohol, or equity as poorer groups suffering the same proportion of alcohol related harm.

3.2.3 Outputs from the interviews

These interviews enabled me to build positive working relationships and gain understanding of the alcohol policy landscape. The key points are summarised into those which were considered for the broader research and those that directly informed the development of the content for workshop one.

3.2.3.1 Informing the broader research

- Understanding the supply chain and how to ensure MUP is enforceable would be crucial to the success of MUP and although this could not be modelled it needed to be acknowledged in the discussion.
- It was clear that modelling scenarios around substitution effects for homebrew was important as well as considering other unintended consequences.
- The industry may use arguments around black economic empowerment to oppose any additional pricing restrictions.
- The economic cost of alcohol to society and the balance between the costs and benefits was seen as an important part of the argument.

3.2.3.2 Informing workshop one

- The term equity needed to be dropped, for being too contentious and understood in a multitude of ways, instead I used differential impact or distributions.
- It was clear people were unfamiliar with the tax system and would need an explanation, including the point that MUP would not replace taxation.
- People connect with international comparisons, particularly for MUP (Scotland and Russia).

- Introducing myself and my supervisors at the first workshop was needed. The association with the Sheffield Alcohol Research Group, particularly the Scotland MUP work, was important whilst acknowledging the difference in context.

3.3 Workshop one

3.3.1 Methods

Workshops are useful for engaging a number of stakeholders at once, providing an opportunity for those in the field to meet together and encouraging people to become invested in the work through shaping it. This in turn increases opportunity for impact as the research is more relevant to the context and may be shared and distributed more widely. However, they can also be subject to their own dynamics and require excellent facilitation (Squires et al., 2016).

Following the interviews a detailed plan for the first workshop was created (Appendix 2.4). The workshop had four objectives, written for a lay audience these were:

1. Understand the problem of alcohol harm in South Africa
2. Choose which pricing policies to model
3. Choose which sub-populations matter most
4. Chose important outcomes of the pricing policy

The workshop plan was peer reviewed by supervisors and a pilot workshop delivered to fellow PhD students. Appropriate amendments were made in light of the feedback received. Final slides were checked with a local expert for further revision.

I received general ethical approval for the whole project in May 2019 but a condition from the SA-MRC was for a detailed agenda to be submitted as an amendment in advance of each workshop. Approval for the workshop one agenda was granted in September 2019 (Appendix 2.1).

I issued invitations in September 2019 to stakeholders who had completed an interview. I extended invitations to others recommended by the interviewees including members of the Western Cape Liquor Authority and co-workers at the Douglas Murray Trust. A focused effort was required to ensure attendance from the National Treasury including official invitations and coverage of expenses. This proved successful. Two weeks prior to the workshop participants were sent the information sheet and the consent form. I also recommended two papers for voluntary advance reading, one on the impact of beer excise taxation on population health in South Africa and a second on the profile of drinkers in South Africa using the National Income Dynamics Study (Stacey et al., 2018, Vellios and Van Walbeek, 2018).

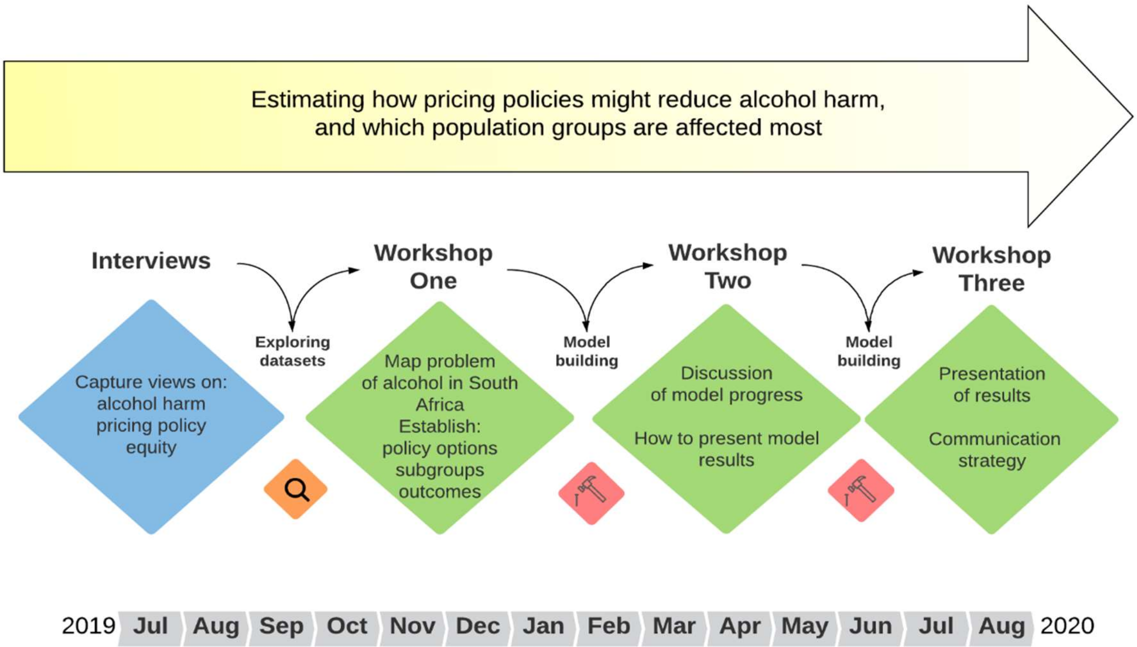
3.3.2 Results

My workshop ran from 9am till 12pm, followed by lunch, on Thursday 14th November 2019. It was introduced by Professor Parry before handing over to me to outline the objectives and the agenda for the day, people were asked to respect confidentiality. Everyone had signed a consent form, been issued a participant information sheet and received R100 to cover their travel expenses. Each individual was asked to introduce themselves, their organisation and role, and their interest in the topic. A range of responses were given including an interest in unlicensed shebeens, local government and regulation, seeking new policy approaches, an interest in data driven evidence, and a desire to reduce harm in their local community. The following organisations were represented:

- National Treasury Tax Directorate
- Department of the Premier: Western Cape Government
- Western Cape Liquor Authority
- Douglas Murray Trust x 2
- Khayelitsha Community Health Forum x 3
- South African Alcohol Policy Alliance
- Violence Prevention through Urban Upgrading
- South African Medical Research Council
- University of Cape Town

Following introductions I gave a ten minute presentation outlining my background and the research plan for the coming year, with a focus on how stakeholder inputs shape the research, including presenting a flowchart (Figure 3.2).

Figure 3.2: Project overview



3.3.2.1 Objective one: Mapping the problem of alcohol harm in South Africa

We then moved on to the first exercise in which participants were split into three groups with policy, academic and civil society groups spread evenly between them. The objective of this exercise was to inform a problem orientated conceptual model of the burden of alcohol in South Africa, an important first step in preparing to model a public health intervention (Squires et al., 2016). I wanted to create a conceptual model to allow for the representation of the wider systems, whilst bringing together the stakeholders and my own understanding of the problem, in a readily accessible form (Chilcott et al., 2010, Tappenden, 2014). I drew upon a framework utilised within operational research for knowledge elicitation in conceptual modelling (Vennix and Gubbels, 1992, Van den Belt, 2004). This specified practical considerations such as the requirement to provide a preliminary conceptual model for stakeholders to work on, rather than expecting them to start from a blank sheet, in order to reduce the time investment of participants.

I presented and explained a simplified map before groups each took an A0 hardcopy of the map to add/remove/edit as they saw fit (Figure 3.3). After 30 minutes the groups re-joined and presented back to the group the key changes/additions they had made. All changes were later merged onto one new diagram and further revisions added after circulation post workshop (Figure 3.4).

Figure 3.3: Simple problem orientated conceptual model

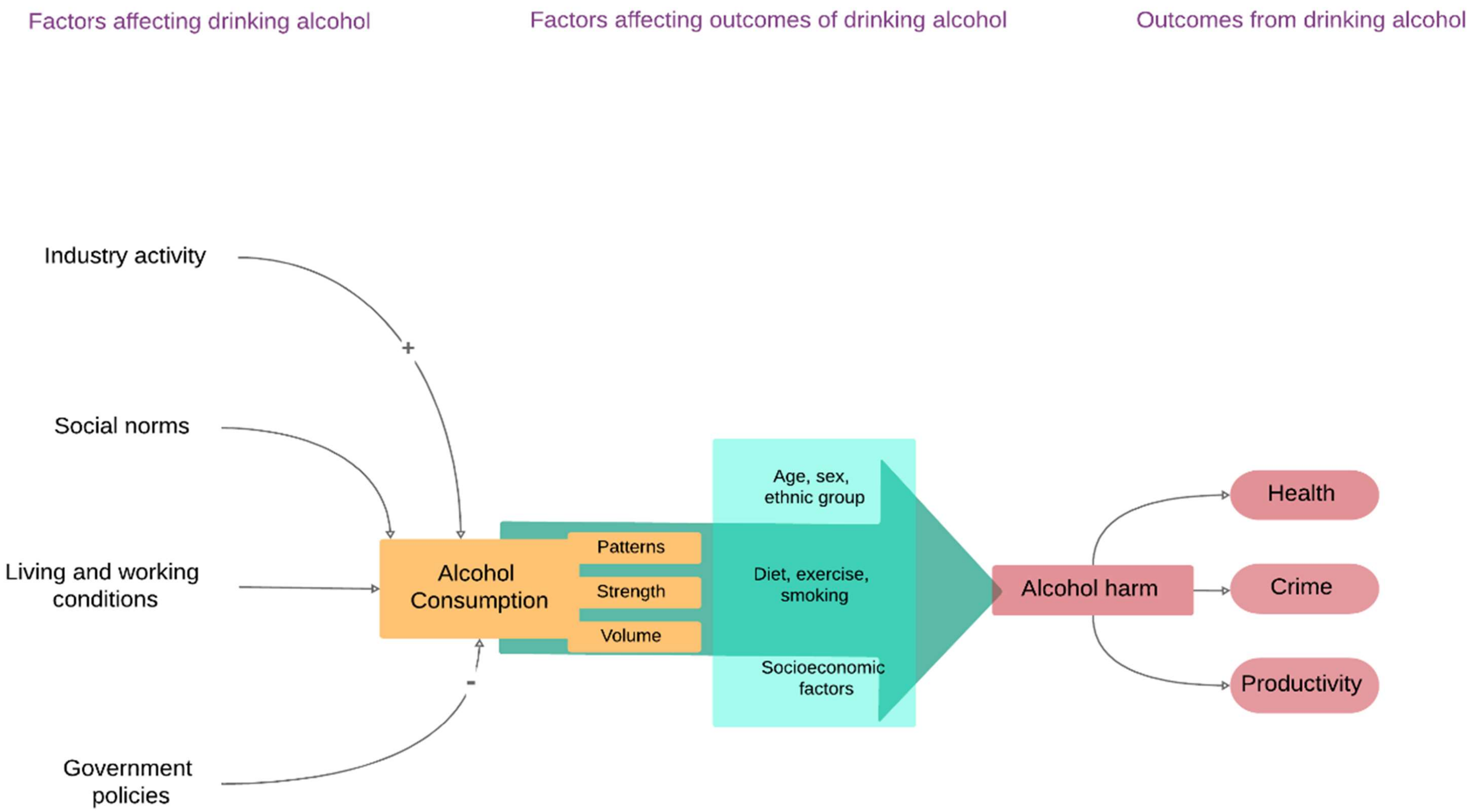
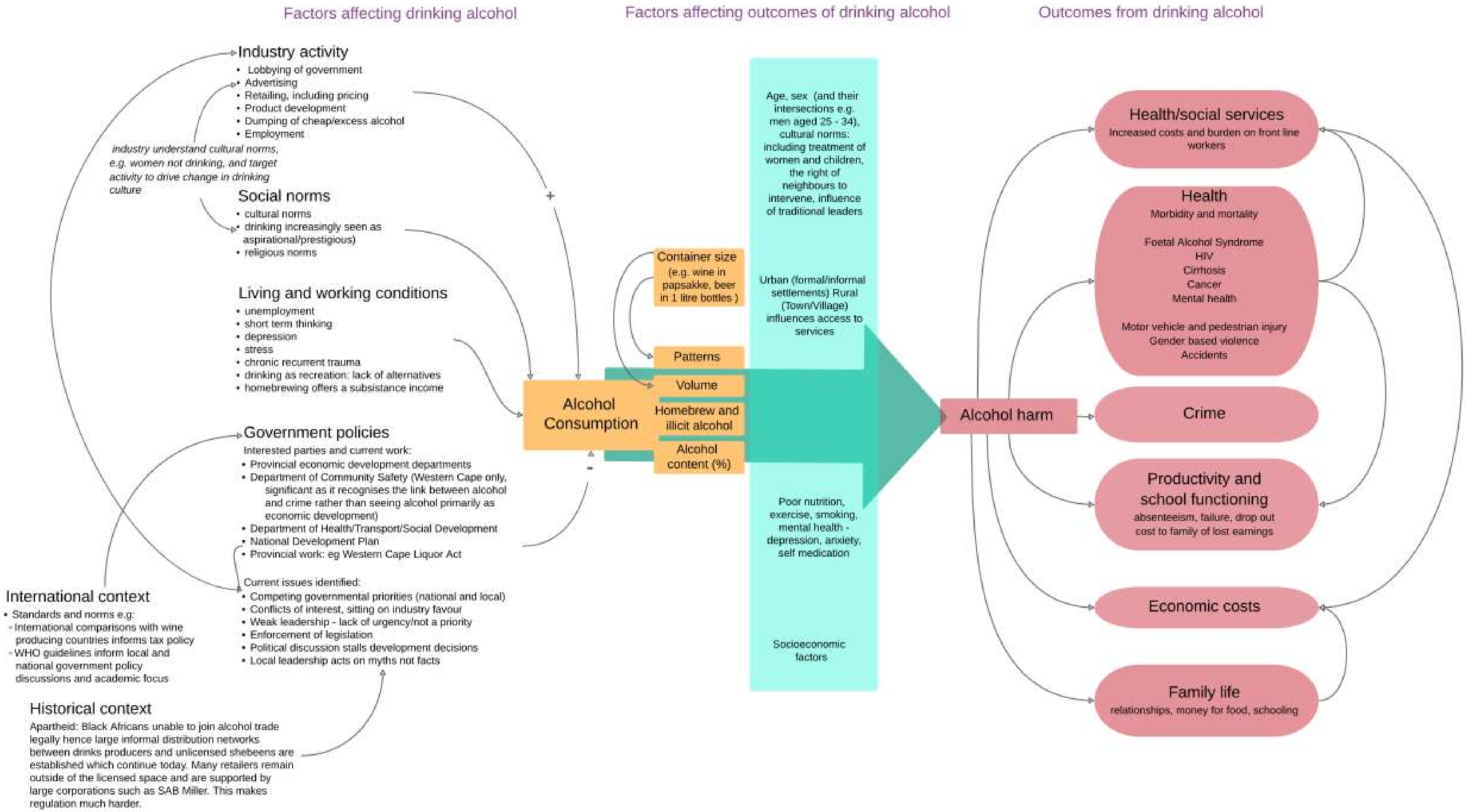


Figure 3.4: Detailed problem orientated conceptual model



3.3.2.2 Objective two, three and four: Choosing policy/sub-population groups/outcomes

After the break I gave a 15 minute presentation outlining the current alcohol taxation system in South Africa and explaining what difference a volumetric taxation system would make. The presentation also included what a standard drink is in South Africa and how minimum pricing works, including providing some context specific examples of price changes, some international examples of minimum pricing policies and some general advantages and disadvantages. I then asked people to regroup at this stage to discuss what policy they would like to see modelled as their primary policy option. One participant felt they could not have this discussion until they had discussed sub population groups. This was met with general agreement therefore I switched the agenda around to consider sub-population groups and outcomes first and then return to the pricing policy choice at the end.

3.3.2.2.1 Sub-population groups

I facilitated a group discussion to capture sub-population groups of concern until saturation point was reached (Table 3.1). It was acknowledged that many of the groups are too specific for the data and sample sizes that are available however there are umbrella categories which can be close proxies. For example a concern for the unemployed can be captured using income quintiles and taking the bottom fifth. It was agreed by the group that a broad focus on sex, age, income and drinker type was appropriate at this stage.

Table 3.1: Sub-population groups

Sub-population groups
• Young men 18 – 35 • Children 15/16 • Binge drinkers and heavy drinkers • Young women, women of reproductive age • The poor and informal sectors, non-salaried people, grant recipients • Unemployed, those in no education, employment or training • Students • People in high stress jobs • Young professionals • Sports people (drinking culture surrounding taking part in sport)
High level categories which cover the above
• Income • Sex • Age • Drinker type

3.3.2.2.2 Outcomes of interest

I then facilitated a second group discussion on outcomes of interest. I outlined that I would be including change in individual spend, change in purchases of alcohol and government revenue in the model. The group then suggested other outcomes thought to be of particular interest to South African policy makers and the public. Once I had compiled the full list on a flipchart I asked everyone to write on a piece of paper the three outcomes they thought were most important. Following this I gave each person three stickers and asked them come up to the flipchart and add stickers to the outcomes they had written on their paper. This enabled the group to receive immediate feedback of how they had voted (whilst not being influenced by each other in their initial choice or spreading their votes as the stickers began to pile up against certain outcomes). The outcomes showed that costs, violence and HIV are the three most important outcomes (Table 3.2).

Table 3.2: Outcomes of interest

(Stars represent number of participant votes, each participant received three votes)

Non- health outcomes
• Impact on individual spend • Change in purchases • Government revenue • Increasing profit (retailers? Manufacturers) • Employment*** • Crime*** • Individual earnings lost due to alcohol*** • Costs (to society)*****
Health outcomes
• HIV mortality**** • Violence (assault/murder/gender based violence(GBV)) ********* • Road traffic injuries* • Cancer** • Mortality (all cause)* • Cardiovascular disease*** • Foetal alcohol syndrome

3.3.2.2.3 Policy of interest

Finally, I returned to the question of which pricing policy to model. I presented the slide listing the three options (keep current system but increase rates across the board, introduce a volumetric tax system, introduce minimum pricing) with some advantages and disadvantages and people moved into their small groups to discuss the policy options. They were also invited to present a different policy or combination of policies than those outlined if they desired. Following a 15 minute debate they returned and stated their preference to the rest of the group. Each group chose minimum pricing as the headline focus but there was disagreement as to the levels. It ranged from R5 to R15. One participant wanted to make sure that a glass of beer should not cost less than milk or bread, meaning it should be at least R15. An unexpected focus that arose was in the definition of a standard drink (currently 12g or 15ml in South Africa). It was felt that this should be changed at the same time, which may help reduce transparency, presented as a good thing, as people would be less likely to understand the policy and therefore less likely to object.

3.3.2.3 Summary and next steps

The slide used at the beginning to illustrate my work plan and their input (Figure 3.2) was revisited before everyone gave one final comment. A key theme that arose (perhaps set by the first person) was that we needed the Department of Trade and Industry and the Department of Health to be present at the next workshop. There was a general consensus that it had been useful to get together and spend some time in discussion. Finally participants were asked to provide feedback on the workshop using post it notes, one positive and one negative, before ending for lunch. One stakeholder felt the session should have been longer, one wrote about the importance of inviting decision makers, positive feedback centred around how well organised and interactive the session had been with a range of groups included (Appendix 2.5).

I created an outputs document and circulated it on Monday 25th November 2019 after review by Professor Parry as he had attended the event. I included a summary of the objectives and the updated problem orientated conceptual model (Box 3.1, Figure 3.4). I sent it to all workshop attendees and two additional academics with modelling expertise who had not been able to attend but were interested in the project.

Box 3.1: Workshop one outputs document

Workshop 14th November 2019 – Outputs document

Thank you to everyone who attended and contributed so much. Please find here a concise summary of the outputs we collectively generated during the workshop. I welcome any feedback regarding these outputs particularly if I have missed or misunderstood anything. I do hope you will be able to attend the next workshop to discuss model progress and present some initial results.
Please do not share this with anyone at this stage as it is still in development and remains a confidential output of the project.

3.3.2.4 Objective one: Mapping the problem of alcohol in South Africa

See visualisation

3.3.2.5 Objective two: Choose which pricing policies to model

The group consensus was to focus on modelling minimum pricing in South Africa with a price range of R5 to R15. A headline choice can be chosen at workshop two.
It was also decided to explore changing the standard drink or unit size from 12g to 10g.

3.3.2.6 Objective three: Choose which sub-populations matter most

The modelling will start with a focus on the following categories: age, sex, drinker type, income and possibly urban/rural.

3.3.2.7 Objective four: Choose important outcomes of the pricing policy

The model will include change in individual spending, quantity purchased and government revenue. The group judged the inclusion of costs to be a high priority (although this was not tightly defined) as well as: employment, crime and earnings lost to the individual. The priority for health outcomes were violence and HIV although cancer, cardiovascular disease and road traffic injuries were also of interest.

3.4 Workshop two

My second workshop aimed to inform and validate the model during its development and to discuss how to present model results. This ongoing engagement with local stakeholders was also crucial to maintaining interest in the research.

3.4.1 Methods

Following the first workshop and a number of months modelling work I created a detailed agenda for the second workshop (Appendix 2.6). The workshop had three clear objectives, written for a lay audience these were:

1. Update on progress
2. Present some preliminary results
3. Discuss how to present model results

I submitted the workshop plan for SAMRC ethical review, as requested, and all attendees were invited to the face to face event planned for May 14th 2020. 17 people agreed to attend, which included every person who had attended workshop one. Travel logistics were planned and bookings made for travel. Then due to Covid-19 all international travel was cancelled. In order to maintain momentum of the research project, and since I already had a slot in people's calendars, I decided to move the workshop online and have it at the same date and time, although shortened to suit the new online format.

All the material needed to be reworked including new submissions to both ScHARR ethics (following consultation with ScHARR information governance) and SAMRC ethics (Appendix 2.1). As part of this I had to move the consent form to an online version. All stakeholders were notified about the change of format and emailed a participant information sheet and link to the online consent form. It was made clear that they would not be able to join the online workshop if they had not completed the consent form in advance of the online workshop. I received training on Blackboard collaborate, a university approved online learning platform, and rewrote all the materials to suit the new format. I had to think about how I would gather feedback without the possibility of free flowing conversation and face to face group work which I had anticipated. I decided to use a variety of live polls, to break up the presentation and maintain engagement, online short questionnaires (using googleforms) for more detailed questions after each presentation, and a chat box for people to record general comments and questions. I also prioritised time for attendees to introduce themselves at the beginning and give a final comment at the end so they felt connected to each other as well as me.

As for the first workshop the plan was reviewed by supervisors and a pilot online workshop delivered to peers. Action was taken on all comments as required. I also undertook a technical test one week before with two South African stakeholders.

3.4.2 South Africa and Covid-19

As a result of Covid-19 South Africa went into a full lockdown on the 27th March 2020. This included a ban on the sale of alcohol. Alcohol became a very high profile policy topic. In the week preceding my online workshop I was invited to attend two webinars, one hosted by civil society organisations and one by academics. This increased my exposure to the conversation surrounding the alcohol ban in lockdown, helping me to understand what the policies were, how they had been justified and what key stakeholders thought this meant for future alcohol policy. This meant I was able to reference accurately the current situation in South Africa at the start of my online workshop. In addition I learnt that equity, or differential impact, had become even more high profile, particularly due to the unequal socioeconomic impact of Covid-19 reported in the UK and USA. This confirmed that illustrating differential impact as part of my modelling represented an important contribution to the debate.

3.4.3 Results

I delivered the online workshop on the 14th May 2020 from 9am until 11am South African time. I started with a welcome, technical instructions, outline of the objectives and the agenda for the day. Technical instructions included a practice poll (where people answer a multiple choice question and the results are revealed straight away), instructions about the google forms, and guidance on where to find the chat box. 15 people attended, although one had to leave after the first hour. People were asked to respect confidentiality.

The following organisations were represented:

- National Treasury Tax Directorate
- Western Cape Government: Department of the Premier
- Western Cape Government: Department of Community Safety
- Western Cape Government: Provincial Treasury (3)
- Western Cape Liquor Authority
- Douglas Murray Trust
- South African Alcohol Policy Alliance (SAAPA)
- South African Medical Research Council (2)
- University of Cape Town (2)
- University of the Western Cape

A member of the Khayelitsha Community Health Forum had planned to attend but did not on the day. A member of Violence Prevention through Urban Upgrading could not get a stable internet connection so attempted to join but kept leaving. The member from SAAPA also had technical problems although was able to connect long enough to give input.

I allowed 20 minutes for introductions as I felt this was vital to create a sense of connectedness. People were asked their name, organisation and interest in the topic. Key points made by the attendees included: the timeliness of the research in terms of the current lockdown and ban of all on- and off-trade alcohol sales; a desire to find a new normal for alcohol control policies post lockdown; a strong desire that the fiscal budget should not have to subsidise the costs of the industry; support for the policy but interest in further evidence; interest in the link between violence and alcohol; parallels with the tobacco industry.

Following introductions I gave a ten minute presentation recapping workshop one and giving a brief update on the latest evidence from Wales and Scotland's minimum pricing policies. The first poll asked whether international examples are helpful when considering MUP for South Africa, 13 said yes, 2 said maybe and zero said no.

3.4.3.1 Objective one: Model progress so far

This section consisted of my delivery of two ten minute presentations each followed by ten minutes to fill in a questionnaire, one on the price to consumption part of the model and one on consumption to harm. There was one poll during the price to consumption part of the model. I made clear that the questions were in no way a test but were purely to gather as much feedback as possible to develop the model. People were also able to pass over questions they did not feel they could answer, nothing was mandatory on the form.

3.4.3.1.1 Questionnaire results following the price to consumption presentation

Stakeholders agreed with the use of the South African Demographic and Health Survey to estimate alcohol consumption (12 yes, 2 maybe, 0 no). They were asked if the baseline alcohol prices used in the model had face validity and the vast majority agreed (14 yes, 2 maybe, 0 no). They also agreed that heavy drinkers would be less responsive to price increases than moderate drinkers (11 yes, 3 maybe, 0 no).

Stakeholders believed that following a price increase on recorded alcohol an individual who drinks both homebrew and recorded alcohol is likely to switch some of their recorded alcohol drinking to homebrew (14 votes out of 15). However, there was a variety of opinion on just how much switching would take place with suggested estimates ranging between 10% to 75%. When asked whether people who did not drink homebrew before the policy would start as a result of the policy most people said maybe (3 yes, 9 maybe, 3 no). If non-homebrew drinkers were to start drinking homebrew as a result of the policy stakeholders thought they would most likely be the poor (9 votes), heavy (10 votes) and occasional binge drinkers (7 votes), participants could vote for more than one category for this question.

3.4.3.1.2 Summary of the information gathered on the price to consumption part of the model

The data sources and the prices I used had face validity although needed written justification. Stakeholders were sure people who drink both recorded alcohol and homebrew would switch some of their drinking to homebrew in the face of a price rise. However, there was no clear consensus as to the level of switching, this is to be expected as it is a more complex question. The stakeholders were unsure about whether people might initiate homebrew drinking (3 yes, 3 no, 9 maybe) but if they did they felt this would likely be amongst heavy drinkers and the poor.

An important comment was made about how the modelling related to the definition of drinker types used, which I followed up later with the attendee who raised it as it was a technical point related to the stakeholder's use of alternative alcohol consumption datasets.

3.4.3.1.3 Questionnaire results following the consumption to harm presentation

By this time one participant had to leave (they had pre-warned me of this) so there are now 14 responses instead of 15. Most stakeholders were not aware of any data sources for the prevalence of disease/injury in South Africa which were preferable to the Global Burden of Disease (2 yes, 2 maybe, 10 no). Those who reported yes or maybe suggested investigating whether the South African Medical Research Council, Statistics South Africa or the Western Cape Department of Health had any better data. When asked whether using data from the UK reduced the credibility of the model most thought it did (10 yes, 3 don't know/it depends, 1 no). When asked whether they knew of any hospital admissions statistics 3 left it blank and 6 said no. There were 5 suggestions, 3 of which related to a data collection programme called HECTIS in the Western Cape.

Stakeholders were asked if it was more important to increase the number of health outcomes in the model (beyond the three included at the time, HIV, intentional injuries and road injury) or to focus on crime. Eight stakeholders chose health, some of whom suggested specific conditions or areas such as cancer and liver cirrhosis, two chose crime and four chose both. Stakeholders were then asked an open ended question about which costs should be included next (costs had already been calculated for the drinker, government, industry and hospitals. Eight participants mentioned cost to the family or household, four mentioned labour market costs such as lost productivity and one suggested cost of mortality using the human capital method.

3.4.3.1.4 Summary of the information gathered on the consumption to harm part of the model

Stakeholders provided South African sources of data for my investigation of baseline harms although these appear significantly old (2012). The use of UK data would reduce the credibility of the model. Suggestions were given for potential hospital admissions data, which were followed up but nothing on a national level. In terms of completing the model there was a preference towards health outcomes although crime was also seen as important. In terms of which costs to include eight participants mentioned cost to the family or household, four mentioned labour market costs such as lost productivity and one suggested cost of mortality using the human capital method. There was concern that costs are underestimated and that communication should highlight the limited boundaries of my research in that it only investigates a small portion of the impact of alcohol in South Africa.

3.4.3.2 Objective two: Presenting preliminary results

Following a ten minute break in the online workshop I presented some preliminary results. This was partly for the interest of the participants but also crucially to inform the next session on how model results should be presented. I delivered a 15 minute presentation which included prevalence of drinking, baseline drinking and spending, post policy change in drinking and spending (for a R5 minimum price), government revenue and industry revenue, and mortality from intentional injury, with a number of polls but no formal questionnaire.

3.4.3.3 Objective three: How to present model results

My final session focused on asking the stakeholders how results should be presented. I asked a few short questions before introducing a simple communication strategy exercise (Appendix 2.7). Highlighting results by drinker types and wealth groups was seen as the most important. Using graphs and tables is also helpful. The participants provided a lot of detail on how/who/what to communicate which will inform planning for the third workshop which is more a presentation of results, the clear priority is to communicate with policy makers.

3.4.3.4 Summary and next steps

I included a final question asking for feedback on the online workshop in general in order to understand how people found the new format. Generally people were positive about the online format appreciating how interactive it was due to the polls, questionnaire and chat box.

Following the final exercise all participants were given the opportunity to make one final comment. Points included enjoyment of the presentation and the interactive use of technology, and satisfaction at the local and national government representation at the workshop. A few key modelling concerns were raised including a concern the model might be underestimating heavy drinking and harm, the importance of getting the drinker type definitions correct, and the need to validate the Tshwane prices. Some broader reflections included the importance of the research for South Africa, a hope that the policy does not become a political football, and people starting to think about how the implications of this research applied to their own work. After the workshop I circulated an outputs document to all participants (Box 3.2).

Box 3.2: Workshop two outputs document

Online workshop 14th May 2020 – Outputs document

Thank you to everyone who attended in this exceptionally difficult time. Please find here a concise summary of the feedback received via the live polls, questionnaires and chat box. I welcome any feedback particularly if I have missed or misunderstood anything.

Please do not share with anyone at this stage as it is still in development and remains a confidential output of the project.

3.4.3.5 Objective one: Model progress so far

Price to consumption: The data sources and the prices used are reasonable. Modelling should include switching behaviour to homebrew. The drinker type definitions should be reviewed and justified.

Consumption to harm: Local data sources for the baseline level of health harms should be investigated. The use of UK data would reduce the credibility of the model and risk appearing Eurocentric. The modelling should prioritise health outcomes although crime is important if possible. Costs already included are good. Discussion of cost to households should be considered and also labour market costs be investigated. As this modelling does not include all societal costs it should be highlighted that the research only investigates a small portion of the impact of alcohol in South Africa.

3.4.3.6 Objective two: Presenting preliminary results

Online workshop attendees agreed that both pie charts and bar charts were understandable. Results demonstrating impact of different minimum price levels were of interest.

3.4.3.7 Objective three: How to present model results

Highlighting results by drinker types and wealth groups was seen as most important, sex and age group impacts were also important. Results should be presented using graphs and tables, quoting figures where appropriate.

Policy makers were the top priority for communication but also the media, civil society organisations and the public. A one page policy briefing was the most commonly mentioned form of communication complemented by online articles with infographics, presenting in person, and online interactive web tools if possible.

3.5 Workshop three

My third workshop aimed to present the final results to stakeholders. It took place on November 12th 2020 from 10am to 11:30am. This was significantly later in the year than originally planned, in part due to Covid-19 but also due to overly optimistic planning.

3.5.1 Methods

Following on from my second workshop the final presentation of results was written primarily for a policy audience as this was overwhelmingly the group highlighted by stakeholders as the top priority for communication. Graphs chosen to present results were also guided by the feedback received in workshop two, for example the inclusion of pie charts to illustrate drinker type, the level of categorisation and the inclusion of a graphic to compare policy levels. I wrote a detailed event plan (Appendix 2.8). I invited all those previously engaged in the research through an interview or attendance at either previous workshop. A key stakeholder, engaged from the start, at the Western Cape government then sent a number of contacts through for government officials who they saw as critical in progressing the policy locally. This included individuals from the Western Cape Liquor Authority and the Provincial Treasury. At this point minimum pricing, though not perfectly understood, had the interest of the Western Cape Premier and was beginning to be reported in the press (Premier Alan Winde, 2020, Phillip de Wet, 2020).

The final workshop had four objectives:

- Explanation of minimum unit pricing
- Brief overview of methods
- Presentation of results
- Discussion of results

My slides were reviewed by all four supervisors. In preparation I presented a number of the results slides to the Sheffield Alcohol Research Group and received detailed feedback verbally and via email from two senior academics with significant policy communication experience. As before I completed a pilot workshop with peers and amended the material accordingly.

During my preparation Professor Parry highlighted how important it was to allocate sufficient time for discussion as the workshop offered a rare opportunity for people from different spheres to come together. To ensure this discussion section was productive and included a diversity of voices I asked three stakeholders representing national government, local government and a civil society organisation, who had all been with the research project from workshop one, if they would speak for five minutes on the following questions:

- What are your reflections on the research that has just been presented?
- What are the next steps or remaining questions to be addressed?

Respondents were provided with presentation slides one week in advance.
Ethical approval was not required for this event as there was no formal data collection. The session was not recorded and I did not ask for written feedback as in my previous activities.

3.5.2 Results

I delivered the webinar on the 12th November 2020 from 10am to 11.30am, South African Time. I started with a welcome and technical instructions before handing over to Professor Parry to give some context to the research and introduce the session. It was made clear that the session was not being recorded and outputs not being formally collected. 29 people attended.

The following organisations were represented:

- National Treasury Tax Directorate
- Western Cape Government: Department of the Premier
- Western Cape Government: Provincial Treasury (2)
- Western Cape Liquor Authority (3)
- Douglas Murray Trust (3)
- Private civil society consultant
- South African Alcohol Policy Alliance (SAAPA) (2)
- South African Medical Research Council (2)
- University of Cape Town (6)
- University of the Western Cape
- University of Witwatersrand

Two members of the Sheffield Alcohol Research Group (SARG) attended. I encouraged participants to use the chat box throughout the session and informed them there would be a number of live polls to aid interaction. The presence of two members of SARG added a breadth of knowledge which greatly enriched the chat box conversation.

The session consisted of my 45 minute presentation of results, live polls, and a facilitated discussion. The three respondents and the attendees provided valuable information, different perspectives,

criticisms, areas of concern and areas of confusion. For example around topics such as differential alcohol prices, impacts on shebeens, and communication materials. Stakeholders challenged the proportion of alcohol burden attributable to HIV, the taxation projection and the number of deaths which I presented. Participants were keen to share my slides with their networks.
In August 2021 my results paper was published (see chapter five) and I circulated it to all stakeholders along with a one page policy brief (Appendix 2.9).

3.6 Reviewing the contribution of stakeholder engagement to the modelling and policy process

3.6.1 Discussion

The objectives of the stakeholder engagement were to shape the direction of the research using expert local knowledge (including understanding the problem, guiding model development and ensuring face validity); and to provide channels for future communication vital for increasing the potential for impact.

Insights from the initial interviews shaped my research through increased understanding of the South African alcohol policy context as well as establishing working relationships with key stakeholders. The first workshop then helped with decisions about which pricing policy to model, as well as allowing me to identify key modelling concerns such as homemade alcohol and unregulated premises. Stakeholders with modelling expertise also highlighted challenges relating to model inputs including getting reliable price data, splitting the data by drink type, and calculating elasticities. Learning about these early on in the modelling process allowed me to explore the options in detail with my supervisors and develop solutions. The second workshop was particularly important for ensuring face validity with the data sources and allowing for a number of the assumptions used in the model to be open to scrutiny.

The stakeholder engagement enabled the creation of relationships with individuals with whom I was able to communicate my research and who were then able to disseminate it further. As an example I received communication from one stakeholder within the Western Cape Provincial government indicating that my work had been used in internal presentations to heads of department and that my slides were a useful internal lobbying tool. Stakeholders who joined at the start of the project identified and invited other key agents with an interest in the research which meant the breadth of engagement grew as the project progressed. Engaging stakeholders led to additional opportunities. For example I contributed to a MUP policy brief written by the Douglas Murray Trust and circulated to government officials in the Western Cape government. I also completed consultancy work, funded by the Douglas Murray Trust on behalf of the Western Cape Government, adapting my national model to the Western Cape Province in collaboration with local academics. I presented my work at a workshop in September 2021 on the five best buys for alcohol in South Africa, organised by Douglas Murray Trust, and attended by national policy makers. I also was interviewed for provincial radio (Maytham and Gibbs, 2021) and my research was written about on a news site (de Wet, 2021).

3.6.2 Strengths

I have identified a number of strengths of the stakeholder engagement. The initial one to one interviews were very helpful in scoping the area of research and initiating relationships. As they were all carried out face to face (either in person in South Africa or online) a stronger sense of connection was achieved which I believe assisted in good attendance at the first workshop.

Workshop one and two were both highly interactive, though one was in person and one online. The group work in the first workshop and the Google Forms, chatbox and polls for the second workshop provided written outputs which I was able to take away and analyse. This enabled me to make clear modelling decisions based on the outputs, for example what to do about homebrew and which outcomes to include in the model. The interactive nature also maintained engagement and energy amongst the participants, according to stakeholder's post-event feedback.

My workshops were well organised and communicated which resulted in trust that I was competent. I was particularly careful to create a strong feedback loop, through the output documents and at the beginning of the next session reinforcing that I had been listening and that their input was directly informing the work.

Attendance grew at every subsequent event as stakeholders not only stayed with the research project but also invited colleagues. In the first workshop there was a concern that I needed more policy engagement. By the second workshop it was noted that the government representation had grown, particularly across different government departments.

The switch to an online workshop format, initially very challenging, was a strength in engaging more policy professionals who may have been reticent to sacrifice the time if travel had been involved.

3.6.3 Weaknesses

There were disadvantages to moving the engagement online as it reduced the input of stakeholders with poorer access to technology. For example, one stakeholder did not attend the second workshop as they live in a township and had been unable to find physical space to join. Another stakeholder who works for a civil society organisation kept entering and leaving the meeting due to poor technology so could not engage. I followed up one to one with both stakeholders who struggled to engage asking for specific feedback on the workshop outputs document. However, it suggests the online format advantages those who work in government or universities who have better access to technology.

Due to the location of my South African supervisor the stakeholders were Cape Town centric. I was not able to achieve the same level of engagement with national government departments. However, we did manage to engage national treasury, after much focused effort, which was a good achievement. In addition, we did not engage stakeholders from every potential category; such as alcohol treatment practitioners, the general public, police or the industry. A pragmatic decision was taken to focus on academics, policy professionals and civil society organisations. This was due to the constraints of the project and the need for workshops to provide key research decisions from a group of experts rather than managing a disparate set of conflicting interests within a highly politicised policy area.

There was a tension (perhaps familiar to academics who engage with policy professionals) between waiting to have results peer reviewed versus having an efficient feedback loop for stakeholders. My preference would have been to have the results published in an academic journal and a policy brief ready to disseminate in time for the third workshop but I was not able to achieve this. I circulated the slides with a disclaimer on them that they were yet to be peer reviewed but this reduces credibility and the results did change from those slides to the final publication. However, I sent a publication and accompanying policy brief out to all stakeholders in August 2021 and was reassured by my key policy contact that I had not missed the policy window and that my work had already been useful in progressing the debate.

In my second workshop the questionnaire relating to the consumption to harm part of the model could have been improved. The questions were too open, particularly the choice of health outcomes or crime, a number of people said both which was not entirely helpful. In part this reflected the fact that this part of the model was less developed at the time of the online workshop. The preparation for the second workshop was a particularly difficult time with Covid-19 pressures and balancing home-schooling.

3.6.4 Personal reflections

In conclusion, the stakeholder engagement enabled me to shape the research, to communicate my results and to increase motivation and transparency. I was able to translate skills and experience from previous work in the third sector into an academic setting. I am particularly grateful to all the stakeholders I worked with who shared their time and expertise so generously. This experience has strengthened my resolve to continue to work at the intersection of research and policy as I move forward in my career.

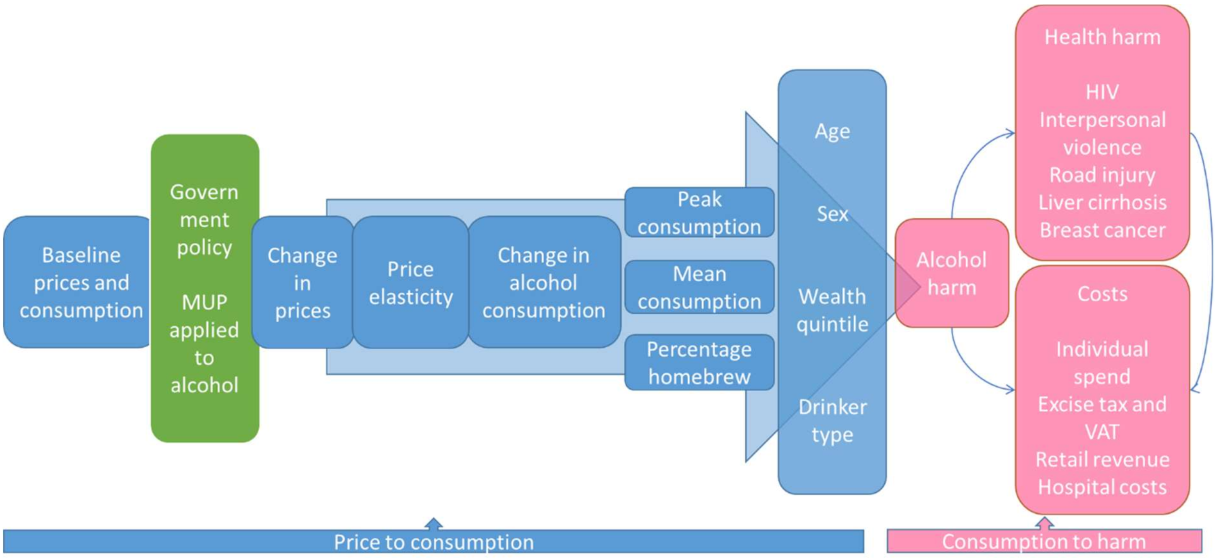
4 Mathematical modelling methods

In this chapter I firstly present a broad overview of the model which includes a high level description, model framework and all data inputs. The chapter then gives methodological detail of the model split into two distinct sections, price to consumption and consumption to harm. Each of these sections outlines the process undertaken for identifying and modifying data inputs as well as the modelling methods used. Finally the sensitivity analysis and the extended cost-effectiveness analysis methods are presented.

4.1 Broad overview of the model

The aim of the modelling is to appraise a minimum unit price for alcohol in South Africa. The problem orientated conceptual model is outlined in chapter 3 (Figure 3.4). The identification of model boundaries and causal pathways, resulted in a simplified conceptual model framework (Figure 4.1).

Figure 4.1: Model framework



To estimate the policy impact two distinct sections of the model were defined.

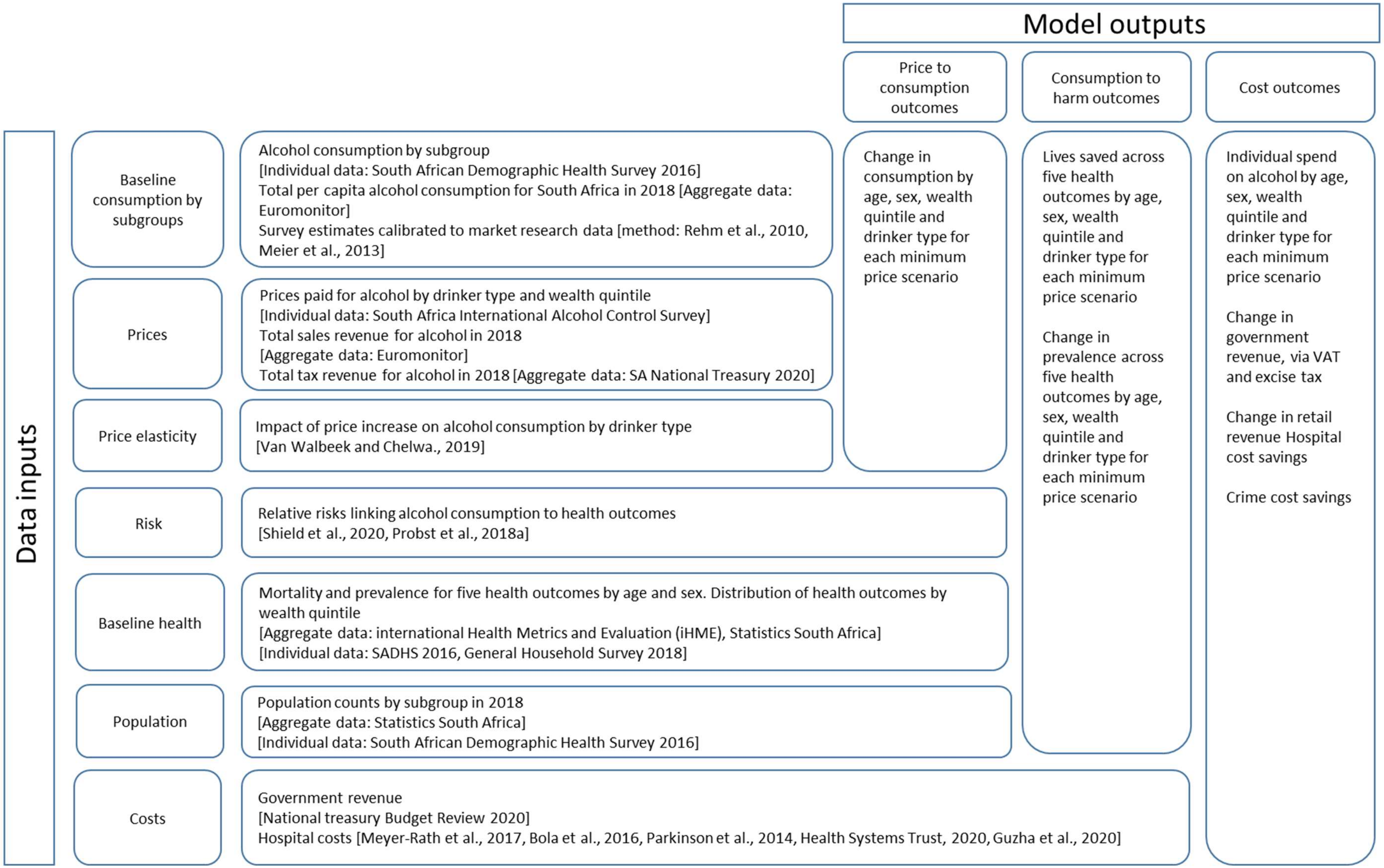
I. Price to consumption: Firstly the relationship between alcohol prices and consumption was estimated. This accounts for both mean (average weekly grams of alcohol consumed) and peak (highest amount consumed on one drinking occasion) alcohol consumption, by drinker group (heavy drinkers, occasional binge drinkers, moderate drinkers: defined in 4.2.1.7) and wealth group.

II. Consumption to harm: Secondly the relationship between mean and peak consumption and alcohol related harm and associated costs was estimated.

There is no single dataset that can provide all the required data for the model and thus a combination of survey datasets, market research data and evidence from published literature was used. Figure 4.2 shows the three main components of model outputs; price to consumption outcomes, consumption to harm outcomes and cost outcomes, together with the categories of inputs and individual data sources that link them. This highlights the lack of consistent data sources for the model and gives an early indication of the need for careful calibration and sensitivity analysis.

The general approach for identifying the most appropriate data was to engage experts both in alcohol modelling and in South African alcohol research, and also to review previous alcohol models both South African and international. I then selected the data by exploring how it met predefined criteria encompassing relevance to the decision problem, model structure and convergent validity. The nature and potential magnitude of the uncertainties associated with the choice of data sets and their adjustment will be covered at the end of the chapter rather than intermittently throughout the chapter.

Figure 4.2: Data inputs and model outputs



Four existing alcohol pricing models were used to inform methods identified via scoping of the literature and consultation with alcohol modelling experts. The SAPM provides an example of a complex alcohol model with detailed data requirements (Brennan et al., 2015). The OneHealth model, conceived by the WHO, is designed to be applicable to a wide range of policy interventions and countries, including the cost-effectiveness of increased taxation in South Africa (Chisholm et al., 2018). Two local models were created by South African academics using nationally available data sources. A brief overview of the four models is provided (Table 4.1).

Table 4.1: Comparing four alcohol policy models

Paper/report	Policy	Subgroups modelled	Alcohol modelled	Price to consumption mechanism	Outcomes
The Sheffield alcohol policy model – a mathematical description. **(Brennan et al., 2015)** **This model has been published in a large number of papers and reports**	Originally built for minimum unit pricing and discounting restrictions, it now includes any level of excise taxation. Best known for modelling 50 pence minimum unit price in Scotland, UK.	Age (4 groups), sex (2 groups), socioeconomic status (5 groups), drinker type (3 groups)	Five types of drink modelled for both on- and off-trade (Consumed *on* the premises such as restaurant/pub/bar/sports event, consumed *off* the premises such as at home/friends home/picnic).	Price distributions modelled for every subgroup at baseline and following the policy A matrix of own price and cross price elasticities applied to change in mean price	Alcohol consumption 45 health harms (modelled using change in relative risks) Can include: crime and work absence
Are the "Best Buys" for Alcohol Control Still Valid? An Update on the Comparative Cost-Effectiveness of Alcohol Control Strategies at the Global Level **(Chisholm et al., 2018)**	50% increase in excise taxes on all alcoholic beverages.	Sex (2 groups)	Beer, wine, spirits.	No prices in model. A percentage increase in price (50% increase in tax fully passed through) combined with price elasticity used to model change in consumption	Alcohol consumption 22 health harms modelled using change in relative risks Government cost of implementation

Using price-based interventions to reduce abusive drinking in the Western Cape province. **(Van Walbeek and Chelwa, 2018)**	Provincial taxation: R20 per litre of absolute alcohol for beer R1 per litre of beverage for wine R50 per litre of absolute alcohol for spirits Minimum unit price: 50%, 70% and 100% of the median unit value.	Drinker type (4 groups)	Alcohol was aggregated and considered as one commodity.	Each drinker type's proportion of alcohol purchased at various percentages below the median price was estimated. This proportion of their purchasing was then adjusted using the price elasticity when the minimum price was increased to a proportion of the median value.	Alcohol consumption There are no health harms modelled Government revenue
Simulating the impact of excise taxation for disease prevention in low- and middle-income countries: an application to South Africa **(Stacey et al., 2018)**	Excise tax increases for cigarettes, beer and sugar sweetened beverages Beer excise taxation: Intervention scenarios 25%, 27%, 29% (Baseline 23%) .	Sex (2 groups), age (unknown number of groups), drinker type (3 groups)	Beer was only drink type with excise taxation change applied. Wine and spirits are included due to cross price elasticities.	No prices in model. A percentage increase in price (resulting from excise tax rise) combined with price elasticity used to model change in consumption	Alcohol consumption Health harm is all-cause mortality Government revenue

The above four models provided a starting point which informed the initial conceptualisation of the model. The relative importance of different aspects of my model can be informed by sensitivity analyses undertaken in the previous studies. However, the only model with published sensitivity analysis was SAPM. In the primary paper outlining the model the authors varied time lag assumptions for chronic harms from a 10 year base case to 5 or 15 years, changed the elasticity parameter set, and compared model outputs against external data or other studies, including government reports (Brennan et al., 2015). Sensitivity analysis using a more probabilistic approach was later undertaken for base case elasticity estimates and demonstrated that parameter uncertainty, for these parameters, was less significant than the uncertainty related to structural assumptions (Meier et al., 2016). This evidence suggests results are most sensitive to structural modelling assumptions and further emphasises the importance of engaging stakeholders in developing the model structure. None of the sensitivity analysis completed by the team who use SAPM, across the various publications, changed the overarching conclusions from the modelling work.

4.2 Price to consumption data inputs

In order to model the relationship between price and consumption I estimated mean and peak alcohol consumption at current alcohol prices at an individual level. A government policy of legislating for a minimum price is then imposed which results in changing prices, this is modelled for three potential minimum prices chosen by stakeholders (R5, R10 and R15). The change in price is then translated into a change in individual consumption using an elasticity of demand for alcohol, dependent on the individuals drinking patterns and wealth group. Individual level changes in consumption and spend are aggregated to estimate population level spend, retail and government revenue at baseline and each of the policy scenarios. My model was populated with data from surveys, market research and government sources.

4.2.1 Consumption data

4.2.1.1 Criteria for an ideal consumption dataset

The model started with an estimation of baseline consumption. Consumption estimates needed to be stratified by demographic factors of interest to stakeholders and/or critical to the harm outcomes (age, sex, drinker group, wealth/income) in order for the model to demonstrate impact for population subgroups. Administrative datasets do not provide this information, providing only aggregate sales volume and revenue, therefore alcohol surveys were used.

There were a number of criteria, in addition to demographic stratification, which made for an ideal consumption survey dataset. It should have high response rates and be drawn from a large nationally representative sample in order to provide face validity and sufficient observations for all subgroups of interest. It should capture as much of the alcohol consumption as possible, known as coverage. 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. The survey dataset should include peak as well as mean consumption due to the epidemiological link with stakeholder priority outcomes (intentional injury and road injury). Finally, in order to increase its credibility and contextual relevance for South Africa, it should include a measure which allows estimation of unrecorded alcohol, of which the major source is attributed to homebrew (Van Walbeek and Blecher, 2014).

4.2.1.2 Scoping and appraising consumption datasets in relation to these criteria

Alcohol surveys vary in the way they collect consumption data. Some use multiple choice quantity/frequency questions others ask respondents to recall consumption in a specific time period such as the previous week, or each day of the previous week. Quantity/frequency questions can underestimate a drinker's consumption whereas recall tends to lead to better coverage, allows for estimation of peak consumption and provides more accurate estimates of unrecorded consumption (Stockwell et al., 2004). 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. Ideally a combination of recall and quantity/frequency should be used (Stockwell et al., 2004).

I explored four surveys informed by local stakeholders and scoping of the literature (Probst et al., 2017), choosing ones that were more recent in order to ensure face validity for stakeholders. The questions used for eliciting consumption varied (Table 4.2). SADHS used a combination of recall and some quantity/frequency measures as well as asking about homebrew. National Income Dynamic Study (NiDS) uses only quantity/frequency questions. The All Media and Product Survey (AMPS) uses seven day recall and focuses on the different brands of alcohol consumed. The IAC is unique in the level of detail it requires, asking quantity/frequency questions but including container size, drink type and drinking locations.

Table 4.2: Survey questions

Survey	Alcohol questions [Possible responses]
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 liquor (Advocaat, Baileys etc), beer, sorghum beer, wine, fortified wine, white spirits, brandy, whisky, rum, other spirits.
International Alcohol Control Study 2014/15	How often do you usually drink alcohol? (repeated for 16 different locations) [2 or more times, 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]

To appraise these surveys further I obtained the datasets and computed summary statistics including prevalence of drinking, total litres of alcohol per capita, and total litres of alcohol per drinker. Calculating litres per drinker allowed easier comparison with the IAC data which was a survey of drinkers so did not include any abstainers (Table 4.3). For the SADHS figures I started by producing estimates based only on the seven day recall data. In the table I also include data from Euromonitor (a market research company) and the WHO Global Information System on alcohol and health (GISAH) which bases estimates on a range of government and industry sources.

The prevalence of drinking amongst women is far higher in the AMPS data compared to NiDS, SADHS and GISAH. This data was collected in four metropolitan areas; Cape Town, Durban, Johannesburg, and Pretoria which are likely to be systematically different to rural areas. This survey therefore lacks the ability to be nationally representative. The IAC survey has a similar problem as it is a small survey drawn from one locality and not including abstainers, so if it were used a number of assumptions would still be required relating to prevalence amongst different subgroups. These assumptions would need to be drawn from other datasets.

Table 4.3 also highlights the significant gap between market research data and estimates from survey data. Euromonitor data estimates recorded per capita alcohol consumption in South Africa at 7.1 litres for 2016, listing over 100 sources including press, government and company data. The GISAH produce the same estimate for recorded alcohol (their 9.3 estimate includes unrecorded alcohol) and lists many of the same sources including the South African Wine Industry Information and Systems (SAWIS) 2000-2016. The surveys significantly underestimate consumption (NiDs provides the worst coverage estimating 1.3 litres per capita as opposed to Euromonitor 7.1) this has been found to be universal across South African alcohol surveys (Probst et al., 2017), and is an international problem although to varying magnitudes, this was later accounted for in the model.

Table 4.3: Summary of four surveys and two other data sources

	Year	Sample size	Response rate	Prevalence of drinking		Sample size: drinkers	Annual litres of alcohol - per capita			Annual litres of alcohol - Just drinkers		
Survey				Female	Male		Total	Female	Male	Total	Female	Male
SADHS (7 day recall only) Population weights applied	2016	n = 10,333 females = 6126 males = 4210	81.3%	9.3%	32.7%	n = 1949 (report drinks in the 7 day recall) females = 571 males = 1378	2.2	0.65	4.5	10.6	6.54	12.2
NiDS (one wave of panel survey) (quantity * frequency) Population weights applied	2014/ 15	n = 26,804 females = 13278 males = 9445 (NAs = 4195)	65%	17%	45%	n = 6416	1.3	0.4	2.2	3.96	2.22	4.78
AMPS (7 day recall) Population weights applied	2015	n = 25,584 females = 12,829 males = 12,755	not reported	37%	54%	n = 11,062	3.89	2.4	5.5	9.09	7.4	10.2
IAC (a survey of drinkers)	2014	n = 949 females = 354 males = 595	78%	NA	NA	n = 949	NA	NA	NA	15.32	8.87	19.2
Other data sources												
Euromonitor	2016	-	-	-	-		7.1	-	-	-	-	-
GISAH (Global status report on alcohol and health WHO)	2016	-	-	19.4%*	43.2%*		9.3	2.7	16.2	29.9	13.7	37.5

* The GISAH estimates of the prevalence of drinking come from two sources: The South African National Health and Nutrition Examination Survey (2011/12) and the South African national HIV prevalence, incidence and behaviour study 2012.

Surveys inform not only prevalence and total per capita consumption but also the distribution of volume consumed amongst drinkers. Density plots were computed for each of the survey datasets and for the WHO GISAH data (World Health Organisation, 2021) (Figures 4.3 and 4.4). The GISAH only provide a mean which I combined with assumptions relating the mean to the standard deviation and the assumption that the distribution of drinkers follows a gamma distribution, as stated in the international alcohol modelling literature (Chisholm et al., 2018, Kehoe et al., 2012).

Figures 4.3 and 4.4 demonstrate drinking is left skewed (there are a higher number of moderate drinkers than heavy drinkers) with a long tail, more sharply for women than for men. The NiDS data (which uses quantity/frequency questions) has the highest left peak indicating there is a higher proportion of low level drinkers. You can also see, strongly for the women, that the NiDS distribution has peaks corresponding to the limited choices given to respondents. The AMPS and SADHS datasets (that use 7 day recall, although SADHS asks for each specific day and AMPS asks for a weekly figure) are relatively similar for both men and women and have a lower and wider peak. This is consistent with expectations as seven day recall is likely to capture regular drinkers and abstainers well but not infrequent drinkers.

The GISAH data (which applies a gamma distribution to a per capita consumption mean) appears to estimate a relatively lower number of lighter drinkers and higher proportion of heavy drinkers, compared with the four surveys. Once drinking reaches 25 litres for men and 10 litres for women the GISAH gamma distribution is higher than all other surveys. The gamma distribution suggests a higher mean level of drinking, this is achieved through a larger number of heavy drinkers, rather than large numbers of drinkers somewhere in the middle. The IAC data is based on a small sample in one locality. For men the IAC data most closely approximates the GISAH whereas for women it is far more left skewed with most of the women drinking at lower levels.

Figure 4.3: Comparing the distribution of female drinkers in South Africa

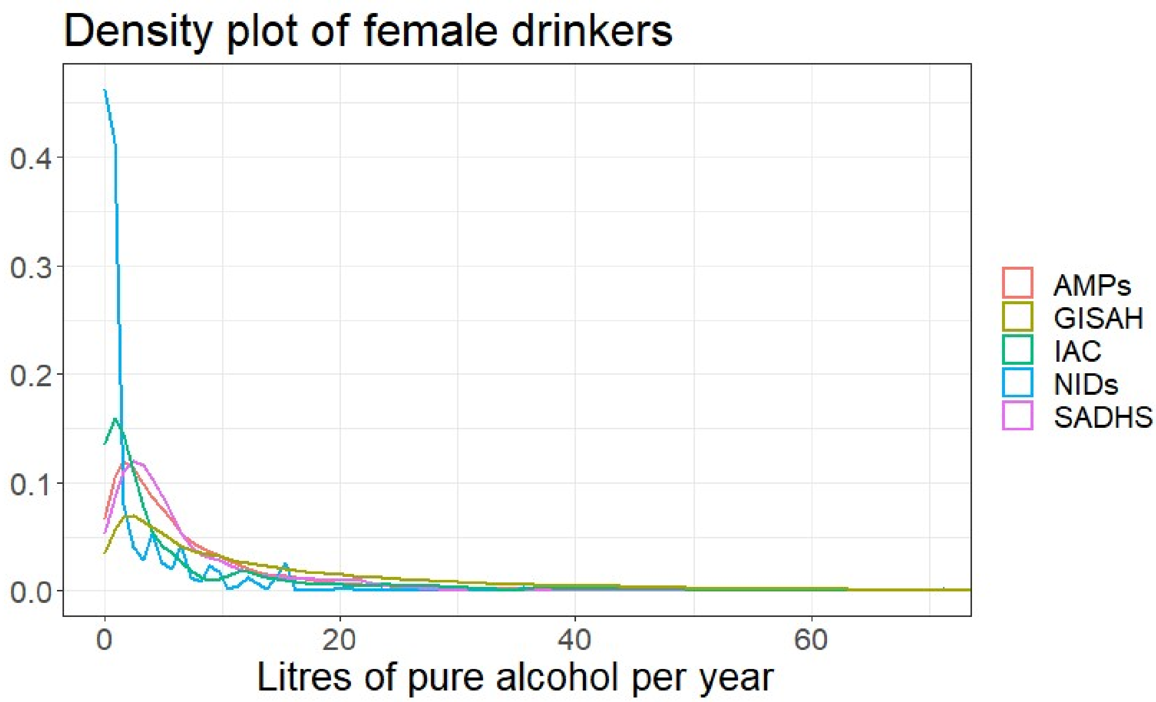
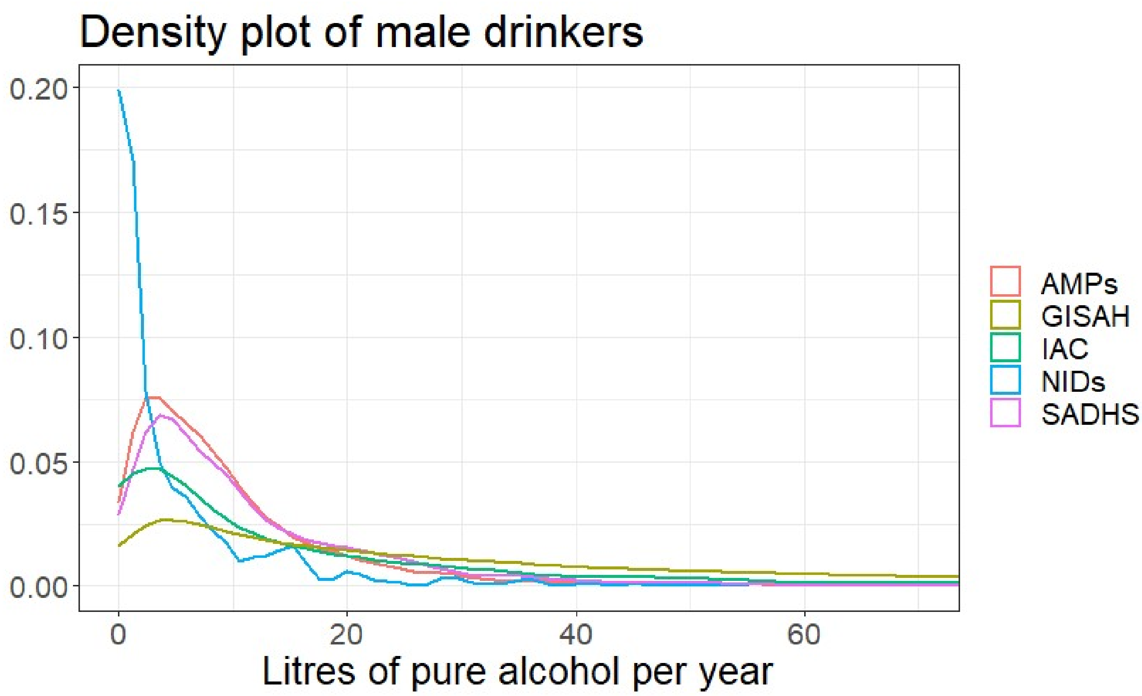


Figure 4.4: Comparing the distribution of male drinkers in South Africa



Using all of the information gained during the scoping of these survey datasets I assessed the strengths and weaknesses against the ideal criteria and chose the SADHS dataset to inform baseline consumption (Table 4.4).

Table 4.4: Summary of strengths and weaknesses of potential datasets

Dataset	Strengths	Weaknesses
SADHS (7 day recall)	National coverage Includes peak drinking Includes homebrew Good response rate Most recent	Excludes a large number of people who claim to be drinkers
IAC	Provides detailed data on prices Highest consumption estimates – may capture drinking better	Sample size too small to cover equity relevant groups One locality
AMPS	Large sample size	Only covers four cities 7 day recall will not capture occasional drinkers well No homebrew Prevalence of drinking amongst women high compared with all other surveys, suggesting systematic difference in sample
NiDS	National coverage Large sample of drinkers	Does not capture homebrew Low response rate Very low coverage

One weakness of the SADHS estimates, using seven day recall, was the exclusion of a large number of people who had reported drinking infrequently, resulting in low prevalence particularly for women. As the survey asked additional questions of frequency and peak drinking I decided to combine these data as described in the following subsections, thereby utilising the strengths of recall and quantity/frequency as recommended in the literature (Stockwell et al., 2004).

4.2.1.3 Adjusting SADHS consumption estimates

In order to capture the infrequent drinkers I combined the seven day recall data with the frequency of drinking occasion data, and the question of whether the respondent has drunk 5 or more at least once in the last month. Drinkers were categorised by their drinking frequency and by whether or not they had reported drinking in the last seven days (Table 4.5).

Table 4.5: Survey respondents by category

Drinking occasion frequency	Count	Reported drinks in last 7 days	Reported zero drinks in last 7 days
5 or more days a week	293	*266*	27 (6 binge, 21 drinker)
1-4 days per week	668	*565*	103 (29 binge, 74 drinker)
1-3 days per month	1,163	799	364 (all drinkers)
less often than once a month	1,187	404	783 (all drinkers)
NA	7,025		

The single underlined numbers are respondents who say they only drink 1 -3 days per month or less often than once a month but have drunk in the last 7 days. If this were multiplied by 52 it would be an overestimate. Therefore, I assumed for those that drink 1-3 days per month we have captured their one drinking week in the month and multiply by 12 to get their annual consumption. There are 799 people in this category. I assumed for those who drink less often than once a month but who did drink in the last week we have caught their one drinking week that occurs every two months. I multiplied by six, to get the annual figure. There are 404 people in this category. The numbers in italics do not require adjustment as respondents report drinking every week and have a seven day drinking pattern.

For all those who did report a drinking frequency but who did not report drinking in the last seven days the following adjustments were made. For those with a drink frequency of five or more days per week I used the mean standard drinks for drinkers who reported the same frequency but who do have a seven day pattern, there are 27 people that this applies to (dashed underlined).

For those with a drink frequency of 1 – 4 days per week I used the mean standard drinks for drinkers who report the same frequency but who do have a seven day pattern, there are 103 people in this group (dashed underlined).

For those with a drink frequency of 1 – 3 days per month I used the mean annual drinks of the equivalent frequency group who did report a drinking pattern. There are 364 drinkers in this group (double underlined).

For those with a drink frequency of less than once per month I used the mean adjusted annual drinks (adjusted above) of the equivalent frequency group who did report a drinking pattern. There are 783 people in this group (double underlined).

All of these adjustments were computed for subgroups based on sex and binge drinking.

Using the same process as above I applied a peak drink to those observations without one. As an additional check I validated that all those reporting binge drinking had a peak drink at minimum of 5. Comparing the adjusted SADHS data with the estimates using only 7 day recall as expected prevalence of drinking increases and per capita estimates reduce (Table 4.6). The prevalence estimates are now broadly similar to the NiDs and GISAH estimates (Table 4.3).

Table 4.6: Comparing 7 day recall with the adjusted figures

	Prevalence of drinking		**Sample size: drinkers**	**Annual litres of alcohol - per capita**			**Annual litres of alcohol - Just drinkers**		
	Female	Male		Total	Female	Male	Total	Female	Male
SADHS (7 day recall only) Population weights applied	9.3%	32.7%	n = 1949 (report drinks in the 7 day recall) females = 571 males = 1378	2.2	0.65	4.5	10.6	6.54	12.2
SADHS adjusted (7 day recall plus adjustments based on frequency questions) Population weights applied	18%	54%	n = 3311 females = 1125 males = 2186	1.65	0.50	3.4	5.0	2.59	6.25

The density plots demonstrate how incorporating the frequency data into the seven day recall moves the distribution towards the left (Figure 4.5 and 4.6). This is consistent with expectations as the sample will now include those drinkers who stated that they drink but did not record any for the last seven days, it also adjusted down those who report drinking less than weekly but who did recall drinks for the last seven days.

Figure 4.5: SADHS density plot before and after adjustment

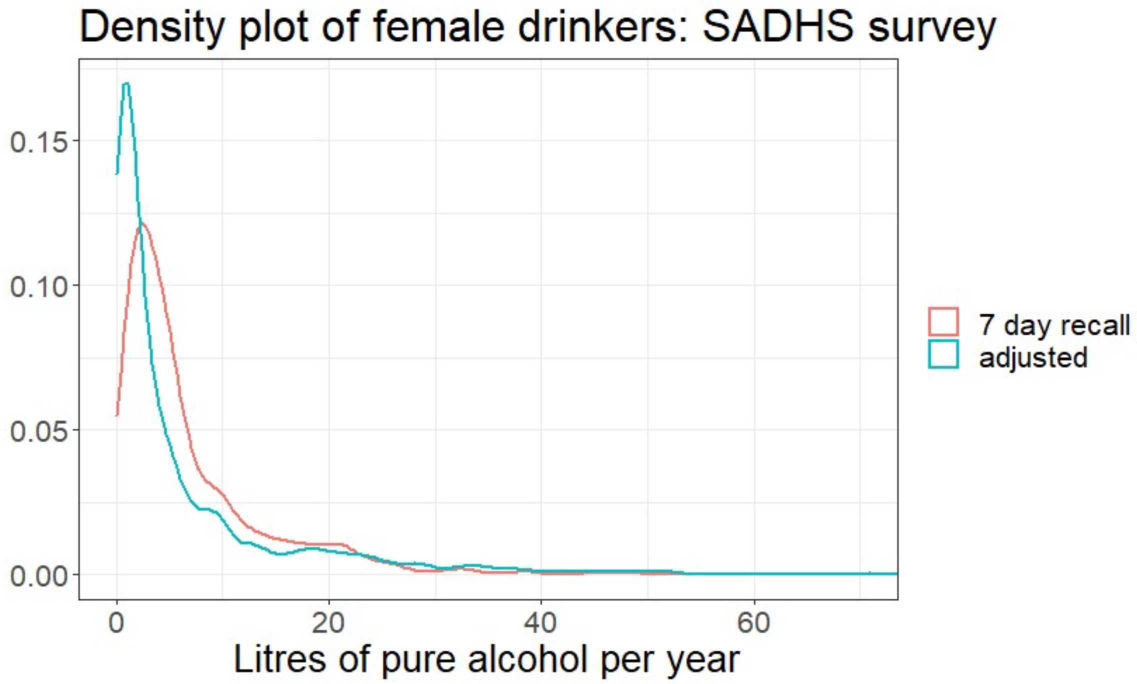
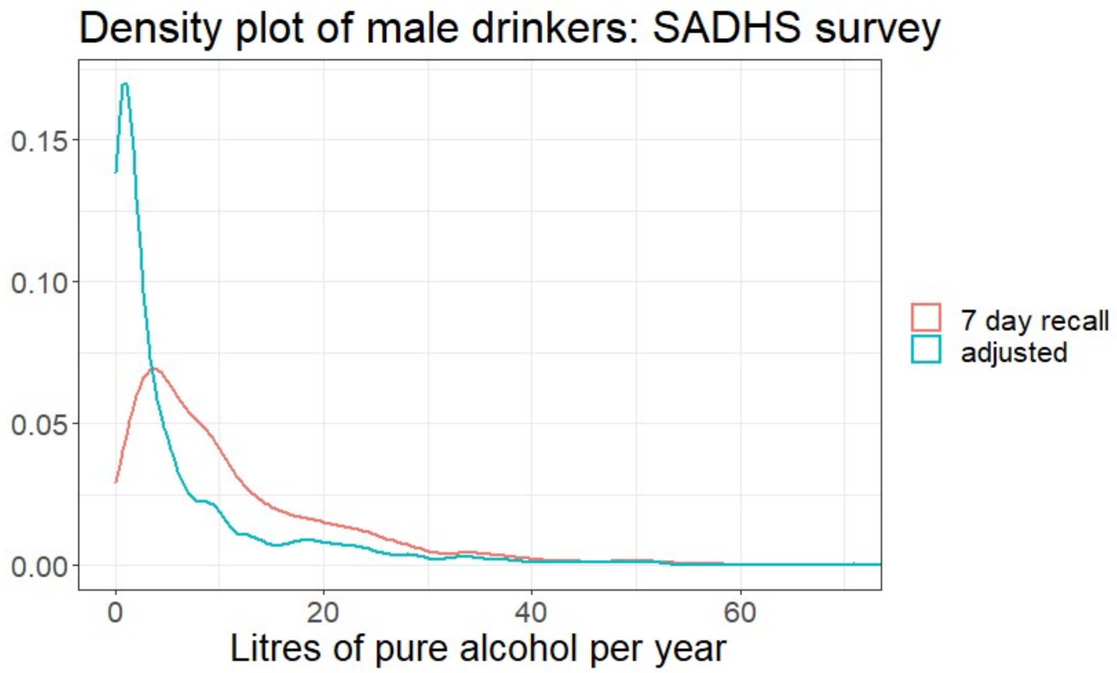


Figure 4.6: SADHS density plot before and after adjustment



SADHS uses population weights to create a nationally representative population for 2016. These weights were increased so the survey represents the 2018 population which is the base for the model, I assumed that there were no significant changes to the age sex structure of the population in the interim.

4.2.1.4 Upshifting mean consumption

Surveys provide important data about drinking patterns within the population but total consumption estimates are far smaller than that indicated by administrative sources (Probst et al., 2017). As this is a global phenomenon there are established statistical calibration methods in the academic literature. The steps are broadly as follows:

- compute the ratio between survey and sales per capita consumption (known as coverage)
- use this ratio to adjust the mean for each subpopulation of interest
- use the new mean to estimate an associated standard deviation based on a published relationship, estimated using a large global dataset and the following equation (Rehm et al., 2010b):

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

- use the new mean and standard deviation to generate the shape and rate parameters and fit a gamma distribution

This method relies on three assumptions. Firstly that the sales data accurately reflects per capita consumption. Secondly, that the true proportion of abstainers has been captured by the survey, and finally that under-estimation of consumption is the same across all population groups.
Two additional key limitations have been identified with regards to this method. Firstly, there is no empirical evidence that under-coverage is distributed as implied by the shifts needed to fit the adjusted consumption to the gamma. Secondly, that shifting consumption to a gamma can artificially reduce the long tail of heavy drinkers (Meier et al., 2013). To address the second point a proposed method is to fit a gamma distribution to the original survey then for each percentile of the distribution calculate the percentage consumption increase (between the original and the gamma shifted distributions) and apply these percentage shifts to the corresponding percentile of the survey data.

The following steps outline, in detail, how I calibrated the SADHS dataset to Euromonitor figures:

- First a cap was applied to all drinkers of 68 litres of alcohol per year or 150 grams of alcohol per day. As the model includes long term effects (20 years) the cap is needed as a higher level of alcohol cannot be sustained in the long term (Gmel et al., 2013). This cap impacted one woman and ten men. Of this small group only two men drunk both homebrew and recorded alcohol and so their total consumption was reduced to 68 litres and then split into recorded and homebrew using their previous percentage split.

- Survey coverage level was calculated as the difference between total per capita consumption recorded in the SADHS survey and per capita consumption using Euromonitor recorded sales data for 2018. 80% of the sales data is used to account for spillage, stockpiling and tourist consumption. This sales figure was then increased to take account of the 4.15% of total alcohol consumed in the SADHS survey reported as homebrew (representing unrecorded alcohol in the model). The comparison of total consumption according to the survey and the adjusted official sales data was used to calculate a coverage of 27%.

- For female and male subgroups the mean litres of alcohol was adjusted by the multiplication factor. This adjusted mean was used to estimate an associated standard deviation based on the established relationship between the two outlined above. These were then used to fit a "shifted" gamma distribution (maintaining the cap of 68 litres), calculated for male and females separately.

- A gamma distribution was fitted to the original sample of drinkers, by sex, and percentiles were taken across this and the shifted distribution. Percentage differences in consumption were calculated. These increases were then applied to the percentiles of the original survey sample.

- Each individual's total consumption was split into homebrew and recorded alcohol using the original percentage split (this assumes underreporting is equal across homebrew and recorded alcohol).

- Results were compared visually and via a table (Table 4.7 and Figures 4.7 and 4.8). There is a small difference between the two methods, more visible for males than females. It appears adjusting by percentiles only makes a difference at the extremes, lowering the left hand peak slightly but also falling below the Gamma shifted distribution after 60 litres of alcohol per year for men meaning there is a smaller number of the very high drinkers.

The percentile adjusted distribution was used for the main model based on expert opinion.

Table 4.7: Key statistics for the gamma shift

Females – litres of alcohol per year	Mean	Min	Max
SADHS Survey data (weighted mean and capped)	2.57	0.09	68
Gamma fitted to survey (difference due to weights)	2.50	0.09	68
Gamma shift	10.78	1	68
Adjusting each percentile (weighted mean)	10.74	0.5	68
Males – litres of alcohol per year			
SADHS Survey data (weighted mean and capped)	6.13	0.09	68
Gamma fitted to survey (difference due to weights)	5.6	0.09	68
Gamma distribution shifted	18.55	1	68
Adjusting each percentile (weighted mean)	19.2	0.5	68

Figure 4.7: Comparing distributions pre and post shift females

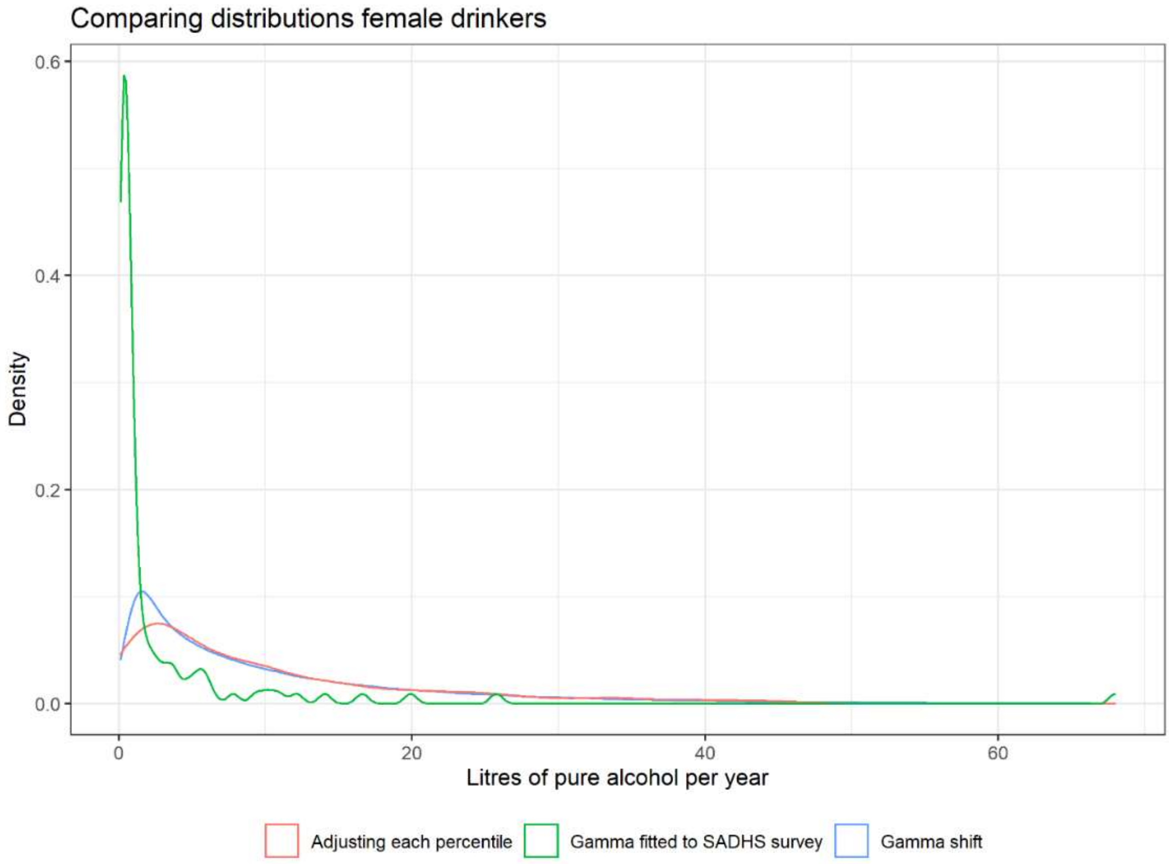
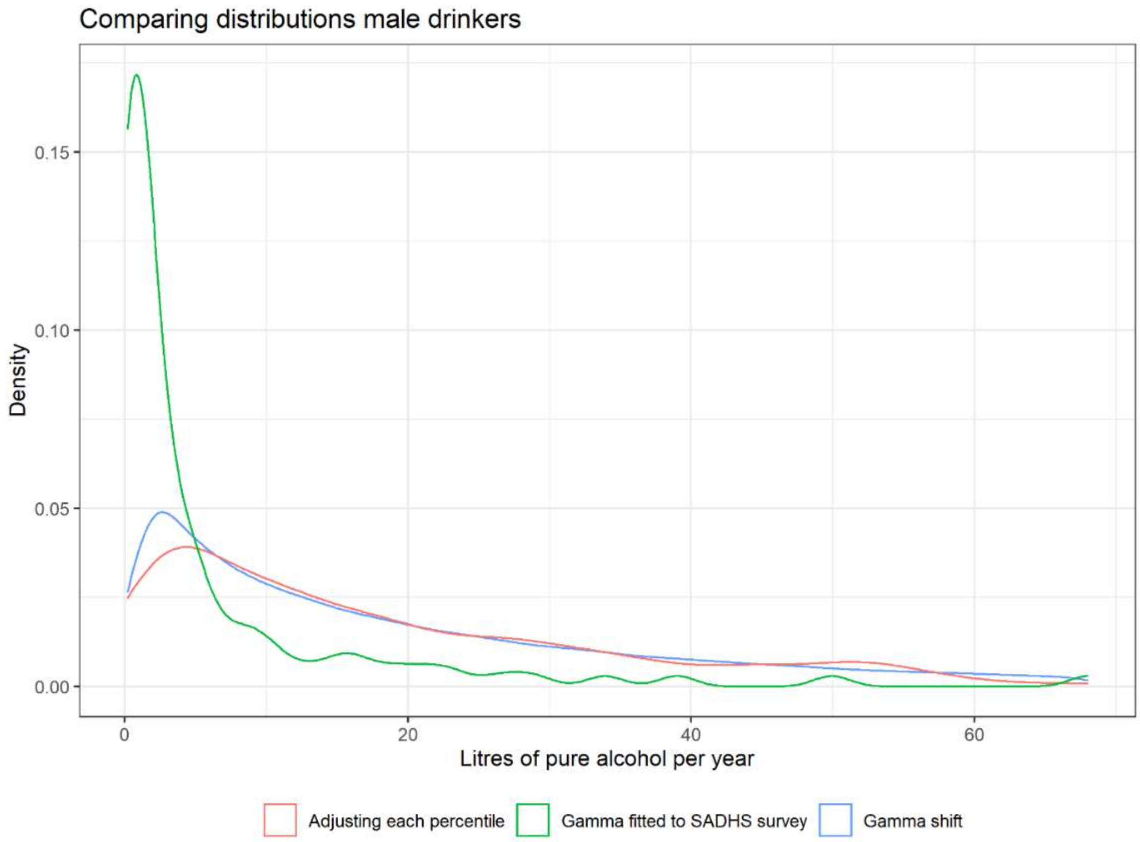


Figure 4.8 Comparing distributions pre and post shift males



4.2.1.5 Upshifting peak consumption

Peak drinking measures the highest number of drinks consumed on a single drinking occasion and therefore relates to intoxication which is associated with harms such as road injury, interpersonal violence and self-harm. Following the method used in the Sheffield Alcohol Policy Model (Brennan et al., 2015), a linear regression model was fitted, for all drinkers, to the non-shifted SADHS data, relating peak drinking to mean consumption (β_0), age and sex, using the following equation:

$$peak_{\ ij}(SADHS) = \beta_0 + \ \beta_1 \times ageband + \ \beta_2 \ \times sex$$

The model was used to compute fitted values for the non-shifted data. The model assumes there is a linear relationship between peak and mean consumption, the magnitude of which is allowed to vary by age and sex.

After the mean consumption was shifted as above the corresponding new peak consumption was computed using the following equation:

$$peak_{\ ij}(shifted) = \text{peak}_{ij}\ (SADHS) \times \left(\frac{E(peak_{ij}(shifted))}{E(peak_{ij}(SADHS))}\right)$$

The linear relationship between mean and peak estimated from the SADHS survey is maintained for the shifted mean and peak consumption, this assumes individuals under reported peak and mean consumption by the same magnitude. The method also assumes the prediction error for the model is of the same magnitude for all levels of consumption.

The predictions were checked to ensure that peak estimates were not below mean daily drinking. There were 88 people (out of the 3311 drinkers) for whom this was true. These people had their peak drinking increased to match their mean daily drinking.

4.2.1.6 Defining drinker groups for the model

Drinkers are categorised by how much they consume on average and whether they binge drink. Binge drinking defined as five or more standard drinks on a single occasion. A standard drink in South Africa is 15 ml or 12 grams of pure ethanol. Defining drinker groups is important as it will relate to the prices paid, consumer demand behaviour (i.e. price elasticities) and the harm experienced. The initial plan was to follow the three categories used by South African academics to estimate price elasticities in a report on minimum pricing in the Western Cape (Van Walbeek and Chelwa, 2019).

- **Heavy drinkers**: Drinks three times a week or more, drinks two or more standard drinks per session
- **Occasional binge drinkers**: Drinks twice a week or less but drinks five or more standard drinks per session
- **Moderate drinkers**: All other drinkers

However, by the time of the second stakeholder workshop the authors had revised their definitions. The authors attended my workshop and passed on their latest refinements to the definitions. They were concerned that "heavy drinkers" include both committed binge drinkers as well as those that drink just two drinks three times a week. They shared with me their revised definitions which were as follows:

- **Moderate drinkers**: Drink one or two standard drinks on a typical drinking day
- **Intermediate drinkers**: Drink three or four standard drinks on a typical drinking day
- **Occasional heavy drinkers**: Drink five or more drinks on two or less days per week
- **Regular heavy drinkers**: Drink five of more drinks on three or more days per week

I looked at many different ways to redefine the categories after this. SADHS data is different to NiDS data (used by Van Walbeek and Chelwa) as it contains frequency and recall questions, allowing the calculation of mean and peak drinking. One option I explored was to select those who drink 15 or more and then split into binge (heavy) and not binge (intermediate) and those who drink under 15 split them into binge (occ_binge) and not binge (mod). However, the sample size for intermediate was simply too small, only 21 observations.

As the intermediate category was so small I decided to move all intermediate drinkers into the heavy category and redefine the categories in the following way:

- **Heavy**: 15 standard drinks or more per week (95% of these are also binge drinkers)
- **Occasional binge**: Less than 15 standard drinks per week but binge drinks
- **Moderate**: Less than 15 standard drinks per week, does not binge

To validate this choice I checked the proportion of heavy drinkers who also binge drink, this was 95% of people in the category, which reinforces the decision. After shifting the SADHS consumption, to calibrate with market research data, proportions of drinkers in each category were recalculated. Many of the drinkers moved to heavier drinkers as expected (Table 4.8). The heavy drinking group was checked to see if there was now a disproportionate amount of non-binge drinkers in the category. It had changed but only slightly, 92% of the heavy drinkers were also binge drinkers.

Table 4.8: Proportions of drinkers in each drinker category

	Abstainer	Moderate	Occasional Binge	Heavy
Males	46%	27%	18%	9%
Males after shift	46%	17%	7%	31%
Females	82%	14%	4%	1%
Females after shift	82%	10%	2%	6%

4.2.2 Pricing data

4.2.2.1 Criteria for an ideal pricing dataset

I needed price distribution data to inform modelling of how price distributions would change in response to a new minimum price. This enables adjustment of all those prices currently below the minimum unit price, up to the floor price, and a subsequent recalculation of the mean price. A large nationally representative set of accurate transaction level purchasing data would be ideal. Unfortunately, this was not available so survey data was again explored.

I required a survey that would enable me to calculate price paid per standard drink, i.e. it reported the exact amount (ml) and type of alcohol (strength) that had been purchased and at what price. Coupled with this I needed the survey to provide mean and peak drinking in order to match the price distributions with the associated drinker group from the SADHS survey. Finally the survey must also provide demographic data which enabled me to model prices paid by different wealth groups, a subgroup of interest to stakeholders and correlated with baseline harm. It would also be preferable to have a large sample size and good geographical coverage.

4.2.2.2 Scoping and appraising the pricing datasets in relation to these criteria

Three potential surveys, identified through scoping the literature and stakeholder engagement, were explored. These were the National Income Dynamic Study (NiDS) 2014/2015, the Income and Expenditure Survey (IES) 2010/2011 and the IAC 2014/15.

The NiDS survey asked for total monthly spend on alcohol alongside individual quantity/frequency consumption questions, this does not provide real prices but rather average values per household, not individual. The Income and Expenditure Survey (IES) 2010/2011 (intended to be updated every five years but unavailable for more recent years) does provide prices for various drinks both on- and off-trade but does not capture drinking behaviour.

The IAC study 2014/2015, completed in the metropolitan district of Tshwane, asked for highly detailed pricing data in both on- and off-trade locations taking into account container size, drink type and number of drinks purchased. For example, they ask for the price and container size and frequency of beer purchased at a supermarket and drunk at home (or at someone else's home, or work, or car, or outdoors). Drinking patterns, both mean and peak, and demographic data was also captured. Although there are limitations to this dataset (lack of geographical coverage and small sample size) on balance it met with more of my criteria than the other two options.

4.2.2.3 Adjusting the IAC price estimates

Due to the small sample size and limited geographical location I sought additional data sources with which to validate the IAC prices. These were: pricing data from the Consumer Price Index (CPI) (provided by a South African health economist stakeholder); data from a report by SAWIS (provided by a South African alcohol expert stakeholder); and stakeholder engagement both at the second workshop and via email.

4.2.2.3.1 Validating prices using CPI data

Firstly I used data from the CPI to validate prices. The CPI prices are collected from liquor stores and supermarkets i.e. off-trade only. The dataset provided monthly prices from January 2017 to July 2020. There were 67,863 price observations in total. Although this data gives no indication of the volumes bought at each price it can helpfully indicate reasonable minimum, maximum, and mean off-trade price by drink type. Comparing the reported off-trade prices and the IAC prices shows that the IAC data does align overall although it has not captured the expensive beer or spirits (Table 4.9). I have been unable to access a similar dataset for on-trade prices.

Table 4.9: Consumer Price Index data

	Min price per SD* CPI prices (IAC prices inflated to 2018)	**Mean price per SD* CPI prices (unweighted mean IAC prices inflated to 2018)**	**Max price per SD* CPI prices (IAC prices inflated to 2018)**
Beer	R4** (R4.9)	R9.82 (R8.11)	R134.9 (R15.9)
Cider	R4.45 (R4.18)	R11.5 (R12.6)	R43.7 (R55.7)
Liqueur	R2.33 (none)	R7.31 (none)	R19.2 (none)
Spirits	R1.76 (R1.65)	R7.59 (R8.72)	R202.3 (R28.5)
Wine	R2.50 (R2.50)	R8.88 (R7.85)	R54.2 (R51)

*** SD = standard drink 15ml or 12 grams of pure ethanol**

****The lowest single price observation for beer was actually R1.97 but this price was an anomaly, the next lowest was R4 which was common**

4.2.2.3.2 Validating prices using the South Africa Wine Industry Information and Systems (SAWIS)

The wine industry publish estimates of South African alcohol sales by volume and include some limited pricing data relating only to wine. (SA Wine Industry Information and Systems, 2019). The proportional market shares indicate that the IAC data underrepresents wine and overestimates beer (Table 4.10). I considered adjusting the weightings of different drink types but this would impact the amount people drunk which was crucial to generating price distributions by drinker groups. Any adjustment between the proportions of wine drunk and the proportions of beer/wine/spirits risked distorting the data. The underrepresentation of wine as a proportion of all alcohol consumed is acknowledged as a weakness.

Table 4.10: Wine industry market share data compared with IAC share

	SAWIS 2018 market share based on alcohol content	**IAC % share**
Wine	17.1%	6%
RTDs	8.8%	11%*
Beer	55.5%	74%
Spirits	18.6%	10%
*** includes cider**		

SAWIS also reported the proportion of still wine sold in the off-trade in 2018 that falls within different price bands (still wine accounts for 93% of the total volume of wine). These data were used to adjust the price of off-trade wine downwards (Table 4.11). Taking the lowest price category (<R30) as an example, the price observations were sorted in ascending order and a cumulative volume variable created. The price closest to the 49th percentile was then adjusted down to R3.74 and all prices below adjusted using the same proportion. The same adjustment process was applied to each of the other four groups.

Table 4.11: Wine prices from SAWIS data

Retail price per litre of wine for 2018	**Price per standard drink (15ml) assuming 12% abv**	**Cumulative percentage of total still wine sold at price SAWIS data**	**Cumulative percentage of IAC data for off-trade wine pre-adjustment**	**Cumulative percentage of IAC data for off-trade wine post-adjustment**
Less than R30	Less than R3.75	49%	33%	51%
> R30 – R48	> R3.75 – R6	82%	60%	83%
> R48 - R72	> R6 – R9	89%	77%	89%
> R72 - 108	> R9 – R13.5	95%	89%	95%
> R108	> R13.5	100%	100%	100%

4.2.2.3.3 Validating prices using stakeholder consultation

The mean prices for each drinker group and wealth quintile were checked with the stakeholders at workshop two for face validity. I also contacted a representative from the Khayelitsha community health forum (a large township on the outskirts of Cape Town) to ask what the cheapest price for a R750 ml bottle of beer at a shebeen is. They informed me that the price is generally R15, and the very cheapest would be R13. That converts to R6 (or R5.2 for the cheapest) per standard drink. Comparing this with CPI data implies the cheapest alcohol is not beer sold at shebeens.

I also calculated a number of off-trade prices from a supermarket promotional drinks flyer sent through by a stakeholder. On this flyer the cheapest prices were for boxed wine at R2.41 per standard drink (Also R2.62, R2.90, R3.54) and the next cheapest was beer at R4.55.

4.2.2.3.4 Validating prices by comparing between provinces

As the IAC prices were collected in one locality, I checked them against national data sources. Beer is the most popular drink, accounting for over 50% of the alcohol sold. I accessed data from the South Africa Consumer Price Index for January 2020 to compare the Gauteng province (where Tshwane is located) with other provinces (Table 4.12). The prices given are for supermarkets only.

Table 4.12: Consumer Price Index for South Africa (Statistics South Africa, 2020a)

	Beer 330ml	White Wine 750ml	Red wine 750ml	Whisky 750 ml	Vodka 750ml
Western Cape	R15.33	R75.02	R92.50	R180.40	R162.34
Eastern Cape	R12.85	R53.06	R56.38	R171.30	R128.50
Northern Cape	-	R52.6	R59.21	R211.56	R149.58
Free State	R14.00	R46.37	R55.82	R203.17	R191.86
Kwazulu-Natal	R13.53	R67.48	R89.79	R199.44	R130.53
North West	R12.34	R51.25	R62.33	R186.84	R162.90
Gauteng	R13.76	R51.8	R61.51	R206.02	R158.90
Mpumalanga	R14.03	R42.75	R47.14	R203.01	R157.97
Limpopo	R13.14	56.62	R57.33	R196.41	R162.49

The price of beer in Guateng was R13.76 for a 330ml can. The average across the other eight provinces was R13.66, close to Guateng's price. In the absence of better data it appears not unreasonable to assume the same price distributions across the whole of South Africa.

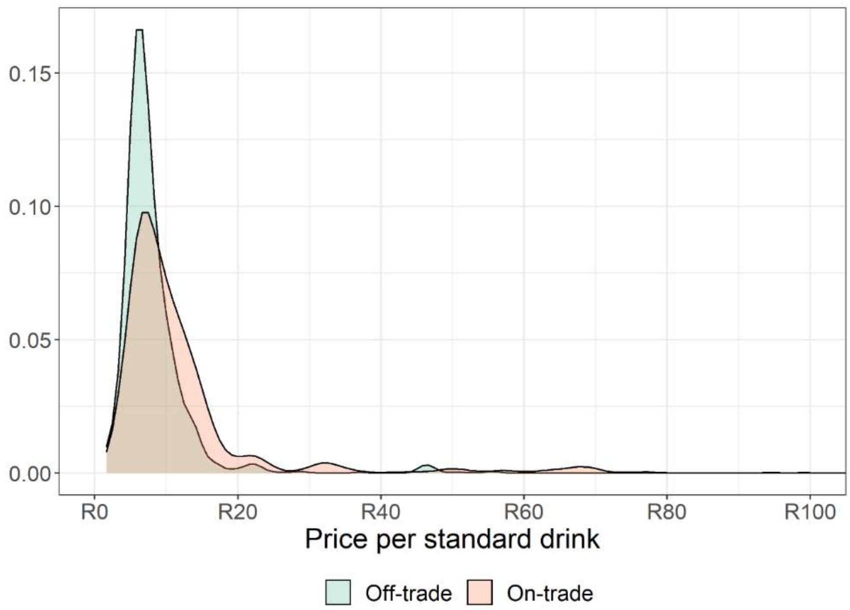
4.2.2.3.5 IAC observations and price distribution

Following data cleaning and adjustment 863 price observations across 556 individuals were obtained (Table 4.13, Figure 4.9).

Table 4.13: Final numbers of price observations

Number of observations in IAC dataset	Off-trade	On-trade
Beer	202	247
Stout	3	6
Low alcohol beer	10	8
Cider	51	106
Wine	80	29
Spirits	64	47
Ready to drinks	7	3
TOTAL	417	446

Figure 4.9: IAC price distribution



In considering the limited number of price points and the focus of the research (estimating differential impact by drinker and wealth groups) I disaggregated prices by population subgroups rather than by drink type (wine/beer/spirits etc). This provided a closer match to the South Africa specific price elasticities which were calculated for drinker groups treating alcohol as a single commodity. The IAC respondents were categorised into drinker groups using the definitions above. Each price was weighted by the number of standard drinks over 6 months calculated using the container size, drink strength and the frequency of purchase variables. Prices were adjusted for inflation to the baseline year of 2018.

At this point I calculated total sales revenue using my preferred price and consumption sources. Total sales revenue was estimated for 2018 at R181 billion which I compared with Euromonitor sales revenue for the same year, 262 billion. My calculations accounted for 70% of the market research estimate. As I had already calibrated consumption to total market research consumption(using the Gamma shift method above) the shortfall must be due to underestimating prices. Either all prices were underestimated or I have failed to capture the more expensive drinks. Table 4.9 shows that the IAC data is missing some of the more expensive off-trade alcohol and it is possible it has also not captured the more expensive on-trade alcohol. This second scenario would likely impact more on wealthier groups, and moderate drinkers, as they tend to pay the higher prices, therefore it is slightly less concerning than if we had underestimated all prices equally, as stakeholders indicated an interest for the heavier drinkers and poorer groups.

4.2.3 Matching wealth quintiles between consumption and pricing datasets

Differential impact by income or wealth is an important aspect of the research. To estimate prices by income/wealth a measure common to both the SADHS dataset and the IAC dataset was needed. The SADHS dataset does not include income but uses a wealth index. This is a measure computed from the ownership of assets (for example: car, fridge, phone) and access to amenities (for example: water, sanitation, electricity). Each individual is given a score, the population is then ranked and split into five equal groups. The IAC dataset does not include the same measure. It does offer incomplete income data alongside a list of ten assets (which are complete), eight of which overlap with the assets in the SADHS data.

In order to match wealth groups between the two datasets an ordered choice model was created using SADHS data with wealth quintile (1 – 5) as the dependent variable, using the MASS package in R (Venables and Ripley, 2002). All the variables that were common across the two datasets were included in the initial model, these were not just asset ownership but also age, sex, educational level and population group (race). Stepwise regression was performed using the "step.AIC" function. This chooses the best variables to include by running the regression with all variables, then taking one out and computing a goodness of fit measure (the AIC). If the goodness of fit measure is improved then that model is preferred, it runs this for many models until it finds the model with the best AIC. This method resulted in the selection of the following variables: age, sex, population group, education level, car, landline, electricity, fridge, computer, radio, tv. The only asset variable it removed was mobile phone which fitted anecdotally with conversations I had with stakeholders in South Africa regarding the extent to which poorer groups prioritise mobile phones. The ordered choice regression model is represented by the following equation:

$$wealthquintile = \beta_0 + \beta_1 car + \beta_2 electricity + \beta_3 tv + \beta_4 fridge + \beta_5 radio + \beta_6 telephone + \beta_7 computer + \beta_8 age + \beta_9 education + \beta_{10} populationgroup$$

The goodness of fit matrix evaluates the success of the model, comparing the closeness of the predicted and observed outcomes (Table 4.14). Although there is estimation error the model does not predict the poorest as the richest or the richest as the poorest.

Table 4.14: Goodness of fit matrix

	Prediction					
		Poorest	Poorer	Middle	Richer	Richest
Actual	Poorest	1300	593	196	9	0
	Poorer	299	975	744	192	17
	Middle	62	612	1042	595	26
	Richer	5	236	763	818	244
	Richest	0	10	108	422	1068

The SADHS dataset has two measures for wealth. The primary measure and then one which adjusts for urban/rural. The primary measure is potentially biased towards urban areas according to the SADHS supporting documentation. A model for the secondary measure of wealth was predicted but it was less successful according to the goodness of fit matrix. It was applied to the IAC data and price distributions visualised which showed a less clear link between wealth and price paid for alcohol. Also crucially the IAC price data were collected from a metropolitan area of Tshwane so there are no rural people in the sample. Therefore using the primary wealth measure appears more consistent in this case.

4.2.4 Estimating base prices by drinker and wealth group

All IAC drinkers were now categorised by drinker group and by wealth quintile (Table 4.15). Wealth quintile was predicted using the ordered choice model. Drinkers in the lowest wealth quintile appear the least likely to drink in moderation leaving a very small sample size (this is not weighted by number of drinks). Consequently, price distributions were not available for three of the 15 categories; moderate drinkers in the bottom three wealth quintiles.

Table 4.15: Count of IAC respondent within each category

	Moderate obs (individuals)	**Occasional Binge obs (individuals)**	**Heavy obs (individuals)**
Poorest	2 (2)	29 (23)	35 (24)
Poorer	8 (8)	23 (18)	28 (20)
Middle	11 (11)	132 (90)	88 (40)
Richer	23 (20)	95 (59)	60 (30)
Richest	93 (68)	135 (93)	101 (50)

The mean price for each of these drinker categories demonstrates there is a wealth gradient for moderate and heavy drinkers (Table 4.16).

Table 4.16: Mean price of standard alcoholic drink (15ml of pure alcohol) for each subgroup

	Moderate	**Occasional Binge**	**Heavy**
Poorest	R6.79	R7.97	R7.78
Poorer	R9.43	R10.0	R9.65
Middle	R10.2	R10.1	R9.23
Richer	R11.3	R26.7	R10.6
Richest	R11.7	R11.1	R12.8

In order to ensure adequate sample size the poorest/poorer/middle and richer/richest categories were aggregated for moderate drinkers and mean price recalculated (Table 4.17). Each of these groups now have a price distribution which was used for the model.

Table 4.17: Mean price of standard alcoholic drink (15ml) within each subgroup

	Moderate	**Occasional Binge**	**Heavy**
Poorest	R9.13	R7.97	R7.78
Poorer	R9.13	R10.0	R9.65
Middle	R9.13	R10.1	R9.23
Richer	R11.6	R26.7	R10.6
Richest	R11.6	R11.1	R12.8

4.2.5 Price elasticities by drinker and wealth group

Two of my academic South African stakeholders had completed recent work estimating South African specific price elasticities (treating alcohol as one commodity) for different drinker groups. They estimated -0.4, -0.22 and -0.18 for moderate, occasional binge and heavy drinkers respectively (Van Walbeek and Chelwa, 2019). Their work was updated with revised drinker categories, including intermediate drinkers, and corresponding elasticities (Van Walbeek and Chelwa, 2021). I mapped my drinker categories as close as the data would allow onto their definitions, this was almost identical for heavy drinkers.

I then adjusted the drinker group elasticities to incorporate an income gradient using -0.86 and -0.5 elasticity for low and high socioeconomic status (Van Walbeek and Blecher, 2014). I counted the bottom two quintiles as low SES and the top three as high (Table 4.18). My baseline elasticities for the model were then sense checked by Professor Van Walbeek a South African expert in the economics of alcohol and tobacco in South Africa.

Table 4.18: Elasticity set used in the ECEA

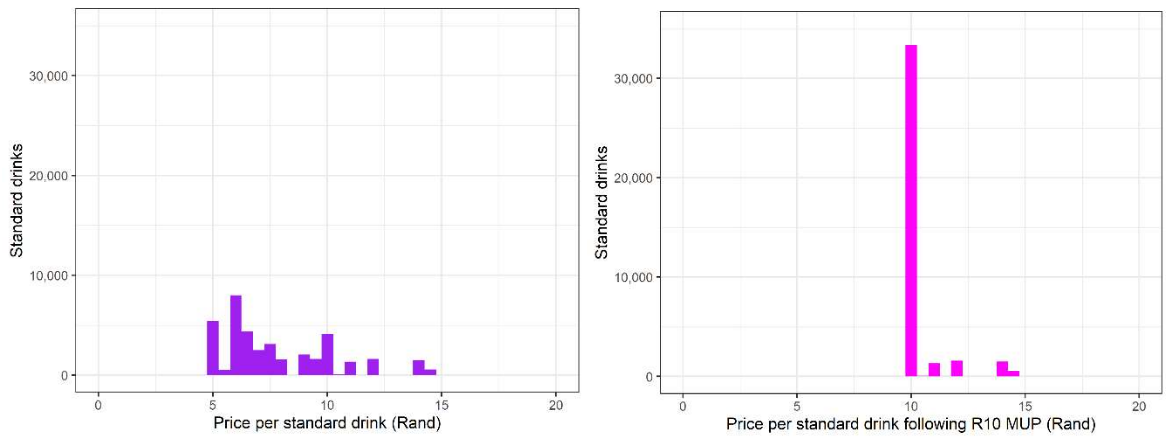
Drinker type	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**
Moderate	-0.53	-0.53	-0.31	-0.31	-0.31
Occasional binge	-0.29	-0.29	-0.17	-0.17	-0.17
Heavy drinkers	-0.24	-0.24	-0.14	-0.14	-0.14

4.3 Price to consumption modelling methods

4.3.1 Modelling the impact of MUP on price distributions

In order to simulate a MUP policy each drinker/wealth subgroup's price distribution was adjusted so that prices below the minimum price where moved up to exactly that price, prices at or above the MUP were unchanged (Figure 4.10). This assumption assumes the industry response is to leave prices above the threshold unchanged, evidence of this was found in Scotland (Stead. M et al., 2020). However, if the price of products above the MUP level also increased then the policy would be more effective, albeit somewhat less targeted as this would affect all drinkers not only those who purchase the cheapest drinks. I ran the model for three MUP levels chosen by stakeholders; R5, R10 and R15. This allowed the calculation of a new mean price and percentage change in mean price for each subgroup. The price change faced by different groups will depend on their purchasing at baseline, for example groups who bought less of their alcohol below the threshold will experience less of a price increase.

Figure 4.10: Impact of R10 MUP on price distribution faced by heavy drinking poor



4.3.2 Modelling the impact of change in price on consumption

The price elasticity for each drinker/wealth group was then applied to the percentage change in price using the following equation:

$$\%\ \text{change in price} \times \text{price elasticity of demand} = \%\ \text{change in consumption}$$

This allowed the calculation of new consumption levels in response to the change in prices created by the MUP policy. This was repeated for each price scenario. The new peak consumption was calculated by applying the peak drinking model, detailed above, to the newly estimated mean consumption.

4.3.3 Modelling a reduced policy impact for homebrew drinkers

After the introduction of a minimum price the literature, and presence of negative price elasticities, suggests there will be a drop in recorded alcohol consumption. At the second workshop stakeholders indicated that people who drink both recorded alcohol and homebrew would switch to more homebrew in the face of a price rise. Therefore homebrew consumption was increased by 30% (elicited from stakeholders in the absence of other data) of the reduction in recorded alcohol consumption, dampening the impact of the policy on homebrew drinkers. The same switching percentage was used for all MUP levels and there were no assumptions made around non homebrew drinkers initiating homebrew after the introduction of the policy.

4.3.4 Modelling alcohol consumption expenditure

The total retail spend at baseline, and each scenario, was computed by adding up all the individual spends multiplied by their population weights. When the SADHS consumption estimates were shifted to calibrate to market research data only 80% of the consumption figure was used (to take account of spillage, stockpiling and consumption by foreign visitors) but the remaining 20% of alcohol consumption needs to be included in the headline sales revenue. Therefore to make it comparable I estimate the total sales revenue by increasing the modelled alcohol consumption revenue by 1.25 (100/80).

4.3.5 Modelling government revenue, Value Added Tax (VAT), excise tax and retail revenue

The following steps outline how I computed government and retail revenue:

1. Calculate VAT by assuming 15% of the retail spend is VAT
2. Calculate total volume consumed of alcohol at all four scenarios (baseline/R5/R10/R15)
3. Calculate the percentage change in volume from baseline for each of the three policies
4. Apply the percentage change in volume to base excise tax using 2018 excise figures from the Treasury Budget Report (Treasury, 2020). A fixed ratio between volume and excise tax is assumed.
5. Calculate retail revenue by: spend - vat - excise tax

It is likely this is a lower bound on the excise tax revenue as generally the cheaper alcohol, which this policy targets, generates a lower proportion of excise tax than the more expensive.

4.4 Consumption to harm data inputs

This section, and the next focus, on the consumption to harm part of the model. I start with the data inputs and adjustments before going on to outline the modelling methods used.

4.4.1 Relative risk data

Relative risks were calculated for each of the health outcomes of interest at baseline, and each policy scenario using published international relative risk equations (Shield et al., 2020, Probst et al., 2018a). The same relative risk equations are used for morbidity (or prevalence) and mortality. These published equations estimate HIV risk as a stepped function of mean drinking (varied by socioeconomic status), intentional injuries and road injury as a continuous function of mean drinking (varied by whether the individual binge drinks), liver cirrhosis and breast cancer as a continuous function of mean drinking. For breast cancer the relationship between risk and alcohol consumption is only applied to females (Table 4.19).

The only relative risk equation not taken from Shield et al. (2020) was for HIV as additional South African evidence demonstrated risk differs not only by drinking level but also by socioeconomic status, with the poorer groups more at risk (Probst et al., 2018a). The original research calculated an asset score and split it at the median resulting in just two SES groups, high and low. The SADHS data also provides an asset score which splits the population into five equally sized wealth quintiles. In the model a conservative approach is taken to allocate the bottom two wealth quintiles to the low SES relative risk and the top three to the high SES relative risk.

Table 4.19: Relative risks used in the model

Health Condition	**Relative risk Current drinkers**	**Relative risk former drinkers**	**ICD-10 codes**
HIV	Low SES $RR = 2.99$ if x > 61/49 grams per day (males/females) $RR = 1.94$ if x > 0 $RR = 1$ otherwise Higher SES $RR = 1.54$ if x > 61/49 grams per day (males/females) $RR = 1$ otherwise	RR = 1	B20-24

Intentional Injuries **(self-harm and interpersonal violence)**	Heavy episodic drinkers (HED) $RR = \exp(00199800266267306 \,.\, x + 0.647103242058538)$ Otherwise $RR = \exp(00199800266267306 \,.\, x)$ if x > 0	RR = 1	ICD-10 codes: X60 – Y09 Y35 –36 Y870 Y871
Road Injury **(pedestrian, cyclist, motorcyclist, motor vehicle, other road)**	Heavy episodic drinkers (HED) $RR = \exp(0.00299550897979837 \,.\, x + 0.959350221334602)$ Otherwise $RR = \exp(0.00299550897979837 \,.\, x)$ if x > 0	RR = 1	V01–04, V06, V09–80, V87, V89, V99
Breast Cancer	Females only $RR = \exp(0.01018 \,.\, x)$	RR = 1	C50
Liver	if x <= 1 $1 + x.\exp((\beta_1 + \beta_2) \,.\, \sqrt{\frac{1 + 0.1699981689453125}{100}})$ If x > 1 $\exp((\beta_1 + \beta_2) \,.\, \sqrt{\frac{x + 0.1699981689453125}{100}})$ Female b1 = 2.351821 b2 = 0.9002139 Male b1 = 1.687111 b2 = 1.106413	RR = 3.26 for both females and males	K70, K74
x = grams of alcohol consumed per day among current drinkers HED = defined as drinking 60 grams or more on one drinking occasion ICD = International Classification of Disease			

4.4.2 Baseline health data

The criteria for an ideal dataset for baseline health was for it to be nationally representative, include morbidity and mortality of each of the five included health conditions, be disaggregated by at least age and sex, and provide data for the model baseline year, 2018. The only dataset that met this criteria was the institute for Health Metric and Evaluation's (iHME) Global Burden of Disease (GBD) data. The data provides mortality and prevalence for each of the included health outcomes by sex and single year of age. At the second workshop one stakeholder challenged the use of iHME data citing a letter to the Lancet in 2018 which claimed GBD overestimate HIV deaths for South Africa (Dorrington and Bradshaw, 2018). Nationally produced burden of disease estimates were suggested as an alternative (Pillay-van Wyk et al., 2016). To assess the extent of the differences I compared estimates (Table 4.21).

Table 4.21: Comparing mortality estimates across National and Global Burden of Disease estimates

Health condition	**Second national Burden of disease study for South Africa 2012 (Pillay-van Wyk et al., 2016)** Count of deaths, percentage of total deaths	**GBD estimates** Count of deaths, percentage of total deaths
HIV	153,661, 29.1%	193,635, 33.17%, (2012) 153,281, 28.78% (2018)
Interpersonal violence	18,741, 3.5%	19,910, 3.4%, (2012) 18,792, 3.5% (2018)
Road injuries	17,597, 3.3%	18,500, 3.2%, (2012) 18,649, 3.5% (2018)
Breast cancer	3,962, 0.75%	5,009, 0.86% (2012) 5,302, 1.00% (2018)
Liver Cirrhosis	3,408, 0.64%	1,349, 0.23% (2012) 1,354, 0.25% (2018)

Examining the 2018 GBD estimates (Table 4.21) demonstrates that the latest GBD figures are now broadly in line with national estimates. There would be two major drawbacks to using the national burden of disease study. Firstly, it only covers mortality and not prevalence. Assumptions would need to be made to estimate prevalence. Secondly, it dates back to 2012. Considerable work would be needed projecting the population forward, incorporating changes to the age structure as well as disease trends, all of which would be subject to error. The stakeholder informed me that the next National Burden of Disease Figures would not be available until 2022.

The Lancet letter also noted the discrepancy between estimates from iHME, the Thembisa model and UNAIDs. The Thembisa model is an HIV model developed at the University of Cape Town to evaluate health interventions (Johnson et al., 2017). To investigate further I compared HIV estimates across five data sources which demonstrated a level of concurrence on prevalence but discrepancy on deaths (Table 4.22). The team producing the National Burden of Disease estimates suggest HIV deaths are often misclassified as AIDS indicator causes, such as TB, due to medical doctors reluctance to report HIV on the death certificate or not knowing the HIV status of the patient (Groenewald et al., 2005). Communication with the two researchers responsible for building and maintaining the Thembisa model has further clarified the different methods used to create the estimates. Thembisa estimates the number of deaths on the basis of epidemiological and other assumptions about the development and continuation of the epidemic and treatment and interventions to deal with it. While the National Burden of Disease estimates were derived from national cause-of-death data combined with identifying the 11 or so causes by which HIV/AIDS deaths are likely to be misclassified, and then, by extrapolating the trend of pre-HIV/AIDS deaths and making use of an indicator of the prevalence of HIV, estimate the extent of the misclassified HIV/AIDS deaths.

Table 4.22: Comparing burden of HIV by data source

	Burden of disease study for South Africa 2012	**Statistics south Africa 2018 report**	**UNAIDS 2018**	**GBD 2018**	**Thembisa model**
Prevalence adults 15 - 49	-	18%	20.4%	20%	18.1% (2012) 19% (2018)
People living with HIV	-	7.52 million	7.7 million	7.8 million	6.2 million (2012) 7.1 million (2018)
Aids related deaths	153,661	115,167	71,000	153,281	115,424 (2012) 71,831 (2018)

All the above considered, I decided to use the iHME data given that it is now broadly consistent with the local burden of disease estimates and it more closely aligns with my criteria for a baseline health dataset for the model, specifically it provides age disaggregated data and includes morbidity.

4.4.3 Socioeconomic gradient of ill health data

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. I needed data that provided demographic details, measures of wealth and reports of a broad range of health conditions. The General Household Survey (GHS) had been used previously in the literature to measure socioeconomic gradients (Ataguba et al., 2011) and covered a more comprehensive range of health conditions than the SADHS. No other datasets found through searching or known to stakeholders could provide this information.

I applied my ordered choice regression model computed previously, using SADHS data, to the GHS data to split the survey population into wealth quintiles. The percentage within each wealth quintile with the disease was computed (Table 4.23). Liver cirrhosis was not one of the health conditions included in the survey and breast cancer was not specifically included although the broader category of cancer was.

Table 4.23: Raw count of General Household Survey data 2018

	poorest	**poorer**	**middle**	**richer**	**richest**
15+ raw count (648 NAs)	4966	11462	14396	9633	7630
HIV raw count percentage	395 8%	684 6%	614 4%	155 2%	41 0.5%
Intentional injuries* raw count percentage	11 0.2%	30 0.27%	24 0.18%	11 0.12%	3 0.02%
Road injuries** raw count percentage	7 0.16%	26 0.22%	22 0.16%	32 0.33%	13 0.015%
Cancer raw count percentage	2 0.038%	27 0.12%	41 0.06%	27 0.29%	68 0.8%

nb: percentages within each quintile were calculated incorporating the survey weights

* gunshot wounds; severe trauma due to violence, assault, beating; intentional poisoning; accidental poisoning; fire and burn; crime related injury – left out sports related, disability related and other

** motor vehicle -occupant, motor vehicle – pedestrian, bicycle related

As some of the counts are very small I also searched the literature to see if alternative estimates of socioeconomic gradients of health in South Africa were available in order to validate my estimates or to provide alternative estimates. Ataguba et al. (2011) also used data from the General Household Survey, up to 2008, to explore socioeconomic-related health inequality in South Africa. Another study used data from 21 villages of the Agincourt Health and Socio-Demographic Surveillance System between 2001 and 2013 to demonstrate a significant inverse relationship between wealth and HIV mortality. The same study found injury and non-communicable disease were not found to be significantly associated with wealth (Kabudula et al., 2017). Most recently, in a paper focused on alcohol-attributable mortality, in order to allocate mortality by socioeconomic status, hazard ratios were derived from the Demographic and Surveillance Area data using Cox proportional hazards survival analysis (Probst et al., 2018b). All three sources are compared with my analysis of the GHS data (Table 4.24).

Table 4.24: Comparing estimates for socioeconomic gradients of health

	Direct analysis of GHS survey data (2018) Percentage share of illness	**Ataguba et al. (2011)** **GHS 2008** Percentage share of illness	**Kabudula et al. (2017)** **Agincourt survey** *Mortality only* Percentage share of illness	**Probst et al. (2018b)** **DHS** *Mortality only* Hazard ratios
HIV	Q1 (poorest) – 38% Q2 – 32% Q3 – 20% Q4 – 9% Q5 – 3%	Q1 (poorest) - 23.4% Q2 - 33.2% Q3 – 22.8% Q4 – 14.4% Q5 – 6.2% Standardised concentration index -0.1976 (significant at 1%)	Q1 (poorest) – 25% Q2 – 22% Q3 – 20% Q4 – 18% Q5 – 14% converted from relative risk ratios	Low SES – 4.24 Medium SES – 2.69 High SES - 1

Intentional injury	Q1 – 9% Q2 – 29% Q3 – 26% Q4 – 26% Q5 – 10% Road injury and intentional injury combined	Q1 - 19% Q2 - 22% Q3 - 20% Q4 - 22% Q5 - 18% Proxy by trauma Standardised concentration index -0.0183 (not significant)	Q1 – 20% Q2 – 20% Q3 – 19% Q4 – 20% Q5 – 22% converted from relative risk ratios Proxy by injuries	Low SES – 2.15 Medium SES – 2.02 High SES - 1 Proxy by injuries
Road injury	As above	Proxy by trauma as above	Proxy by injuries as above	Proxy by injuries as above
Liver cirrhosis	Proxy by injuries as above	See note*	Proxy by injuries as above	Low SES – 2.73 Medium SES – 2.07 High SES - 1 Proxy by all causes**
Breast cancer	Q1 – 7% Q2 – 7% Q3 – 22% Q4 – 18% Q5 – 47% (quintile 1 and 2 were combined due to low numbers)	See note*	Q1 (poorest) – 21% Q2 – 21% Q3 – 20% Q4 – 19% Q5 – 18% converted from relative risk ratios Proxy by non-communicable causes see above	Low SES – 2.26 Medium SES – 1.75 High SES - 1 Proxy by all cancer
*Ataguba et al. (2011) covered flu, diarrhoea, trauma, TB, drug abuse, depression, diabetes, high BP, HIV, STDs **Probst et al. (2018b) covered HIV, TB, Pneumonia, Injuries, Diabetes, Ischemic heart disease, Stroke, all cancers and "All causes".				

Research of health inequality in 22 European countries demonstrated that inequalities in alcohol-related deaths (which are dominated by liver disease) are broadly similar to inequalities in injuries (Mackenbach et al., 2008). Therefore the base case will use the same gradient for injuries as for liver cirrhosis. This assumption was sense checked with local alcohol experts (Professor Parry and Professor Matzopolous) who approved the approach.

For the socio economic gradient of HIV there is another option which is to use the HIV positive tests from the SADHS survey, reported at an aggregate level in the SADHS final report for age and sex across the wealth quintiles (Table 4.25). This has the advantage of not requiring wealth quintiles to be predicted from the ordered choice model. However, the SADHS report states that overall only 52% of the women and men eligible for HIV testing were both interviewed and tested and therefore the prevalence estimates may not be generalisable.

Table 4.25: HIV positive tests from the SADHS survey

Percentage HIV positive who were tested as part of the SADHS	**Females 15 - 49**	**Females 50+**	**Males 15 - 49**	**Males 50+**
Q1 (poorest)	0.304	0.173	0.163	0.208
Q2	0.322	0.17	0.174	0.084
Q3	0.29	0.205	0.163	0.092
Q4	0.269	0.106	0.092	0.16
Q5	0.151	0.089	0.123	0.031

In conclusion, I will use the GHS 2018 data for the socioeconomic gradients. At baseline I will apply the percentage shares computed from the 2018 GHS data (Table 4.24, column 2) to split deaths and cases between the five wealth quintiles.

4.4.4 Healthcare cost data

The prevalence of disease/injury at each policy scenario for each year of the model run was multiplied by the proportion who would then go on to receive hospital treatment (Table 4.26) and the relevant hospital cost applied (Table 4.27). The costs taken from the literature were increased by inflation using the CPI where necessary to reach the baseline year of 2018. Future costs were discounted at 5% as recommended by the Department of Health in the guidelines for pharmacoeconomic submissions (Republic of South Africa, 2012). Currently the costs are not split between those paid by the government and those paid for by the individual, this was added into the analysis as part of applying the extended-cost-effectiveness methodology which I outline later in the chapter. For context, in South Africa most of the population use public hospitals where there is a sliding scale of payments depending on income, around 10 – 15% of the population have private insurance.

The below assumptions and data sources were discussed with a health economist based at the SAMRC (Donnela Besada) to ensure face validity. She also uses Health Systems Trust data and relies on literature searching to produce estimates. She shared her latest costing model and the data sources used. This was used to refine my search strategy for costs.

Table 4.26: Estimated multiplier from population prevalence to hospital admission

Condition	**Multiplier (cases in population who go on to receive healthcare treatment)**	**Source**
HIV	0.62	UNAIDS estimates that 62% of people living with HIV in 2018 in South Africa were on treatment (UNAIDS, 2020)
Intentional Injury	0.41	Survey estimating trauma admissions (Matzopoulos et al., 2006) combined with iHME data from the same year to predict multipliers (Appendix 3.1).
Road injury	0.19	Survey estimating trauma admissions (Matzopoulos et al., 2006) combined with iHME data from the same year to predict multipliers (Appendix 3.1).
Liver Cirrhosis	0.5	Paper on liver cirrhosis in sub-Saharan Africa suggests 50% of patients are admitted to hospital with end-stage liver disease (Vento et al., 2018).
Breast Cancer	0.75	A study estimated what proportion of patients present with late stage breast cancer (51%) but not what proportion never receive hospital treatment (Joffe et al., 2018). Therefore an estimate of 0.75 is used.

Table 4.27: Hospital costs and sources

Condition	**Cost per patient**	**Source**
HIV	R 3,318.62 (2017/18)	This is the annual cost. Taken from a systematic literature review of per patient costs of HIV services in South Africa (Meyer-Rath et al., 2019). There are many different levels of treatment, this cost is only for first-line treatment, so this is a lower bound.
Intentional Injury	R58,928 (2013)	This retrospective case note review included 143 violence related emergency hospital admissions from January to March 2013. Average inpatient stay was 9.8 days with treatments including emergency surgery, intensive care and resuscitation beds on admission (Bola et al., 2016).

Road injury	R56,592.17 (2012)	A prospective cohort study followed 100 patients admitted following a Road traffic injury between late 2011 and early 2012 at Edendale Hospital Pietermartizburg (Parkinson et al., 2014).
Liver Cirrhosis	R2,967 (2018)	50% multiplier used above comes from paper suggesting 50% of liver cirrhosis patients get admitted to hospital with end stage liver disease. Treatment for end stage liver disease includes A specific study on liver cirrhosis was not found so general costs have been used from the district health baromenter. Expenditure per patient day equivalent (district hospitals) was R2967 (average taken from across the 9 provinces). This assumes just one patient day. Conservative. (Health Systems Trust, 2020a)
Breast Cancer	Early stage R14,915 Late stage R16,869 (2015)	This retrospective case review included 200 women at a government hospital in South Africa. The average cost is different depending on whether they were diagnosed at an early (56%) or late (44%) stage (Guzha et al., 2020).

4.4.5 Population data

The population data was taken from Statistics South Africa mid-year population reports (Rebublic of South Africa, 2019). I used 2018 and 2019 population data plus projections for 2020 to 2023 (estimated before Covid-19).

4.4.6 Distributing baseline deaths and cases and calculating probabilities

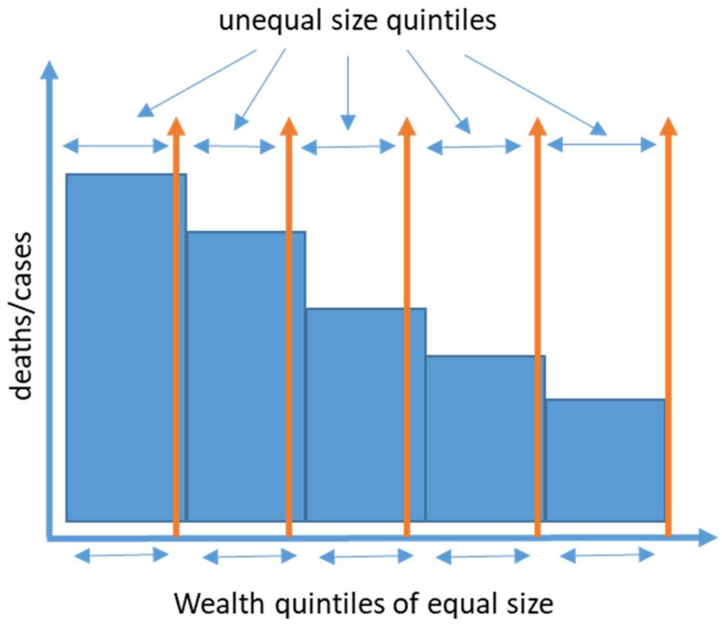
The deaths/cases (which come disaggregated by sex) at baseline were split between the five wealth quintiles using the GHS data to account for the socioeconomic gradient, as explained above. However, a preparatory step was necessary as the proportions of the population (using the SADHS proportions) in each quintile were not perfectly equal, for example Q1, Q2, Q3, Q4, Q5 corresponded to 0.19, 0.19, 0.20, 0.21, 0.21 for females and 0.19, 0.20, 0.21, 0.20, 0.21 for males. The probability of death was calculated for each quintile first by assuming the population was split into quintiles of equal size. The total deaths/cases for each quintile using the SADHS proportions were then calculated by applying the relevant probability of death/cases for that part of the quintile which overlapped with the underlying equally sized quintile. This concept can be best illustrated by a graph (Figure 4.12) and using the following equation:

$$Number_{cases}(SADHS_{Q1}) = Pop_{SADHS} \quad \times Prob_{EqualQ1}$$

$$Number_{cases}(SADHS_{Q2})$$
$$= (Pop_{EqualQ1} - Pop_{SADHS} \quad) \times Prob_{Equal}$$
$$+ (Pop_{SADHSQ1} + Pop_{SADHSQ2} - Pop_{Eq} \qquad) \times Prob_{EqualQ2}$$

$\ldots .\, and\ so\ on$

Figure 4.12: Adjusting the wealth quintiles



The existence of relative risk equations implies that the baseline mortality/morbidity will also not be distributed equally between drinker groups, one would expect a higher proportion of baseline cases amongst heavy drinkers, followed by occasional binge, moderate then abstainers. In order for the baseline mortality/morbidity to vary by drinker group the total risk, for each disease, was calculated for each drinker group, by sex and wealth quintile. The proportional share of risk between drinker groups is then calculated and used to distribute the mortality/morbidity, which has already been assigned to each quintile, between each drinker group within that quintile.

Life tables to get the probability of death by single year of age were only available for 2017 from iHME so these were used. The 2018 population is split proportionally into the sex/wealth/drinker types using the SADHS proportions.

The probability of death for each disease at baseline scenario was estimated and taken away from the overall probability of death for each single year of age given in the life table to give a probability of death from non-modelled causes.

4.5 Consumption to harm modelling methods

The consumption levels (mean and peak) at baseline and for each policy scenario are taken from the price to consumption part of the model and used to calculate impact on harm.

4.5.1 Modelling potential impact fractions

Potential impact fractions are ratios between the new (reduced) level of risk of the alcohol related condition after the policy to the level of risk before the policy. They are needed to adjust the underlying probability of disease or death from each of the five included health conditions under the policy. Potential impact fractions (PIFs) were calculated by dividing relative risk under each policy by relative risk at baseline. These incorporated population weights and were computed by sex *(i)*, wealth group *(j)* and drinker group *(k)* using the following equation:

$$PIF_{ijk} = \frac{\text{relative risk}_{ijk}\ (\text{policy})}{\text{relative risk}_{ijk}\ (\text{baseline})}$$

Before calculating PIFs by subgroup, counts in each category were checked to ensure sufficient sample size (Table 4.28 and 4.29). The sample was too small to disaggregate by every possible variable therefore sex, drinker and wealth groups were prioritised as of more interest to stakeholders.

Table 4.28: Raw counts in each wealth category for females

Females (raw count SADHS data)	Poorest	Poorer	Middle	Richer	Richest
Abstainer	1099	1079	1085	1001	737
Moderate	72	102	171	148	132
Occasional Binge	18	22	31	41	27
Heavy	48	68	79	87	79

Table 4.29: Raw counts in each wealth category for males

Males (raw count SADHS data)	Poorest	Poorer	Middle	Richer	Richest
Abstainer	448	458	429	380	309
Moderate	134	166	185	121	96
Occasional Binge	56	76	75	55	41
Heavy	223	256	282	233	187

4.5.2 Modelling the population and health outcomes under each policy scenario

The population was projected forward for 20 years in order for the full effect to be realised for all of the included health conditions. We only model alcohol consumption for those aged 15 and over. I created a life table, starting at age 0, to which I added births for 5 years after baseline so that I did not miss any 15 year-olds in the 20th year of the model run.

The population was split into wealth quintiles and drinker groups using the proportions from the SADHS dataset. Multistate life tables are created in which the population faces a probability of mortality for each of the five disease/injury conditions and for other cause mortality each year (Briggs et al., 2016). 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 although it assumes diseases are independent of one another.

The model generates alternative potential impact fractions (as above) for each policy scenario (R5, R10, R15) which allowed me to rerun the multistate life table model for each scenario. An 'extreme scenario' was also simulated in which everyone stops drinking entirely and therefore their relative risks become 1 (except for liver cirrhosis where former drinkers still have an increased relative risk). Comparing the results of the extreme scenario with the baseline scenario provide an estimation of alcohol attributable harm related to the five health conditions over the 20 year time horizon. This is calculated to validate the model as total alcohol attributable figures can then be compared with external sources (such as iHME alcohol attributable figures). It also allows quantification of the extent of the disease burden that can be impacted by the policy.

HIV, road injuries and intentional injuries realise the full impact of the reduction in drinking from the first year of the drinking reduction whereas liver cirrhosis and breast cancer are subject to lags in the effect. 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 (Table 4.28).

Table 4.28: Modelled time-lags by condition – proportion of overall change in risk experienced in each year following a change in consumption (Holmes et al., 2012)

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

The life tables for the 20 year model run 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.

4.6 Sensitivity analysis

Sensitivity analyses were informed by previous published alcohol modelling work (Brennan et al., 2015), knowledge of the limitations of the data and accompanying assumptions used in the model highlighted throughout this chapter, and stakeholder input.

Firstly, starting with the estimation of baseline consumption stakeholders highlighted concern regarding self-reported abstinence. Self-report surveys are proven to be unreliable in the amount a drinker reports consuming (such that there is a standard method of adjustment in the alcohol modelling literature) but there is no corresponding method for adjusting the number of abstainers, the accepted approach assumes reliability of abstinence reports. The low coverage rate in SADHS (27%) common to most South African alcohol surveys, in comparison with other countries such as Germany (39%) and France (56%) (Knibbe and Bloomfield, 2001), might imply that it is not simply volume underestimation by drinkers but also drinkers reporting as abstainers. To explore the potential magnitude of this affect I increased the survey weightings of drinkers in the SADHS data so that 67% of females and 36% of males abstain as opposed to 82% and 45%, and reran the model. The only available evidence to inform this scenario was a South African study which used surveys and biomarkers to estimate alcohol consumption (Pisa et al., 2015), I validated these new abstinence levels with stakeholders.

Secondly, there is uncertainty surrounding the elasticities, so I modelled a number of alternative scenarios. I applied estimates based only on drinker group, removing the wealth gradient, -0.4 for moderate, -0.22 for occasional binge, -0.18 for heavy drinkers, which brings my study closer to the primary alternative MUP model for South Africa (Van Walbeek and Chelwa, 2021). As an alternative I removed the drinker group differences and used estimates based only on wealth applying, -0.5 for high income and -0.86 for low income drinkers (Van Walbeek and Blecher, 2014). Finally, I drew on the literature review of South African specific price elasticities in the same report by Van Walbeek and Blecher (2014) which quoted a Selvanathan and Selvanathan (2005) estimate of -0.8, which corresponds closely to price elasticity estimates for beer (-0.8), wine (-0.9) and spirits (-0.9) produced by South African Liquor Brand owners Association. These last two scenarios provide much higher price elasticities so I would expect a greater policy impact.

Thirdly, the homebrew switching scenario had not been informed by data but by expert opinion elicited from stakeholders. To check the sensitivity of the model to the assumption that individuals would compensate 30% of their reduction in recorded alcohol with homebrew I tested the limits, simulating the model with 0% switching behaviour and with 100% switching behaviour.

Fourthly, there was a lack of consistency between datasets regarding HIV mortality. Of the five included health conditions HIV has the greatest prevalence and mortality at baseline so will contribute significantly to the estimated policy health impact. To explore this uncertainty the model will be simulated with Thembisa estimates of deaths and cases for 2018. The Thembisa estimates were chosen as they had a high level of credibility with stakeholders, the model having been built specifically for the South African context.

Fifthly, the distribution of baseline health utilised estimates from the GHS 2018. A few concerns arise when considering this data source; the small sample size, the requirement to use proxies for some of the health conditions and the lack of consistency with other studies. Specifically, as no data was collected for liver cirrhosis intentional injury was chosen as a proxy. Although this was validated with stakeholders they also noted that cirrhosis is most often the consequence of long-term heavy use (i.e. affecting dependents/alcoholics who can be an older demographic) whereas injuries most often arise from heavy long-term and heavy episodic use (i.e bingers are over-represented including young adults). These groups might cohere around a particular socio-economic group in Europe. However in South Africa with all the other injury and disease risks affecting young black African men, who account for a large proportion of injuries, many will not survive to an age when they are more likely to develop long-term conditions like cirrhosis. As such wealthier groups could well be over-represented in South Africa. For this reason they suggested sensitivity analysis by applying values for another condition that is less concentrated amongst the poor, to operationalise this I applied the gradient for cancer.

Linked to this I also explored applying a different set of socioeconomic gradients for all the health conditions based on data from an alternative study (Kabudula et al., 2017). These estimates suggested intentional injuries/road injuries/liver cirrhosis were less concentrated amongst quintiles three and four (as in GHS) but are more evenly spread through the population. They also reverse the gradient for cancer with the poor, rather than the rich, most effected. This will significantly impact the estimated policy impact on health between quintiles.

Finally I applied a 0% discount rate to costs, instead of 5%, as this is considered best practice in health economic modelling in South Africa (Republic of South Africa, 2012). A summary of each of these scenarios follows (Table 4.29).

Table 4.29: Sensitivity analysis approach

Parameter	Central estimate	Alternative plausible values	Rationale
Proportion of abstainers in the population	82% female non-drinkers 45% male non-drinkers	67% female non-drinkers 36% male non-drinkers	Stakeholders have indicated scepticism about the prevalence of non-drinking reported in SADHS (and all alcohol studies). Currently the model only adjusts the consumption of those who report anything at all. I increased the survey weightings of drinkers in the SADHS so that 67% of females do not drink and 36% of males based on a South African study which used both surveys and biomarkers (Pisa et al., 2015).
Price elasticities	-0.53 moderate Q1, Q2 -0.31 moderate Q3, Q4, Q5 -0.29 occasional binge Q1, Q2 -0.17 occasional binge Q3, Q4, Q5 -0.24 heavy Q1, Q2 -0.14 heavy Q3, Q4, Q5	Scenario 1 -0.40 moderate -0.22 occasional binge -0.18 heavy Scenario 2 -0.5 for high income drinkers (applied to quintiles 3, 4, 5) -0.86 for low income drinkers (applied to quintiles 1,2 to be conservative) Scenario 3 -0.8	Scenario 1 Applies estimates based only on drinker type, removing any wealth gradient. Scenario 2 Estimates using NiDS data for two subsets of the population, the top 50% and bottom 50% of households by total household expenditure (Van Walbeek and Blecher, 2014). Scenario 3 Van Walbeek and Blecher (2014) literature review of South African specific price elasticities found Selvanathan and Selvanathan (2005) estimated -0.8 which corresponds closely to price elasticity estimates for beer (-0.8), wine (-0.9) and spirits (-0.9) produced by SALBA (2010).

Homebrew switching	30%	Scenario 1 0% Scenario 2 100%	The assumption that drinkers will make up 30% of the reduction in drinking recorded alcohol with homebrew comes from consultation with the stakeholders at workshop two. To test the importance of this assumption on the results a null impact and a 100% impact are introduced. 100% would mean that any homebrew drinkers will not receive any positive health impacts from the policy as all of their reduction in recorded alcohol will be replaced with homebrew alcohol.
HIV baseline estimates	iHME 2018 estimates female 77,499 deaths 4,772,473 cases male 70,186 deaths 2,799,754 cases	Thembisa 2018 estimates female 35,487 deaths 4,542,677 cases male 36,345 deaths 2,578,747 cases	Stakeholders highlighted the difference between GBD estimates and local estimates for HIV deaths. The Thembisa model was built by local academics and is used by UNAIDs (Johnson et al., 2017).

Socioeconomic gradients of ill health	HIV Q1 (poorest) – 20% Q2 – 36% Q3 – 32% Q4 – 9% Q5 – 3% Intentional Injury/Road Injury/Liver Cirrhosis Q1 – 9% Q2 – 29% Q3 – 26% Q4 – 26% Q5 – 10% Breast cancer Q1 – 7% Q2 – 7% Q3 – 22% Q4 – 18% Q5 – 47%	Scenario 1 Changing the liver cirrhosis gradient to match the one used for breast cancer Scenario 2 HIV Q1 (poorest) – 25% Q2 – 22% Q3 – 20% Q4 – 18% Q5 – 14% Intentional injury/ Road injury/Liver cirrhosis Q1 – 20% Q2 – 20% Q3 – 19% Q4 – 20% Q5 – 22%	Scenario 1 Stakeholders indicated that for long-term conditions like cirrhosis wealthier groups could well be over-represented in SA. They suggested sensitivity analysis by applying values for a condition that is less concentrated amongst the poor. Scenario 2 Recent data from another South African survey is used to provide plausible alternative socioeconomic gradients across all the conditions used in the model (Kabudula et al., 2017).

		Breast cancer Q1 (poorest) – 21% Q2 – 21% Q3 – 20% Q4 – 19% Q5 – 18%	
Discount rates for costs	5% discount rate	Scenario 1 0% discount rate	Discount rate was changed to 0%

4.7 Extended cost-effectiveness analysis

Following completion of the above analysis and writing the results into an academic paper I then applied the ECEA methodology to my research. I took this decision for three reasons. Firstly, a concern from stakeholders about the financial impact on the poorest groups. Secondly, my earlier scoping review had highlighted ECEA as a well-established method in the published literature particularly appropriate for health policy analysis in LMIC contexts. Lastly, I had built a professional network which included Assistant Professor Stephane Verguet, who devised the method, and had expressed an interest in supervising the work as an independent paper. He also linked me with Priority Cost-Effective Lessons for Systems Strengthening in South Africa (PRICELESS SA) at the University of Witwatersrand who then provided a Research Associate (Dr. Boachie) to work on the project with us, whose role was to provide, or validate, additional input parameters.

An extended-cost-effectiveness analysis (as outlined in the scoping review) is characterised by the inclusion of out of pocket healthcare expenditure associated with disease/injury, the resulting level of financial risk protection and presenting results by income or wealth quintiles (Verguet et al., 2016a). Health care in South Africa is a mix of public and private, with contributions from the individual determined on a sliding scale. My modelling distinguished between healthcare expenditure averted by the individual (named out of pocket (OOP) costs) and that averted by the government. Comparing OOP costs averted with household income is one way to quantify how the avoidance of a particular health condition provides financial risk protection, an important consideration in countries without universal healthcare.

A key development to my model was to disaggregate healthcare utilisation rates by quintile across all of the five health outcomes. This is of particular importance to an ECEA as the healthcare costs are then split between government and private payers. In order to estimate as closely as possible the true OOP cost differential healthcare access needs to be quantified. Although poorer groups might suffer a greater level of harm the data suggests they may not access healthcare equally between quintiles (Statistics South Africa, 2020b). I also introduced a new variable to estimate the proportion of the healthcare cost that is paid by the government versus the individual. I compared healthcare costs incurred between quintiles with mean income to calculate financial risk protection measures. Using labour force participation by quintile, which incorporates high unemployment rates, as well as mean wage I modelled lost wages, termed indirect costs within the ECEA framework.

4.7.1 Out of pocket costs

The prevalence of disease/injury at each policy scenario for each year of the model was multiplied by the proportion who go on to receive hospital treatment using quintile specific utilisation rates calculated by Dr. Boachie using data from GHS 2019. He used the question on whether a respondent consulted a health worker as a result of illness in the last 30 days prior to the survey and whether or not the individual had the disease/injury condition in question. Not all conditions are included in the survey so Dr. Boachie provided estimates for HIV, cancer and "all other conditions".

Dr. Boachie's utilisation rates compared reasonably with those I had used in my original model for HIV, liver cirrhosis and breast cancer. Intentional injury and road injury were very different and so I adjusted them closer to my original estimates using evidence which relates population prevalence with admission to hospital (as used above). This is justified because the costs I include only apply to those who are admitted to hospital trauma departments.

South African research giving trauma numbers from 1999 was used in combination with iHME data, from the same year, to estimate the multiplier between prevalence and hospital admissions (Matzopoulos et al., 2006) (Table 4.30).

Table 4.30: Multipliers for intentional injury and road injury hospital admissions

Category in iHME	Prevalence iHME 1999	Category in survey in paper	Number of cases	Multiplier from prevalence to hospital visit
Transport injuries	1,566,017.43	Traffic	302,872	0.19
Unintentional injuries	3,392,764.13	Other injuries	416,449	0.12
Interpersonal violence and self-harm	1,851,637.90	Violence	757,180	0.41

I then used these multipliers to adjust the general utilisation rates generated from the GHS 2019 using the following equation:

$$utilisation_{adj,qi} = \frac{utilisation_{qi}}{\sum_{q=1}^{5} utilisation_{qi}} \times multiplier$$

Final healthcare utilisation rates are given here (Table 4.31). The healthcare costs used for the ECEA were the same as in my original model. The mean proportion of the healthcare cost borne out of pocket, not by the government is taken from the literature (Saxena et al., 2019b) (Table 4.31).

Table 4.31: Quintile specific out of pocket proportion and healthcare utilisation rates

OOP disease-related expenditure and utilisation						
Proportion of disease-related expenditure paid as OOP	21%	18%	41%	56%	82%	Saxena et al. (2019b)
Healthcare utilisation rates (HIV)	63%	71%	69%	60%	89%	Dr. Boachie's calculations using GHS 2019
Healthcare utilisation rates (breast cancer)	52%	56%	50%	68%	89%	Dr. Boachie's calculations using GHS 2019
Healthcare utilisation rates (liver cirrhosis)	52%	55%	54%	53%	63%	Dr. Boachie's calculations using GHS 2019
Trauma care utilisation rates (intentional injury)	39%	40%	40%	40%	47%	Dr. Boachies's calculations using GHS 2019 plus Matzopoulos et al. (2006)
Trauma care utilisation rates (road injury)	18%	19%	18%	18%	22%	Dr. Boachie's calculations using GHS 2019; Matzopoulos et al. (2006)

4.7.2 Financial Risk Protection

The measure of financial risk protection used is catastrophic healthcare expenditure (CHE) defined as healthcare related expenditure exceeding 10% of annual household expenditure, in line with most of the ECEA literature reviewed in Chapter 2. The mean income by quintile was estimated by Dr. Boachie using GHS data 2019 and deflated to 2018 (poorest – richest; R6,052 / R27,434 / R49,306 / R95,627 / R408,923). The annual income is then compared with the healthcare expenditure for each year in the model to calculate the number of cases of CHE averted over the 20 year time horizon.

4.7.3 Indirect costs

I incorporated indirect costs via lost wages from days absent from work only. This is consistent with the valuation method used in the ECEA literature although other methods, such as the friction cost approach, are available. There was insufficient evidence to include reduced productivity whilst at work. The mean income by quintile parameters were provided by Dr. Boachie. Labour and productivity inputs are given in Table 4.32.

4.7.3.1 HIV

A report by a South African insurance company states that those who have been diagnosed with HIV and are being treated take 1,392 out of 36,022 working days off (Maffessanti and Lee-Angell, 2005). Assuming 252 working days in a year this equates to 14 days per year.

4.7.3.2 Intentional Injury and Road Injury

These relate to the days in hospital which are drawn from the micro costing studies used for the hospital costs (Bola et al., 2016, Parkinson et al., 2014).

4.7.3.3 Liver Cirrhosis

Data taken from Matzopoulos et al. (2014) stated that alcohol related absentee rates average 2.3% in workers earning R1,000 or less per month, and 1.3% in workers earning R10,000 – 15,000 per month. The number of working days in South Africa per year is assumed to be 252 (Excelnotes, 2021). We have therefore assumed six days loss a year for the poorest quintile and three days for quintiles 2 – 5.

4.7.3.4 Breast Cancer

Unfortunately South African specific literature was not found so we used an estimate from a study in the USA which estimates 6.1 days loss of work per year (Tangka et al., 2013).

Table 4.32: Labour and productivity inputs for the ECEA

Labour and productivity inputs						
Labour force participation	62%	50%	55%	64%	74%	Dr. Boachie's calculations using GHS 2019 data
Annual income per capita (ZAR)	6,100	27,40 0	49,300	95,600	408,90 0	Dr. Boachie's using GHS 2019 data deflated to 2018
Absenteeism **(days per year)** **HIV** **Intentional injury** **Road injury** **Liver cirrhosis** **Breast cancer**	 14 10 18 6 6	 14 10 18 3 6	 14 10 18 3 6	 14 10 18 3 6	 14 10 18 3 6	 Maffessanti and Lee- Angell (2005) Bola et al. (2016) Parkinson et al. (2014) Matzopoulos et al. (2014) Tangka et al. (2013)

4.7.4 ECEA Sensitivity analysis

I conducted multiple univariate sensitivity analyses on the following key parameters: price elasticities; CHE thresholds; and wage rates. Firstly, I removed the wealth gradient from the price elasticity estimates as in the original analysis. Secondly, I used price elasticities related only to wealth quintiles also as in the original analysis. For the estimation of CHE cases, I varied the threshold to 25% and 40% of mean annual income. Finally, I applied the South African minimum wage (ZAR20.8) across all quintiles to calculate productivity losses instead of using mean income by quintile. This enables the estimation of the lost income by labour force participation which avoids applying less value to those on lower wages although it still applies no value to the unemployed.

4.8 Summary

In this chapter I have outlined in detail the methods used to build my alcohol epidemiological policy appraisal model. I have explained the derivation of a conceptual model and the critical role that stakeholders played in its development. The approach to data scoping and selection has been outlined accompanied by detailed methods of the preparatory adjustments to model inputs. The model mechanisms were then explained. Sensitivity analyses relating to the data inputs and adjustments were then explored and specific scenarios identified to address those uncertainties.

The two following results papers, the first presenting results disaggregated by drinker and wealth group (including a high level of modelling detail) and the second extending the analysis to an ECEA, also provide a brief summary of the methods. They are both included in publication format with methodological detail provided in the appendix to each paper. There is inevitably some overlap.

The model was coded in R: (code available here). The script file library is included here (Appendix 3.2 and 3.3)

5 Chapter five: Effects of minimum unit pricing for alcohol in South Africa across different drinker groups and wealth quintiles: a modelling study

This chapter reports the results of a MUP modelling study for South Africa. Previous research demonstrates MUP is an effective policy in reducing alcohol harm however detailed modelling work has been limited to high-income countries. This chapter presents estimated impacts for South Africa across drinker groups and wealth quintiles, work which incorporated a comprehensive programme of stakeholder engagement. It has the potential to inform MUP policy in South Africa and highlight important avenues for further research, including the collection of pricing data and extended consideration of the impact on the poorest groups.

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The paper in the chapter was written with 4 co-authors; Colin Angus, Simon Dixon, Charles Parry and Petra Meier. All authors conceptualised the study. I completed the modelling, stakeholder engagement and wrote the first draft under the supervision of Colin Angus, Simon Dixon, Petra Meier and Charles Parry. All authors refined various drafts of the manuscript and approved the final version.

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Effects of minimum unit pricing for alcohol in South Africa across different drinker groups and wealth quintiles: a modelling study

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ABSTRACT

Objectives To quantify the potential impact of minimum unit pricing (MUP) for alcohol on alcohol consumption, spending and health in South Africa. We provide these estimates disaggregated by different drinker groups and wealth quintiles.

Design We developed an epidemiological policy appraisal model to estimate the effects of MUP across sex, drinker groups (moderate, occasional binge, heavy) and wealth quintiles. Stakeholder interviews and workshops informed model development and ensured policy relevance.

Setting South African drinking population aged 15+.

Participants The population (aged 15+) of South Africa in 2018 stratified by drinking group and wealth quintiles, with a model time horizon of 20 years.

Main outcome measures Change in standard drinks (SDs) (12 g of ethanol) consumed, weekly spend on alcohol, annual number of cases and deaths for five alcohol-related health conditions (HIV, intentional injury, road injury, liver cirrhosis and breast cancer), reported by drinker groups and wealth quintile.

Results We estimate an MUP of R10 per SD would lead to an immediate reduction in consumption of 4.40% (−0.93 SD/week) and an increase in spend of 18.09%. The absolute reduction is greatest for heavy drinkers (−1.48 SD/week), followed by occasional binge drinkers (−0.41 SD/week) and moderate drinkers (−0.40 SD/week). Over 20 years, we estimate 20 585 fewer deaths and 900 332 cases averted across the five health-modelled harms. Poorer drinkers would see greater impacts from the policy (consumption: −7.75% in the poorest quintile, −3.19% in richest quintile). Among the heavy drinkers, 85% of the cases averted and 86% of the lives saved accrue to the bottom three wealth quintiles.

Conclusions We estimate that MUP would reduce alcohol consumption in South Africa, improving health outcomes while raising retail and tax revenue. Consumption and harm reductions would be greater in poorer groups.

Strengths and limitations of this study

- This study presents the first epidemiological policy appraisal model of a minimum unit price applied to South Africa. Previous similar modelling work has been limited to high-income countries.
- Our model provides equity-relevant information by presenting results disaggregated by wealth quintiles, allowing for a more nuanced consideration of the potential impact of the policy.
- Our model has also benefited from a thorough programme of stakeholder engagement ensuring contextual and policy relevance.
- A key limitation is the alcohol pricing data, which is drawn from a relatively small sample in one locality. Further research would benefit from improved pricing data, specifically the different prices paid for alcohol by different population groups.
- Second, the model has not explored the financial impact on the poorest groups beyond increased alcohol expenditure. Further research should include exploration of broader financial benefits such as reduced private expenditure on healthcare or improved labour market outcomes.

BACKGROUND

In South Africa (SA), there are high levels of reported abstinence coupled with high levels of binge drinking among those who do drink, resulting in significant levels of alcohol-related harm.[1] This harm is not distributed evenly throughout society with the lower socioeconomic groups experiencing higher levels of harm, particularly for infectious diseases such as HIV.[2] The periodic prohibition of alcohol during the COVID-19 lockdown demonstrates political leaders' acceptance that alcohol causes harm to SA and signals a potential willingness to take strong action.[3] Provincial governments, such as the Western Cape, are considering a number of alcohol policy approaches, including the introduction of minimum unit pricing (MUP).[4]

MUP is a policy whereby a legal floor price is introduced, below which a fixed volume of ethanol cannot be sold to the public. It has already been introduced in several areas, which experience high levels of alcohol harm, including Scotland and Australia's Northern Territory. Evidence suggests that MUP has been effective at reducing alcohol consumption, particularly among the heaviest drinkers, as they commonly drink the very cheap alcohol targeted by this policy.[5 6]

A limitation of transferring the current evidence for MUP is its focus on high-income countries. Transferring this evidence to SA would be problematic as it has very different drinking patterns, a very different harm profile with infectious disease and injury contributing significantly to the burden of alcohol, it has an informal sector, which is challenging to capture and it has very high levels of income inequality likely to result in differential baseline prices and price responsiveness.

The current alcohol landscape is rooted in the country's recent political history. In 1926, apartheid legislation prohibited African and Indian access to licensed premises or employment by licence holders. As a result, when the democratically elected government took power in 1994 they inherited a significant number of shebeens. Shebeens are (largely) unlicensed bars or pubs, found in townships, often open late and with a reputation for violence and risky sexual behaviour. Homebrew (mainly beer made from sorghum or other ingredients such as pineapple) can be purchased from shebeens along with other types of branded alcohol supplied by large alcohol manufacturers and mainly distributed through larger licensed outlets using bulk discounts. Although beer is the most popular drink, the consumption of large quantities of cheap wine is also prevalent and can be linked back to farm labourers being paid in cheap wine.[7]

The South African government currently use alcohol excise tax to compensate for some of the social costs they attribute to alcohol consumption.[8 9] The system is based on targets for the proportion of the price that constitutes tax (excise tax plus value-added tax (VAT)). This varies by drink type with wine lowest followed by beer then spirits. The government has indicated a willingness to innovate and pursue public health improvements via fiscal policy with the introduction of a sugar tax in 2018. However, in a country with high levels of socioeconomic inequality, there are concerns regarding possible financial impact of pricing policies on the poorest groups.[10] Evidence on public health pricing policies often fails to consider distributional impact by income-groups.[11]

When designing public health economic models for unique policy contexts, ongoing engagement with local stakeholders is essential. The purpose of engagement is twofold: to shape the direction of the research using expert local knowledge (including understanding the problem, guiding model development and ensuring policy relevance) and to provide channels for communication creating potential for the evidence to contribute to policy design.[12–14]

We aimed to: (1) present estimates of the change to alcohol consumption, individual expenditure, retail and tax revenue following the introduction of a South African MUP, using a purpose built model, (2) estimate the impact on a limited number of alcohol-related health conditions and associated healthcare costs, (3) explore the potential equity implications via the demonstration of impact by both drinker group and wealth quintile, (4) highlight parameters that are particularly influential to the results and areas that require further research.

METHODS

We built an epidemiological policy appraisal model coded in R (code available here), using a comparative risk assessment approach with multistate life tables.[15] A stakeholder mapping exercise was carried out following scoping conversations with three academic experts from three South African institutions. Following this, a shortlist of policy professionals, civil society members and local academics was drawn up and checked via the scientific and ethical review process. They were engaged via scoping interviews and three workshops, at the beginning, middle and end of the modelling process. Stakeholders informed key decisions including the specific policy to simulate, levels of the MUP, health outcomes of interest, assumptions on homebrew switching behaviour and validation of our choice of data sources.

Two distinct sections of the model were defined (figure 1):

I. Price to consumption: baseline prices were estimated for drinker groups (heavy drinkers, occasional binge drinkers, moderate drinkers) and wealth groups. Consumption was estimated at the individual level, this includes the proportion of alcohol drunk that is homebrew. Following a change in price, the new price and subsequent consumption levels were estimated. This accounts for both mean and peak weekly alcohol consumption.
II. Consumption to harm: the relationship between mean and peak consumption and alcohol-related harm and associated costs were estimated.

There is no single data set that can provide all the required data for the model and, thus, a combination of survey data sets, market research data, and evidence from published literature were used (figure 2).

Price to consumption

Baseline consumption and prices

Our model started by estimating mean and peak alcohol consumption at current alcohol prices at the individual level. We categorised drinkers into three exhaustive and mutually exclusive groups; moderate (less than 15 standard drinks (SDs) per week); occasional binge (less than 15 drinks per week but more than 5 on one occasion) and heavy (15 or more drinks per week). An SD in SA is currently 15 mL or 12 g of pure ethanol. We generated price distributions for wealth and drinker groups using real price data linked to individual drinking from the International Alcohol Control Study (IAC)[16] survey 2014/2015 completed in the metropolitan district of Tshwane. The IAC asked for highly detailed data about prices in both

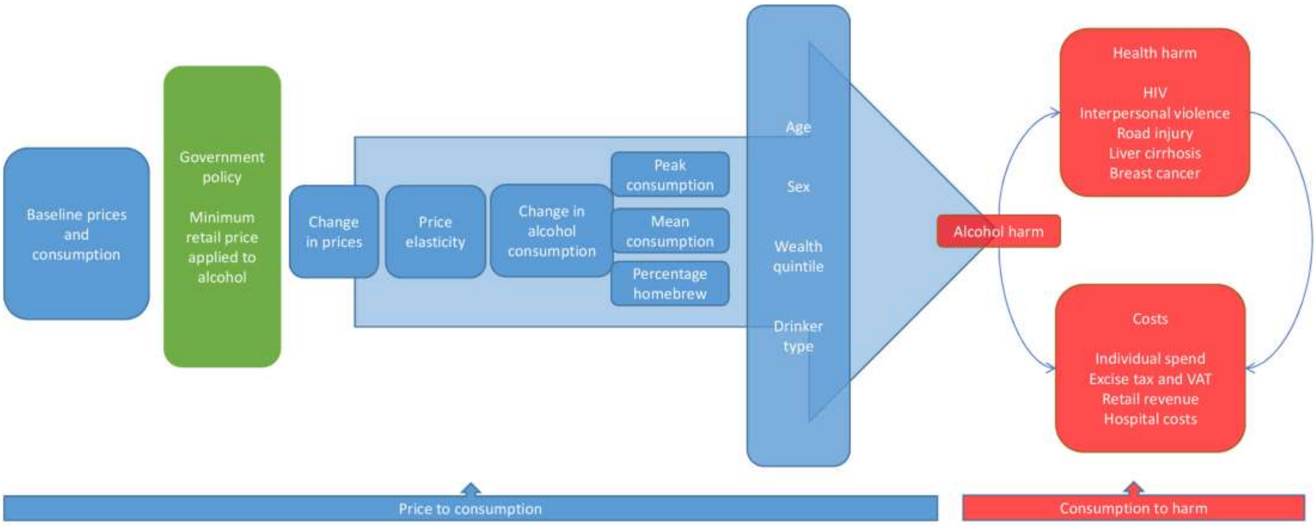

Figure 1 Conceptual model framework.

on-trade and off-trade locations and took into account container size, drink type and number of drinks purchased. Alcohol was treated as one commodity as the 863 price observations were distributed between drinker and wealth groups instead of by alcohol type. Wealth quintiles were chosen as our measure of socio-economic status as income was not available in the pricing data set, whereas asset ownership and common demographic data such as age, sex and education were available. A detailed description of the above is given in the appendix parts 1 to 6.

Applying an MUP

A government policy of legislating for an MUP of R5, R10 and R15 per South African SD was introduced. Prices below the MUP threshold were increased to the threshold, while products above were unaffected. We did not include prices for homebrew. The distribution of prices faced by each wealth/drinker group was used to calculate the mean price per SD before and after the policy. This then provided a percentage change in the mean price (table 1).

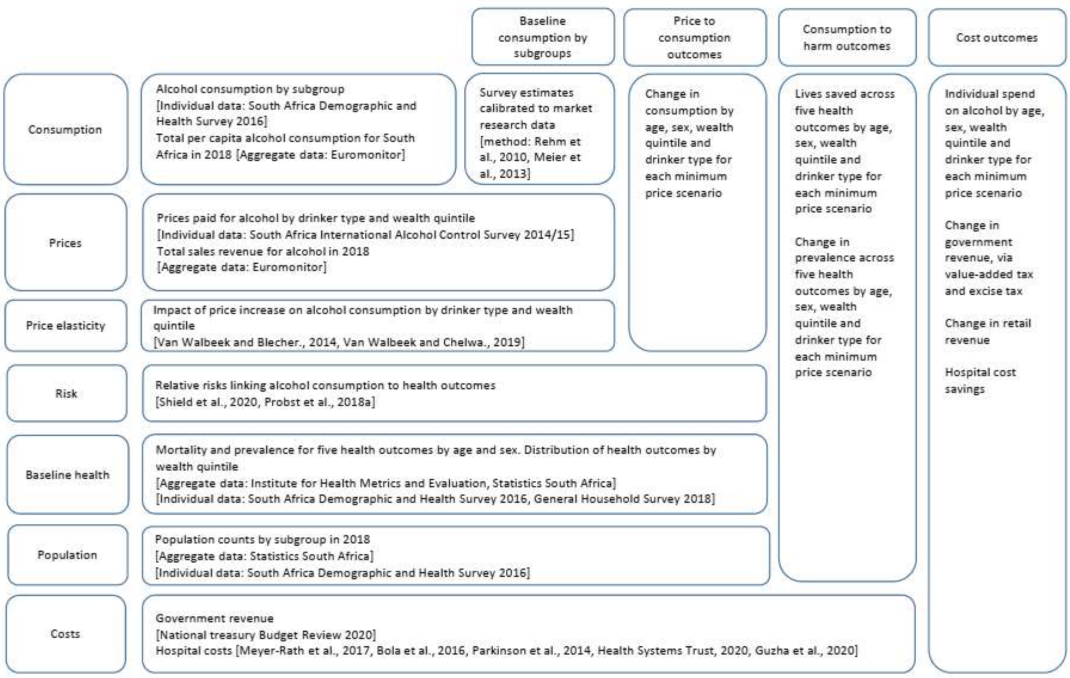

Figure 2 Data inputs for model.

Table 1 Price and elasticity data inputs by wealth quintile and drinker group

	Q1	Q2	Q3	Q4	Q5
Baseline price per standard drink					
Moderate	R9.13	R9.13	R9.13	R11.6	R11.6
Occasional binge	R7.97	R10.0	R10.1	R13.4	R11.1
Heavy	R7.78	R9.65	R9.23	R10.6	R12.8
Percentage change in mean price following R10 MUP					
Moderate	22%	22%	22%	20%	20%
Occasional binge	37%	16%	24%	11%	19%
Heavy	33%	26%	25%	24%	21%
Price elasticities used in the model					
Moderate	−0.53	−0.53	−0.31	−0.31	−0.31
Occasional binge	−0.29	−0.29	−0.17	−0.17	−0.17
Heavy	−0.24	−0.24	−0.14	−0.14	−0.14

*Standard drink in South Africa defined as 15ml or 12 grams of pure ethanol
MUP, minimum unit pricing; Q1, poorest.

Elasticity of demand for alcohol

The change in price was translated into a change in individual consumption using an elasticity of demand for alcohol. We used previously published elasticities for SA, calculated separately by drinker group: −0.4 to −0.22, −0.18 for moderate, occasional binge and heavy drinkers, respectively,[4] and adjusted for wealth quintile using additional evidence from SA[17] (table 1) (online supplemental appendix 7).

Those who drank both recorded alcohol and homebrew dampened the policy impact by switching some of their drinking to homebrew. Stakeholders indicated that 30% of the reduction in recorded alcohol could be assumed as being compensated for via an equivalent increase in homebrew. This was varied between 0% (no switching) and 100% (full switching) in the sensitivity analysis.

Individual spend, tax and retail revenue

Total retail spend was computed by aggregating population-weighted individual spend. This figure was increased by 1.25 (100/80) as consumption was calibrated to 80% of official sales volume data.[18]

As an MUP is applied before VAT is calculated, we estimated VAT as 15% of the total aggregate spend. Excise tax was calculated by starting with the total 2018 alcohol excise tax revenue from the Treasury Budget Report.[9] This was adjusted by percentage change in volume of alcohol sold (we used a fixed ratio between volume and excise tax). Retail revenue was calculated by taking VAT and excise taxation away from total spend (online supplemental appendix 8).

Consumption to harm

Relative risks and potential impact fractions

We used published estimates of relative risks associated with different levels of alcohol consumption (online supplemental appendix 9). We then used these to calculate relative risks for each outcome for each individual.

We used potential impact fractions (PIFs), a widely used approach in epidemiological modelling, to estimate the impact of a change in exposure to risk on a change in outcomes.[19] We incorporated population weights and computed the PIFs by sex, wealth group and drinker groups (online supplemental appendix 10).

Baseline health

Baseline deaths and cases (population prevalence) of the five disease and injury conditions (HIV, road injury, intentional injury, liver cirrhosis and breast cancer) were apportioned by drinker group, sex and wealth quintile. The probability of death for each disease was calculated for baseline and taken away from overall probability of death for each single year of age given in the life table to give a probability of death from non-modelled causes. This probability of death from non-modelled causes remained constant at every policy scenario. The probability of death from the five diseases of interest then varied according to the policy level and the corresponding PIF. A more detailed description is given in online supplemental appendices 11 and 12.

Projecting the population

We modelled counterfactual population structure (ie, in the absence of the policy) over 20 years, starting from 2018.[20] We created multistate life tables in which the population faces a probability of mortality for each of the five disease/injury conditions and for non-modelled causes each year. The model generated alternative population impact fractions (as above) for baseline and for each policy scenario. Using the relevant population impact fraction and rerunning the multistate life table enabled a calculation of the difference between baseline and the policy. HIV, road injuries and intentional injuries realise the full impact of the reduction in drinking immediately, whereas the health impact on liver cirrhosis and breast cancer are subjected to lags in the effect[21] (online supplemental appendix 13).

The life tables for the 20-year time horizon were used in combination with the probability of having the disease and the PIFs under each policy, to estimate the number of cases.

Hospital costs

Prevalence of disease/injury at each policy scenario for each year of the model was multiplied by the proportion who receive hospital treatment and the relevant hospital cost applied (online supplemental appendix 14). We converted all costs to 2018 prices using the Consumer Price Index.[22] Future costs were discounted at 5%.

Sensitivity analysis

We explored key uncertainties in the model using scenario analysis informed by previous published alcohol modelling work,[23] our knowledge of the limitations of the data and stakeholder input. For each alternative scenario, relevant results were compared with central estimates. The key parameters explored were elasticities, proportion of abstainers, HIV baseline estimates, socioeconomic gradients of health, proportion of switching to homebrew and discount rates for costs (online supplemental appendix 15).

Patient and public involvement

Patients were not involved in this study.

RESULTS

Estimated consumption and spend impact

Our findings are presented primarily for an R10 MUP, but with some comparisons across all three pricing levels. The policy appraisal results are reported by quintile further disaggregated by drinker group (table 2). In the model, drinking prevalence increases with wealth (27% up to 38%) as does the prevalence of heavy drinking, ranging from 14% among Q1 up to 20% for Q5. Among all drinker groups, mean consumption is either similar or demonstrates no clear pattern between wealth quintiles. On aggregate, there was a gradient in average baseline weekly spend with the rich paying an average R257.36 per week compared with R148.03 in the lowest wealth group.

Our model estimated, for an MUP of R10, an immediate reduction in population alcohol consumption of 4.40% (−0.93 SD/week) and an increase in spend of 18.09%. Moderate drinkers showed the greatest percentage decrease in their drinking, followed by occasional binge then heavy drinkers (−8.71%, −4.51%, −4.19%). However, this translated to a larger absolute reduction in consumption for heavier drinkers (−1.48 SD/week) than either occasional binge or moderate drinkers (−0.41 and to −0.40).

Our model estimated that there would be an increase in individual spend on alcohol consumption of R32.77 billion in the year following the introduction of the policy. The government would see an increase in VAT as a result of the increased prices although a reduction in excise taxation due to the reduced volume of alcohol sold. Retail revenue would also increase (table 3).

Estimated health impact

Across the five health conditions included in the model, an R10 minimum price estimated 20 585 lives saved and 9 00 332 cases averted of the disease/injury conditions over the 20-year time horizon. For R5 (R15), we estimated 95 (45 326) lives saved and 4126 (2 038 319) cases averted, respectively. The impact differed by drinker group and by wealth quintile (figure 3). The greatest health benefits accrued to the heaviest drinkers, with the dominant effect related to HIV infections, especially in the bottom three quintiles. Among the heavy drinkers, 85% of the cases averted and 86% of the lives saved accrued to the bottom three quintiles. Occasional binge drinkers achieved most of their positive health impact via a reduction in interpersonal violence and road injury as both of these conditions are linked to binge drinking. There was a small increase in HIV incidence among occasional binge drinkers. The high prevalence of HIV is the source of an important competing risk and the avoidance of death related to acute conditions led to longer exposure to the risk of HIV infection. As expected, the cases saved of liver cirrhosis accrued to the heavy drinkers, as this condition relates to heavy drinking in the long term. Q2 realised the highest number of HIV cases averted due to having the highest proportion of cases at baseline.

Healthcare cost savings accrued over the 20 years and were greatest for intentional injury (table 4). The health cost savings are provided by quintile in online supplemental appendix 16.

Results across policy levels

Comparing across the three policy levels demonstrates the relative impact between wealth quintiles remained largely consistent as the MUP level increased for moderate and occasional binge drinkers (figure 4). For heavy drinkers the wealth gradient becomes more pronounced at R15 particularly with regards to the change in consumption.

The sensitivity analysis that produced the most variable results were the alternative elasticity estimates. Two of the alternative scenarios (−0.8 applied to all drinkers and −0.86/−0.5 applied to Q1 and Q2 with −0.5 applied to Q3 – Q5) produced much greater consumption impacts (−14%, – 18%) coupled with much smaller increases in individual spend (5.4%, 0.1%). All other results are included in online supplemental appendix 15.

DISCUSSION

Our analysis estimates that MUP may offer an effective approach to reducing alcohol consumption and related harm in SA. For an MUP of R10, we estimate an immediate reduction in consumption of 4.40%, increase in individual spend of 18.09% and an increase in retail revenue and taxation. In terms of health impact, we estimate 20 585 lives saved and 9 00 332 cases averted in total across HIV, intentional injury, road injury, liver cirrhosis and breast cancer over 20 years. Regarding the equity impact, our model estimates that the distribution of health outcomes is generally pro-poor, critically important, given these groups also see the greatest relative increase in their alcohol expenditure.

Our research aligns with studies from other countries, which suggest that minimum pricing will reduce alcohol sales and also corresponds to mechanisms, such as greater impact with a rising MUP threshold and greater impact on the poor, found in the international literature.[24 25] We add to the South African minimum pricing evidence currently available[26] by incorporating health outcomes,

Table 2 Consumption and spend R10 policy estimates

	Overall	Q1	Q2	Q3	Q4	Q5
Survey respondents	10336 (100%)	2098 (19%)	2227 (19%)	2337 (21%)	2066 (20%)	1608 (21%)
All drinkers						
n (%)*	3311 (33%)	551 (27%)	690 (30%)	823 (33%)	685 (35%)	562 (38%)
Baseline consumption (standard drinks per week)	21.22	20.83	21.40	20.97	21.98	20.89
Baseline spending (R per week)	R208.74	R148.03	R192.82	R186.95	R231.78	R257.36
Change in consumption (%)	−4.40%	−7.75%	−6.42%	−3.76%	−3.41%	−3.19%
Change in consumption (standard drinks per week)	−0.93	−1.50	−1.29	−0.76	−0.72	−0.65
Change in spending (R per week)	R37.95	R32.81	R32.52	R38.27	R42.64	R43.07
Moderate						
n (%)*	1336 (12%)	206 (10%)	272 (13%)	354 (12%)	273 (13%)	231 (15%)
Baseline consumption (standard drinks per week)	5.05	5.01	5.49	4.90	4.86	4.98
Baseline spending (R per week)	R49.97	R42.75	R48.84	R43.54	R54.38	R56.59
Change in consumption (%)	−8.71%	−12.20%	−12.89%	−7.14%	−6.35%	−6.43%
Change in consumption (standard drinks per week)	−0.40	−0.55	−0.63	−0.33	−0.29	−0.30
Change in spending (R per week)	R5.79	R3.52	R3.91	R6.16	R6.97	R7.30
Occasional binge						
n (%)*	433 (4%)	76 (4%)	89 (4%)	109 (5%)	91 (4%)	68 (4%)
Baseline consumption (standard drinks per week)	9.53	9.69	9.27	9.59	9.27	9.82
Baseline spending (R per week)	R96.87	R68.13	R84.04	R94.63	R120.59	R109.00
Change in consumption (%)	−4.51%	−10.16%	−4.21%	−4.05%	−1.89%	−3.32%
Change in consumption (standard drinks per week)	−0.41	−0.89	−0.37	−0.37	−0.17	−0.32
Change in spending (R per week)	R14.58	R16.69	R9.28	R17.86	R11.31	R16.42
Heavy						
n (%)*	1542 (16%)	269 (14%)	329 (14%)	360 (16%)	321 (17%)	263 (20%)
Baseline consumption (standard drinks per week)	36.72	35.02	39.53	36.20	38.22	35.16
Baseline spending (R per week)	R360.19	R244.13	R356.68	R320.18	R394.90	R439.14
Change in consumption (%)	−4.19%	−7.15%	−5.75%	−3.41%	−3.23%	−2.85%
Change in consumption (standard drinks per week)	−1.48	−2.34	−2.15	−1.19	−1.19	−0.97
Change in spending (R per week)	R69.68	R57.17	R65.17	R67.85	R77.47	R75.08

Data for 10336 survey respondents.
*Numbers refer to absolute sample size, percentages incorporate survey weights, the relevant base is indicated in the top row of their column.
Q1, poorest.

accommodating homebrew and exploring differential impacts by wealth groups. Van Walbeek and Chelwa[26] who produced an economic model to simulate the impact of a MUP on consumption (with no epidemiological modelling) suggest both a higher reduction in consumption and a greater difference in consumption impact between heavy and moderate drinkers. The difference in our estimates is largely due to different price estimates. Their prices are crucially far more heterogeneous between drinker groups, outweighing the impact of the price elasticities. Our prices are drawn from a detailed survey asking for real prices paid by beverage, container and location, which allows us to calculate real prices per SD. Van Walbeek and Chelwa used an average unit value derived from reported monthly alcohol consumption (calculated using quantity/frequency questions) and one

Table 3 Aggregate spend, taxation and retail revenue

Change from baseline in billion rand, per year	R5 MUP	R10 MUP	R15 MUP
Individual spend	R1.24	R32.77	R78.29
Taxation			
VAT	R0.16	R4.27	R10.21
Excise tax	−R0.03	−R1.24	−R3.40
Retail revenue	R1.11	R29.74	R71.48

MUP, minimum unit pricing; VAT, value-added tax.

Table 4 Healthcare cost savings over 20 years, millions

	R5 MUP	R10 MUP	R15 MUP
Antiretroviral therapy costs	−R0.15	R565.82	R1356.51
Intentional injury hospital costs	R32.55	R4304.13	R9088.97
Road injury hospital costs	R16.46	R1975.45	R4265.68
Liver cirrhosis hospital costs	R0.66	R27.60	R68.19
Breast cancer hospital costs	R0.22	R4.00	R10.59

variable asking for monthly spend on alcohol,[26] which gave very low prices for heavy drinkers. Their prices may be too low and ours too high for the heaviest drinkers. If this is the case, our findings may present a conservative estimate of the potential impact of the policy.

Our study has a number of strengths relevant to providing policy-relevant research in LMICs. In the absence of detailed market research purchasing data, we demonstrate how survey, administrative data and the academic literature can be used, in partnership with local stakeholders, to build a contextually relevant epidemiological policy appraisal model. A further strength is our focus on stakeholder engagement from project inception increasing the likelihood of findings being taken into consideration during policy decision-making.[27] MUP was chosen as the policy to model as it was seen as both innovative and potentially well targeted for the South African heavy drinking culture. Stakeholders were pleased the estimates combined improved health with increased taxation and increased retail revenue, as supporting business was considered politically important. The financial cost of MUP is borne by drinkers and there were concerns about how this may impact poorer groups and we recommend this as an area for further research.

A limitation of our study is the lack of high-quality pricing data for SA. Previous studies in HIC have found that moderate drinkers, even those on lower incomes, purchase relatively little cheap alcohol,[24] while the price data used in our model suggest that all drinker groups purchase some cheap alcohol. It is unclear whether this is a true reflection of alcohol purchasing patterns in SA or a limitation of the data. In addition, although we adjusted the off-trade wine prices to be consistent with industry sources, we know that the proportion of wine in the survey is less than the market share. As wine constitutes some of the cheapest available alcohol, an MUP may have a bigger impact than our estimates suggest. If the price of wine increased, we may expect drinkers to switch to other

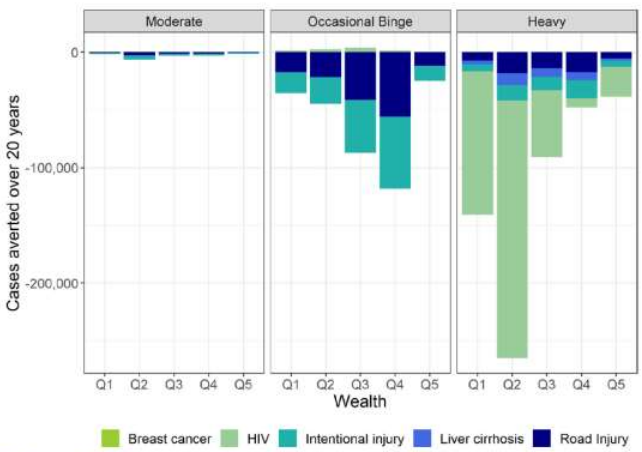

Figure 3 Cases averted by condition, split by drinker group and wealth quintile.

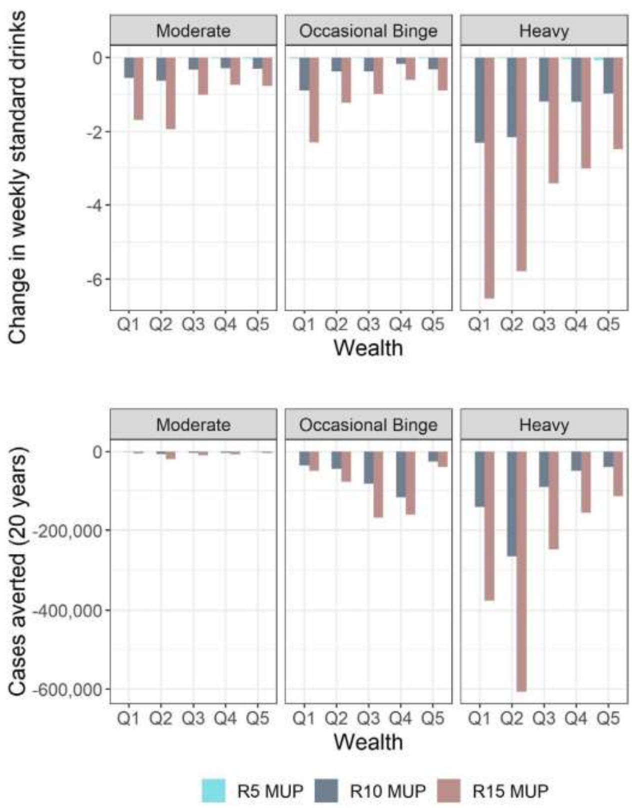

Figure 4 Comparing the three policy levels: change in mean weekly drinks and cases averted by drinker and wealth group. MUP, minimum unit pricing.

cheaper alcohol, however, a key strength of MUP is that the policy applies across all alcohol types, and so drinkers are not able to do this.

Related to this, limitation is the treatment of all drinks as one commodity. South African evidence has suggested that cheap wine has a much higher price elasticity than other drink types.[8] If cheap wine is the drink primarily affected, then this elasticity would lead to less of an increase in individual spend, potentially even a saving, smaller gains to retailers and less of a loss to excise tax revenue as wine enjoys substantially lower rates.

We recommend the following avenues for further research. First, the collection of improved pricing data, specifically the different prices paid for alcohol by different population groups, to explore further the most appropriate level of MUP. Second, the exploration of the financial impact on the poorest groups including any financial benefits such as reduced expenditure on healthcare or improved labour market outcomes. Third, in an alcohol market that includes retailers operating outside of the regulated space (despite largely selling recorded alcohol purchased from licensed outlets), it would be important to understand enforcement mechanisms and the supply chain in order for the policy to maximise effectiveness. However, it should be noted that the IAC pricing data suggest most of the lowest prices are to be found at large supermarkets and bottle stores, which offer bulk discounts rather than small local shebeens that sell alcohol often to be drunk on the premises.

CONCLUSION

Our model estimates that minimum pricing would reduce alcohol consumption in SA, improving health outcomes while raising retail and tax revenue. Consumption and harm reductions would be greater in poorer compared with richer groups. We estimate that minimum pricing is a targeted policy that has the potential to bring health and financial benefits to a country, which suffers a very high burden of alcohol-related harm.

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Conclusion to chapter five

In this chapter, I have estimated the disaggregated impact of a MUP for alcohol in South Africa using a detailed epidemiological policy appraisal model. The model was tailored to the South African context via ongoing stakeholder engagement. The findings indicated that a MUP would reduce alcohol harm in South Africa whilst simultaneously raising retail and tax revenue. The impact of the policy is greatest for poorer groups but the reported financial impact is limited to alcohol expenditure. Exploring the equity impact, via the inclusion of additional financial variables and the illustration of socioeconomic gradients, is the focus of the next chapter (Chapter 6).

6 Chapter six: Equity impact of minimum unit pricing of alcohol on household health and finances among rich and poor drinkers in South Africa

This chapter engages with the concern that the policy is financially regressive by estimating additional financial variables and presenting the socioeconomic gradients of various financial and non-financial outcomes. This enables decision makers to consider a broader range of equity relevant policy impacts.

This chapter is currently in the submission stage with journals.

Once accepted by an academic journal this article will be published open access following the requirement of the Wellcome Trust who financially supported this work. The conditions of the open access publishing allows use of the final published PDF, original submission or accepted manuscript in this thesis (including in any electronic institutional repository or database). The content of the chapter is the same as the currently submitted version of the manuscript. The appendix relating to this chapter is given in Appendix 5.

The paper in the chapter was written with 6 co-authors; Colin Angus, Simon Dixon, Charles Parry, Petra Meier, Micheal Boachie and Stephane Verguet. Naomi Gibbs, with the help of all authors, conceptualised the study. Naomi Gibbs completed the modelling under the supervision of Colin Angus and Stephane Verguet. Micheal Boachie provided data inputs for the model. Naomi Gibbs wrote the first draft, all authors revised it.

TITLE: EQUITY IMPACT OF MINIMUM UNIT PRICING OF ALCOHOL ON HOUSEHOLD HEALTH AND FINANCES AMONG RICH AND POOR DRINKERS IN SOUTH AFRICA

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ABSTRACT

Introduction

South Africa experiences significant levels of alcohol-related harm. Recent research suggests minimum unit pricing (MUP) for alcohol would be an effective, well-targeted policy, but high levels of income inequality raise concerns about equity impacts and potential regressivity of the policy. This paper quantifies the equity impact of MUP on household health and finances in rich and poor drinkers in South Africa.

Methods

We draw from extended cost-effectiveness analysis (ECEA) methods and an epidemiological policy appraisal model of MUP for South Africa to simulate the equity impact of a ZAR 10 MUP over a 20-year time horizon. We estimate the broader impact across wealth quintiles on: (i) the change in alcohol consumption and associated alcohol expenditures; (ii) the change in mortality (i.e. the number of deaths due to alcohol-related diseases averted); (iii) the healthcare cost savings for the South African government; (iv) the financial risk protection benefits for households (i.e. reductions in cases of catastrophic health expenditures (CHE) induced by out-of-pocket (OOP) costs for treatment of alcohol-related diseases) and household savings due to reduced indirect costs linked to health-related workplace absence.

Results

Over 20 years, the ZAR 10 MUP policy would reduce alcohol consumption more among the poorest than among the richest South Africans. Alcohol expenditures would increase by around ZAR 353,000 million (1 USD = 13.2 ZAR), with the poorest quintile contributing the smallest proportion (13%) and the richest the largest (28%) although this still remains regressive when compared with mean income. Of the 22,600 alcohol-related deaths averted, 56% of these accrue to the bottom two quintiles; and the healthcare cost savings would be substantial (ZAR 3·9 billion) for the South African government. Household OOP and indirect cost savings would amount to ZAR 2·9 billion and ZAR 51·1 billion,

respectively; and 564,700 CHE cases would be averted, 46% of these among the poorest two quintiles.

Conclusions

A MUP policy in South Africa has the potential to reduce harm and reduce health inequality. Fiscal policies for population health require structured policy appraisal, accounting for the totality of effects using mathematical models in association with ECEA methodology.

SUMMARY BOX

What is already known?

- Alcohol pricing policies, such as taxation and minimum unit pricing (MUP), are consistently recommended by the World Health Organisation as one of the most cost-effective measures governments can use to reduce alcohol harm.
- Two recent South African studies have estimated that MUP would be an effective policy in the South African context.
- Pricing policies on harmful products often face criticism for their potentially disproportionate financial burden imposed on the poorest socioeconomic groups.

What are the new findings?

- This study estimates that the policy is regressive if analysed using only alcohol consumption expenditures.
- However, we demonstrate that health impacts and other financial outcomes such as avoiding catastrophic health expenditures follow a pro-poor distribution.
- We also demonstrate healthcare cost savings to the government which could potentially be redistributed to further support poorer groups.

What do the new findings imply?

- Pricing policies cannot be judged merely by financial regressivity of the consumption expenditures.
- Structured policy appraisal accounting for the totality of effects using mathematical models in association with ECEA methodology can support decision-makers who must make trade-offs across relevant domains.

INTRODUCTION

In 2019, alcohol use was identified as the eighth highest risk factor for mortality in South Africa (1). Despite the fact that the prevalence of drinking (and of heavy drinking) increases with wealth there is an inverse relationship with alcohol harm, with lower socioeconomic groups experiencing the greatest harms (2). In South Africa, alcohol harm is wide-reaching, encompassing non-communicable diseases (NCDs), injuries and infectious diseases. There are high levels of abstinence (82/46% among women/men) coupled with high levels of heavy episodic drinking amongst those who drink (3). As a result of the heavy episodic drinking the alcohol harm profile contains significant levels of alcohol-related violence and road injury (1). South Africa also has a high HIV prevalence (14% (4)) in which alcohol plays a role via increasing risky sexual behaviour and reducing treatment adherence.

Pricing policies are consistently recommended as one of the most cost-effective strategies in reducing the burden of alcohol (5). South African research has found that fiscal policies are effective in improving population health including raising excise taxes on beer (6) and levying a tax on sugar-sweetened beverages (7, 8). The South African government has used high excise tax increases on tobacco since 1994 which effectively reduced consumption (7).

Taxation is the most common pricing policy utilised in combating alcohol harm but minimum unit pricing (MUP) is increasing in profile and has been adopted by a number of jurisdictions around the world, including Scotland, Wales, Australia’s Northern Territory and Russia (8, 9) and is now being considered by the Western Cape provincial government in South Africa (10). MUP is a policy whereby a retail floor price is set contingent on the alcohol content of the drink. This means the policy targets the very cheapest alcohol on the market, consumed primarily by the heaviest, and often the poorest, drinkers. This is in contrast to the effect of raising excise taxes which increases prices across the price distribution in a more uniform manner.

The current South African alcohol taxation system is inconsistent, with wine and traditional African beer taxed per litre of drink (ZAR4.4/ZAR0.8 for wine/African beer) and malt beer and spirits taxed per litre of absolute alcohol (ZAR106.6/ZAR213.1 for beer/spirits) (11). This taxation system results in wine and traditional beer benefiting from much lower rates of tax by volume of absolute alcohol. There are currently no minimum prices in effect. Two recent policy appraisal studies have estimated that MUP would be an effective policy in the South African context to reduce overall consumption and harm, particularly amongst the heaviest drinkers (12, 13).

South Africa experiences high levels of income inequality and around 45% of households are in receipt of at least one form of social grant in 2015 (14). In addition, income-related health inequality has increased as a result of COVID-19 (15). Against this backdrop a significant equity concern relating to pricing policies such as MUP for South Africa, and many other countries, is their potentially financially regressive nature. That is, the ratio of increase in alcohol expenditures to income would become smaller as wealth or income increases, and as such poor income groups could bear a disproportionate financial burden following MUP implementation (16, 17). However, this partial view fails to account for the broader set of financial consequences following enforcement of pricing policies including MUP. Importantly, these financial consequences include, for example, the reductions in out-of-pocket (OOP) costs associated with decreased alcohol-related disease treatment costs and the potentially ensuing medical impoverishment for drinkers and their families, as well as household income savings associated with reduced absenteeism tied to alcohol-related disease. A wider perspective would also consider non-financial flows (e.g. health benefits associated with reduction in alcohol-related disease morbidity and mortality) where low-income groups are likely to benefit more due to their disproportionate disease burden at baseline. Finally, any increase in revenue to the government, either through taxation or through savings to the healthcare sector budget, are likely to result in a progressive redistribution of resources, such that the increased budget is used to make payments or provide services which benefit the lowest income groups (18, 19). In summary, examining a broad range of effects, along both the health and financial dimensions, of pricing policies for harmful products (e.g. alcohol, tobacco, and sugary drinks), is absolutely essential to enable the comprehensive assessment of their equity and redistributive impact.

In this paper, we build upon a recently published modelling study of MUP in South Africa (12) which details an epidemiological policy appraisal model. We draw from extended cost-effectiveness analysis (ECEA) methods (20-22), which enable the equity impact evaluation of health policies along socioeconomic groups, so to exhibit a broad range of outcomes and the potentially pro-poor (or regressive) features of MUP for alcohol in South Africa.

METHODS

General approach

We build upon a recent MUP model contextualized to South Africa that is described in great detail elsewhere (14). The model uses a public health epidemiological model that can be best described as a comparative risk assessment model using multistate life tables (23). We expand this MUP model in applying the ECEA framework. ECEA examines the impact of policy along both health and financial dimensions (22): (i) health gains, in other words the number of deaths related to a selection of alcohol-related diseases averted; (ii) financial gains, which include the amount of OOP costs tied to treatment of alcohol-related diseases averted and their associated financial risk protection (FRP) benefits (e.g. corresponding to the prevention of medical impoverishment from OOP treatment costs of alcohol-related diseases). All health and financial dimensions are then displayed in a disaggregated manner across socioeconomic groups (e.g. wealth quintiles) so as to point to the potentially pro-poor impact of the policy. We populate our expanded model while drawing from multiple sources of data disaggregated across South African socioeconomic groups including household surveys, administrative datasets, and the published literature (Table 1; webappendix sections 1-2).

Table 1: Data inputs and corresponding sources used in modelling of the equity impact of the minimum unit pricing policy for alcohol in South Africa.

	Wealth quintiles (QI = poorest)					
Input	**QI**	**QII**	**QIII**	**QIV**	**QV**	**Source**
Alcohol consumption, prices and elasticities						
Prevalence of drinking	27%	30%	33%	35%	38%	SA DHS 2016
Prevalence of heavy drinking (more than 15 standard drinks per week)	14%	14%	16%	17%	20%	SA DHS 2016
Mean individual baseline consumption (standard drinks per week)	20.6	21.4	20.9	21.7	20.7	SA DHS 2016 calibrated to Euromonitor
Mean price per standard drink **Moderate** **Occasional binge** **Heavy**	 R9.1 R8.0 R7.8	 R9.1 R10.0 R9.7	 R9.1 R10.1 R9.2	 R11.6 R13.4 R10.6	 R11.6 R11.1 R12.8	International Alcohol Control Study (2014) adjusted for inflation to 2018 prices Gibbs et al. (2021)
Price elasticity by drinker groups* **Moderate** **Occasional binge** **Heavy drinkers**	 -0.53 -0.29 -0.24	 -0.53 -0.29 -0.24	 -0.31 -0.17 -0.14	 -0.31 -0.17 -0.14	 -0.31 -0.17 -0.14	Van Walbeek and Chelwa (24) authors' calculations (webappendix section 3) Gibbs et al. (2021)
Share of disease at baseline**						
HIV	20%	36%	32%	9%	3%	Authors' calculations using GHS 2018
Intentional Injury **road injury** **Liver cirrhosis**	9%	29%	26%	26%	10%	Authors' calculations using GHS 2018
Breast cancer	7%	7%	22%	18%	47%	Authors' calculations' using GHS 2018
Disease-related expenditure and utilisation						
Proportion of disease-related expenditures paid as OOP	21%	18%	41%	56%	82%	Saxena, Stacey (20)
HIV utilisation rates	63%	71%	69%	60%	89%	Authors' calculations using GHS 2019 (webappendix section 5)
Trauma care utilisation rates – intentional injury	39%	40%	40%	40%	47%	Authors' calculations using GHS 2019 data plus Matzopoulos, Prinsloo (25) (webappendix section 5)
Trauma care utilisation rates – road injury	18%	19%	18%	18%	22%	Authors' calculations using GHS 2019 data; Matzopoulos, Prinsloo (25) (webappendix section 5)
Healthcare utilisation rates – liver cirrhosis	52%	55%	54%	53%	63%	Authors' calculations using GHS 2019 (webappendix section 5)
Healthcare utilisation rates – breast cancer	52%	56%	50%	68%	89%	Authors' calculations using GHS 2019 (webappendix section 5)
Labour and productivity						
Labour force participation	62%	50%	55%	64%	74%	Authors' calculations using GHS 2019 data
Annual income per capita (ZAR)	6,100	27,400	49,300	95,600	408,900	Authors' calculations using GHS 2019 data deflated to 2018
Absenteeism (days per year) **HIV** **Intentional injury** **Road injury** **Liver cirrhosis** **Breast cancer**	 14 10 18 6 6	 14 10 18 3 6	 14 10 18 3 6	 14 10 18 3 6	 14 10 18 3 6	Maffessanti and Lee-Angell (26) Bola, Dash (27) Parkinson, Kent (28) Matzopoulos, Truen (29) Tangka, Trogdon (30) (webappendix section 6)

SA = South Africa; DHS = Demographic and Health Survey. GHS = General Household Survey. OOP = out-of-pocket.
***Drinker groups: Moderate = less than 15 standard drinks per week; Occasional binge = less than 15 drinks per week but drinks more than 5 on at least one occasion; Heavy = 15 or more standard drinks per week. Standard drink = 12 gram or 15ml of pure ethanol.**
****Share of disease at baseline indicates how the cases of the disease/injury conditions are distributed amongst the quintiles.**

Importantly, we examine a broad range of effects of a MUP policy for alcohol, along both the health and financial dimensions and across socioeconomic groups, in South Africa. We track the following outcomes, as a result of MUP, across national wealth quintiles: the impact on alcohol consumption; the change in mortality attributed to alcohol-related diseases (five major alcohol-induced conditions are included: HIV, intentional injury, road injury, liver cirrhosis, and breast cancer); the change in alcohol consumption expenditures; the reduction in expenditures, both for the government and households (i.e. OOP cost savings), associated with treatment of alcohol-related diseases, and the FRP benefits for households linked to reductions in those OOP costs for treatment of alcohol-related diseases; and the household savings tied to indirect costs (associated with absenteeism) following the decreased burden of alcohol-related diseases.

Policy simulation

A MUP policy is where the government legislates for a retail floor price based on the alcohol content of the drink, in this case ZAR 10 (USD 0.76) for one standard drink (12 grams of pure alcohol, i.e. 330mL beer or a 125mL glass of wine), a level chosen by policymakers. It pushes all prices currently below that level up to that level. We assume all prices above that level remain unchanged. This results in a price increase experienced by the consumer (dependent upon how much cheap alcohol they purchase) which, dependent on their price responsiveness (measured by their price elasticity of demand) will change their purchasing decisions. All these simulations are disaggregated across South African wealth quintiles.

Modelling features

Price, consumption, and health impact

To model the relationship between alcohol price and consumption, we first estimate the pre-intervention mean and peak alcohol consumption at the individual level. The base year for the model is 2018 and all monetary inputs are indexed to this year. The model includes the adult population only (those aged 15 years and older). Drinkers are classified as moderate (consumption of <15 standard drinks per week), occasional binge (consumption of <15 drinks per week but drinks >5 drinks on one occasion) and heavy (>=15 drinks per week). The change in price from the policy is translated into a change in individual consumption using an elasticity of demand for alcohol which varies by drinker type and wealth group (webappendix, sections 3-4). Adjustments are made for individuals increasing consumption of homebrew (about 4% of all reported alcohol consumption in the survey was homebrew). Individual-level changes in consumption and spending are then aggregated to get results at the wealth quintile level at baseline and under MUP. Increases in individual consumption expenditures are projected forward and discounted at 5% per year, a rate recommended by South Africa's Department of Health (31) before being aggregated across quintiles.

Given that depending on the health condition there can be a delay between changes in alcohol consumption and changes in health risks, the model uses a 20-year time horizon to assess the full impact of MUP on disease or injury outcomes. Our model calculates relative risks (RR) for each of five major conditions that can be associated with alcohol consumption: HIV, intentional injury, road injury, liver cirrhosis, and breast cancer. It uses individual alcohol consumption at baseline and at ZAR 10 MUP. The five conditions were chosen by stakeholders during the original model development process (14). Potential impact fractions (PIFs) were calculated by dividing RR under MUP by RR at baseline. Using these PIFs and projecting the population forward 20 years we could compute the number of deaths averted by MUP. These projected populations (no MUP vs. ZAR 10 MUP) were then combined with the probability of having the condition (disease or injury) to estimate disease-specific cases and deaths (12).

Healthcare expenditures, OOP costs, and financial risk protection

The prevalence of each condition (disease or injury) under each policy scenario was multiplied by the proportion who would then go on to receive treatment using condition- and quintile-specific healthcare utilisation rates (Table 1). Condition-related treatment unit cost estimates were sourced from the literature and adjusted for inflation (32) (where necessary) to reach the baseline year of 2018. All future costs were discounted at 5% per year (31). The multiplication of those condition-related treatment unit costs by the corresponding condition-related utilisation rates would yield expected treatment costs for each condition.

Healthcare in South Africa is delivered via a mix of public (with contributions from the patients determined on a sliding pay scale) and private providers and health insurance mechanisms. As such, the reduction in the burden of alcohol-related conditions/diseases will lead to decreases in healthcare costs for both the South African government ("government savings") and households ("OOP cost savings"). The partition of these healthcare cost savings into either government savings or OOP cost savings was attributed by using the mean shares (percentages) of OOP health financing (out of total health financing) for each wealth quintile using previously published estimates (20, 33).

Subsequently, financial risk protection (FRP) benefits associated with household cost savings were derived for each quintile. The measure of (lack of) FRP used was the number of cases of catastrophic health expenditure (CHE) averted by MUP. A case of CHE would be counted when, for an instance of alcohol-related condition seeking care, the disease-related OOP treatment costs averted would exceed 10% of total annual household income.

Lastly, we computed indirect costs using the human capital approach. This included an estimation of the value of lost (productive) time, using gross wage as the measure of value, as a result of the morbidity associated with the five conditions enumerated above. Indirect costs were calculated by applying the number of lost days due to disease/injury per year by the mean daily wage by income quintile, taking into account the labour force participation by quintile and prevalence of disease. The evidence relating productivity and alcohol remains inconclusive and so was not modelled (34).

Sensitivity analyses

We conducted multiple univariate sensitivity analyses on key parameters including: price elasticities; CHE thresholds; and wage rates. For price elasticities, we explored two alternative scenarios. Firstly, we removed the wealth gradient from the price elasticity estimates using -0.40, -0.22, and -0.18 for moderate, occasional binge, and heavy drinkers, respectively. Secondly, we used alternative price elasticities estimated by Van Walbeek and Blecher (35) using National Income Dynamic Study data for two subsets of the population, the top and bottom 50% of households by total expenditures. We applied -0.86 to quintiles I and II and -0.50 for quintiles III, IV, and V (to be conservative). These estimates are closer to other South African alcohol elasticity estimates including -0.80 and -0.75 (35). For the estimation of CHE cases, we used alternative thresholds of 25% and 40% of income. Finally, we applied the South African minimum wage (ZAR20.8) per hour across all quintiles to calculate productivity losses. This avoided applying less value to those on lower wages, in the calculation of indirect costs.

Display of findings

All results are given in ZAR (R). Headline results quoted in the text are also converted into USD using the exchange rate at 2018 of R13.2 per USD (36). All computations were realised using R statistical software (code available here). Our results are disaggregated by wealth quintile for the following outcomes: deaths averted attributed to alcohol-related diseases and injuries; net change in alcohol expenditures; government cost savings; household OOP cost savings and number of CHE cases averted; and indirect cost savings.

RESULTS

Firstly, the reduction in consumption would be substantially more among the poorest than the richest (-7.8% relative decrease vs. -3.2%) out of an overall change in consumption of -4.4% (for a R10 MUP). Total deaths averted were estimated at 22,600: the greatest number of deaths averted would accrue to quintile II while overall those benefits would largely be pro-poor with 56% of deaths averted accruing to the bottom two quintiles (Table 2; Figure 1). This in fact reflects the underlying gradients of the five conditions examined. The smallest effect is for the richest quintile which would accrue only 7% of the total deaths averted.

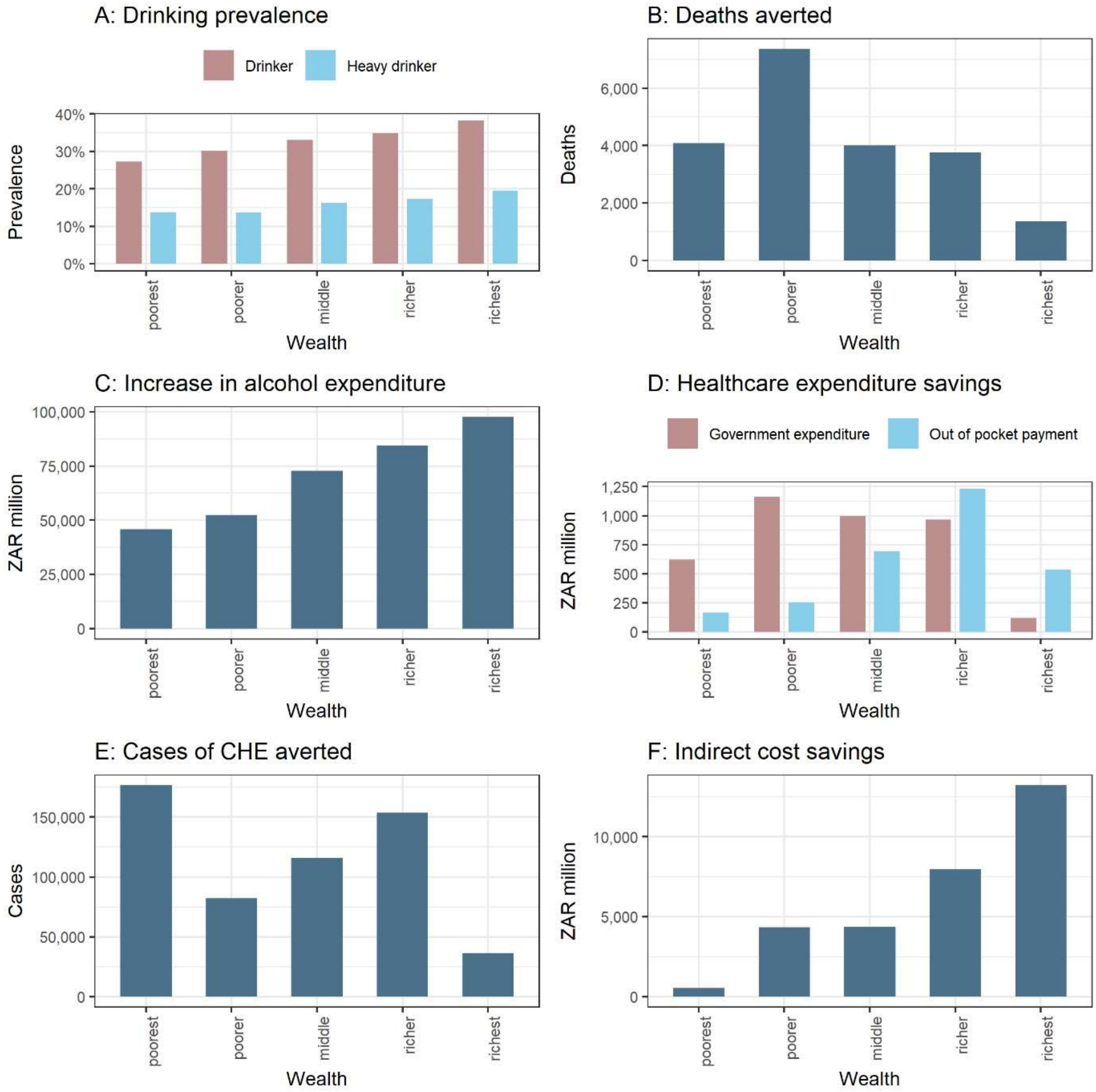
Table 2: Net change in health and financial outcomes across socioeconomic groups for a ZAR10 Minimum Unit Pricing policy in South Africa

	Overall		QI	QII	QIII	QIV	QV
Deaths averted	22,600		4,100	7,400	4,000	3,800	1,400
Net change in alcohol expenditures (ZAR million)	R353,000		R46,000	R52,000	R72,800	R84,500	R97,600
OOP healthcare cost savings (ZAR million)	R2,900		R200	R300	R700	R1,200	R500
Government healthcare cost savings (ZAR million)	R3,900		R600	R1,200	R1000	R1000	R100
Cases of CHE averted	564,700		176,700	82,000	115,900	153,800	36,400
Annual indirect cost savings (ZAR million)	R51,100		R4,700	R11,600	R8,400	R11,800	R14,700

QI = poorest income quintile; QV = richest income quintile. CHE = Catastrophic health expenditures; OOP = out-of-pocket; ZAR/R = South African rand.
All results projected over a 20-year time horizon.
Deaths averted and CHE cases averted rounded to the nearest hundred.
Financial outcomes rounded to the nearest hundred million.

Figure 1: Estimated distributions, across wealth quintiles, of the health and financial outcomes following implementation of Minimum Unit Pricing (MUP) in South Africa.

Panel A = Drinking prevalence, Panels B – F demonstrate the distributional (equity) impact of the policy, all estimates are for a 20-year time horizon; B = Deaths averted; C = Net change in alcohol expenditures; D = Healthcare cost savings (government vs. OOP cost savings); E = Cases of catastrophic health expenditures (CHE) averted, F = Indirect costs savings.



Given the baseline price elasticities of demand for alcohol are relatively inelastic (-0.14 to -0.53), when prices rise, demand would reduce by less in proportionate terms, which leads to increased alcohol expenditures. We estimated increased expenditures of ZAR 353,000 million (USD 26,700 million). The poorest would contribute the lowest proportion (about 13%) while the richest the largest (around 28%) of the expenditures (Figure 1). Despite the richer quintiles experiencing the smallest percentage increase in alcohol prices (driven by their higher baseline mean price) they would still pay the largest share of increased alcohol expenditures due to their lower price elasticity and higher prevalence of drinking. The policy would be regressive (in the narrow consumption expenditure sense) with the ratio between increased expenditures on alcohol and income estimated to be 27.0, 5.9, 3.9, 2.2, and 0.5% from the poorest to the richest quintile.

In addition, we estimated a reduction in OOP healthcare costs of about ZAR 2.9 billion (USD 0.22 billion) and government cost savings of approximately ZAR 3.9 billion (USD 0.30 billion). The relative distribution of these costs across quintiles reflects the sliding scale of payments charged for healthcare in South Africa with the bottom two quintiles paying the least amount of OOP costs (21% and 18% shares, respectively), consequently they would see the smallest OOP savings (Figure 1).

Furthermore, we found that 564,700 CHE cases would be averted. Quintile I would accrue the highest number of CHE cases due to their very low incomes meaning even small OOP treatment costs would lead to CHE cases. Quintile IV also realises high numbers of CHE cases averted as the rise in income is offset by the reduction in government subsidy for healthcare costs incurred. As expected, quintile V would accrue the smallest number of CHE cases averted, with only about 6% of all cases (Figure 1).

Lastly, the savings in indirect costs were estimated at ZAR 51,100 million (USD 3,900 million). There is generally a positive gradient across the quintiles driven by both the increasing labour participation and increasing wage rate (Figure 1).

Sensitivity analyses

A key driver for the results is the price elasticities. We explored two alterative scenarios. Firstly, using -0.40 (moderate), -0.22 (occasional binge), and -0.18 (heavy drinkers), without applying any wealth gradient, the resulting consumption impact would be reduced but remain pro-poor (-5.7% for the poorest vs. -4.1% for the richest). Secondly, using -0.86 for quintiles I and II and -0.50 for quintiles III to V would result in a reduction in alcohol expenditures, compared with baseline, for quintiles I and II (Table 3; Figure 2).

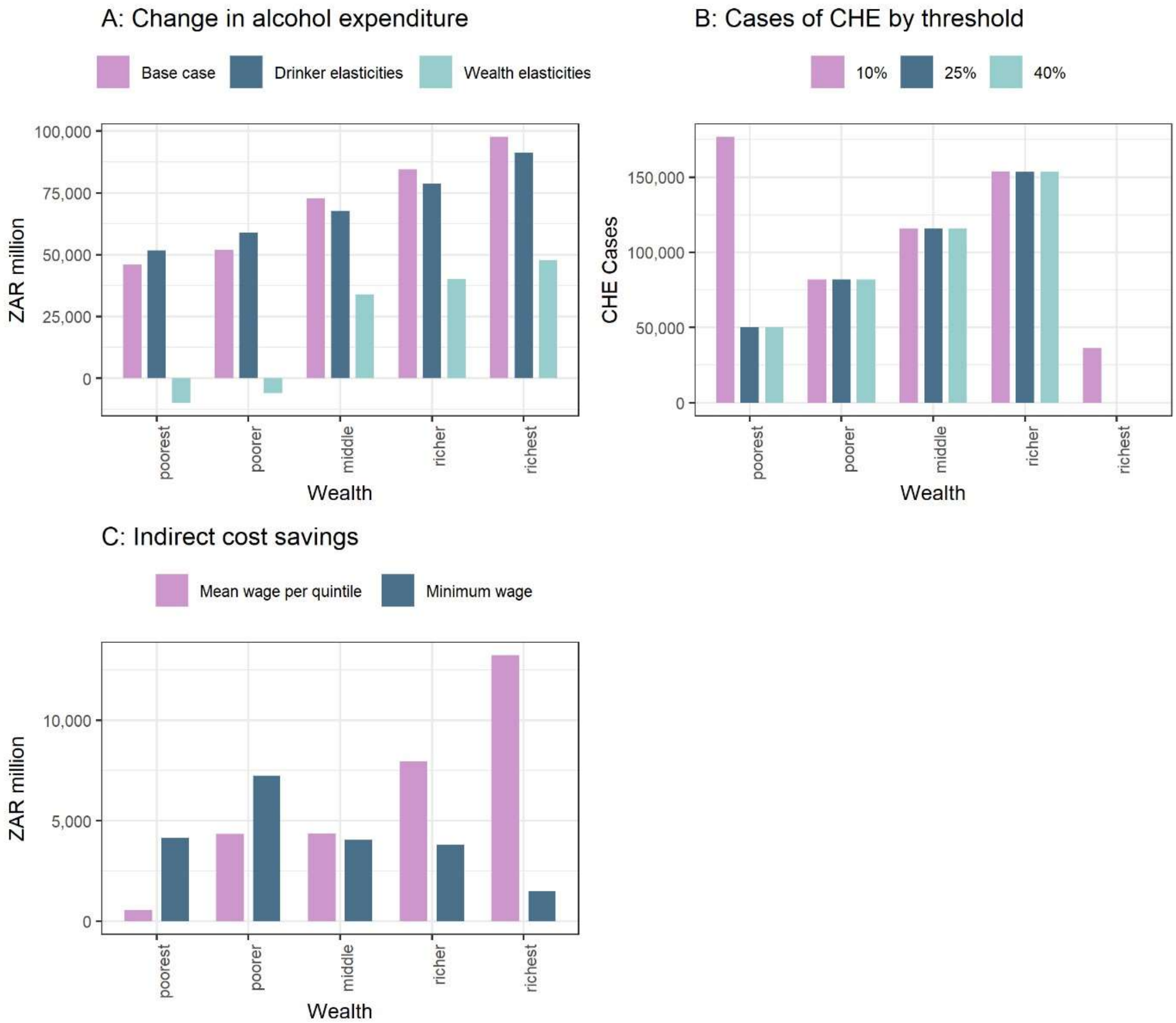
When the CHE threshold was varied from 10% to either 25% or 40%, the number of CHE cases averted would fall to 401,300 for both alternative thresholds (from 564,700 previously) (Table 3). This is driven primarily by a change to the number of CHE cases averted in quintile I (Figure 2).

Lastly, we estimated indirect cost savings using the minimum wage (ZAR 20.8) across all quintiles instead of the mean wage per quintile in the base case (Table 3). As expected, the total indirect cost savings would decrease and the benefits shift towards the poorer quintiles (Figure 2).

Table 3: Key results for the sensitivity analyses (over a 20-year time horizon). A = change in deaths averted and alcohol consumption expenditures for three distinct price elasticity sets; B = cases of catastrophic health expenditures (CHE) with 10/25/40% thresholds; C = indirect cost savings using minimum wage across the quintiles versus wage by quintile.

Sensitivity analysis: Elasticities, CHE thresholds, Wage rates							
	Overall		QI	QII	QIII	QIV	QV
Panel A: Varying elasticities							
Drinker groups adjusted for wealth (base case)							
Deaths averted	22,600		4,100	7,400	4,000	3,800	1,400
Change in consumption expenditures for drinkers (ZAR million)	R353,000		R46,000	R52,000	R72,800	R84,500	R97,600
No wealth gradient: -0.4/-0.22/-0.18 moderate/occasional binge/heavy drinkers							
Deaths averted	18,717		1,500	6,500	4,400	4,500	1,800
Change in consumption expenditures for drinkers (ZAR million)	R348,600		R51,800	R58,900	R67,800	R78,800	R91,200
No drinker gradient: -0.86/-0.5 poorest-poorer/middle - richest							
Deaths averted	52,400		11,800	18,400	10,600	8,300	3,400
Change in consumption expenditures for drinkers (ZAR million)	R106,000		-R9900	-R5900	R33,900	R40,200	R47,800
Panel B: Cases of CHE averted at 10%, 25% and 40% thresholds							
10% (base case)	564,700		176,700	82,000	115,900	153,800	36,400
25%	401,300		50,200	81,900	115,700	153,600	0
40%	401,300		50,200	81,900	115,700	153,600	0
Panel C: Indirect cost savings (ZAR million) for baseline and minimum wage							
Indirect costs savings using mean wage by quintile (base case)	R51,100		R4,700	R11,600	R8,400	R11,800	R14,700
Indirect cost savings using minimum wage applied across all quintiles	R20,700		R4,100	R7,200	R4,100	R3,800	R1,500
QI = poorest income quintile; QV = richest income quintile. ZAR/R = South African rand. Deaths averted and CHE cases averted rounded to the nearest hundred. Financial outcomes rounded to the nearest hundred million.							

Figure 2: Distributional (equity) impact of the sensitivity analyses. All estimates are for a 20-year time horizon. A = Change in alcohol expenditures comparing three different price elasticity sets; B = Cases of catastrophic health expenditures (CHE) using alternative thresholds; C = Indirect costs savings.



DISCUSSION

We demonstrated in this paper that a ZAR 10 MUP policy could significantly reduce alcohol consumption in South Africa, with far greater reductions for the poorest than the richest wealth quintiles. Importantly, we also determined that the number of alcohol-related deaths averted would largely be pro-poor, with 56% of the total deaths averted accruing to the bottom two quintiles. The increase in alcohol expenditures would increase with wealth. However, when calculated as a proportion of income the increase in alcohol expenditures is greatest for the poorest, which was to be expected given the large income inequalities in South Africa.

Additionally, reductions in alcohol-related disease healthcare expenditures (approximately ZAR 6.8 billion or USD 0.52 billion) would be very substantial with consequent government cost savings and household OOP cost savings reflecting South Africa's health system financing structure (37). Importantly, FRP benefits would be large with CHE cases averted concentrated between quintiles I to IV. Indirect cost savings of ZAR 51,100 million (USD 3,900 million) would be distributed towards the rich due to their higher labour market participation rates coupled with higher wage rates.

Despite this range of positive impacts, the increases in alcohol expenditures relating to MUP are regressive in the sense that the increase in alcohol expenditures relative to income is 27% for the lowest income quintile, compared to 0.5% in the richest quintile. The basic reason for this is that the currently available estimates of price elasticity show the demand for alcohol to be inelastic; that is, consumption reductions following a price change are small, thereby increasing expenditures. When increased expenditures are coupled with a very unequal distribution of income then the resulting expenditures become regressive. If the elasticity estimates are correct, this regressive component of MUP is not going to change. However, our modelling provides wider information beyond this natural consequence of a basic economic principle. Importantly, it quantifies the trade-offs that faces the South African government when considering MUP. As we show, MUP is expected to have many benefits, both in absolute terms and in equity terms, and our results provide the information needed to assess whether the overall effects are considered socially desirable (or not). Although the policy might be regressive in a narrow economic sense (yet, this is less clear if you consider CHE), it is almost certainly progressive in a wider health context. In addition, the formulation of a subset of these findings in the form of an ECEA provides a simpler way to communicate this information to decision-makers. Also, but beyond the scope of this paper, by knowing the scale and nature of all these impacts it is possible to use our model to design auxiliary policies that will mitigate the regressivity in relation to alcohol expenditures, for example, redirecting the increased tax revenues and healthcare budget savings associated with MUP to lower socioeconomic groups.

It is also important to consider these findings in the context of South Africa's high abstinence rates. In every quintile, self-reported abstainers are in the vast majority, particularly amongst women (82%). Non-drinkers will experience benefits from a reduction in others' drinking via reductions in intimate partner violence, foetal alcohol syndrome, and other forms of crime and violence (38, 39), as well as reductions in household OOP treatments (which we document in this paper). There may also be benefits from a reduction in alcohol initiation. However, non-drinkers may also suffer as a result of the policy through the impact on the household budget with resources being diverted to pay for alcohol (i.e., crowding-out). This concern is common across pricing policies of unhealthy goods and further reinforces the importance of the pro-poor use of any generated tax revenues or healthcare cost savings (40). The introduction of a MUP policy would benefit from a comprehensive monitoring and evaluation programme including qualitative interviews with households comprising of at least one heavy drinker to assess this impact and possibly also tracking the impact of conditions shown during the COVID-19 pandemic to particularly affect the healthcare system, such as alcohol-related trauma admissions in South Africa (41).

Our sensitivity analyses employing alternative elasticities highlight the importance of these critical input parameters on the distributional impact of MUP. If the poorer quintiles are highly price elastic (as in the scenario with -0.86), then the model estimates cost savings for these groups. This would mean MUP would cease to be regressive in terms of consumption expenditures. We recommend further research to estimate elasticities for poorer drinkers, disaggregated by drinker type group.

In addition, alternative alcohol pricing policies such as moving to a consistent volumetric tax system (in which all alcohol is taxed based on litres of absolute alcohol) could produce similar results by "eliminating" the cheapest alcohol. In addition, they would provide an increase to the fiscal budget rather than to economic operators. This could theoretically be reinvested in policies such as providing alcohol treatment services to low-income groups. In the case of MUP, any increase in revenue is kept by the retailer which may be seen as supporting business by advocates of the policy, however, the government will also realise some of the benefit via increased taxes.

Limitations

This research is limited by a number of factors. First, there are inherent limitations associated with the pricing data we used (e.g. alcohol being considered as one sole commodity) (12). Second, our modelling only included five of over thirty wholly or partially alcohol-attributable conditions, and, as such, would only represent a limited proportion of all potential health outcomes and associated healthcare cost savings (42). Moreover, we have conservatively estimated healthcare costs: for example, HIV-related costs were estimated only for first line antiretroviral therapy, and including higher HIV costs would likely lead to greater savings in quintiles I and II (with higher HIV prevalence). Third, we were unable to include all costs associated with the diseases and injuries examined, such as transport costs, traditional medicine costs, and caregiver costs which may be significant and therefore underestimate the potential cost savings of the policy (43). Fourth, we used wealth quintiles based on an asset score of ownership of certain goods and access to facilities such as water and sanitation, while a number of our input parameters (e.g. utilisation rates, wages) used income to categorise people into quintiles: this may introduce some small variations although they should broadly correspond.

CONCLUSION

This study has demonstrated a complex set of impacts with wealth gradients varying dramatically across the policy relevant health and financial outcome measures. This highlights the critical relevance for structured policy appraisals accounting for the comprehensive impacts of fiscal policies like “sin” or health taxes and pricing policies, which goes beyond the mere assessment of regressivity or progressivity solely based on a narrow income-share accounting definition of price or tax burden

(19). The ZAR10 MUP policy would be financially regressive in terms of increased alcohol expenditures (despite the richest paying the largest share of the increased expenditures), however, the poorest groups would gain more health benefits (greater numbers of deaths averted) and face an increased chance of avoiding CHE and medical impoverishment. Policymakers must balance a broad range of aggregate and distributional effects along with accompanying trade-offs in order to make socially optimal policy decisions, promote health equity and reduce inequalities.

Contributions

NKG, with the help of all authors, conceptualised the study. NKG completed the modelling under the supervision of CA and SV. MKB provided data inputs for the model. NKG wrote the first draft, all authors revised it. An earlier version of this paper was presented at the meeting of the International Health Economics Association (2021), the KBS Alcohol Epidemiology conference (2021) and at the York Centre for Health Economics seminar series (2021), where we received valuable comments from participants.

Competing interests

We declare no competing interests.

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the study had no role in the study. All authors had full access to all the data in the study and were responsible for the decision to submit the article for publication.

Ethics committee approval

Ethical approval for engaging with stakeholders was granted by the South African Medical Research Council (Protocol ID: EC005-4/2019) and the School of Health and Related Research at the University of Sheffield, UK (Reference Number: 023357). All data for the model came from secondary sources and were managed according to an approved information governance plan.

Patient and Public Involvement

Patients or the public were not involved in the design, or conduct, or reporting, or dissemination plans of our research.

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Conclusion to chapter six

In this chapter I applied an extended cost-effectiveness analysis methodology to my published model in order to address the concern the policy is regressive by demonstrating socioeconomic gradients across a number of policy relevant variables. Additional financial variables, namely out of pocket healthcare costs, catastrophic health expenditure and lost wages, are added to the model and the distribution of all outcomes between wealth quintiles are able to be directly compared via simple graphs. This provides decision makers with a breadth of outcomes communicated in an accessible format and adds to the limited number of published studies demonstrating the potential impact of a MUP in South Africa.

7 Discussion

This chapter starts with a summary of the main findings from the PhD. It then outlines strengths, limitations and suggestions for further research. The chapter ends with policy implications and concluding remarks.

7.1 Introduction

7.1.1 Main findings

This PhD has sought to estimate whether MUP of alcohol would be an effective policy to reduce consumption and related harm in the South African context. Further to this, the potential equity impact of the policy has been explored, defined as differential impact by wealth quintile.

This PhD has estimated that a R10 MUP would reduce consumption by around 4.4% (-4.2%/-4.5%/-8.7% for heavy/occasional binge/moderate drinkers) and increase spending by 18%. The absolute reduction in consumption is greatest for heavy drinkers (-1.48 standard drinks per week), followed by occasional binge drinkers (-0.41 standard drinks per week) and moderate drinkers (-0.40 standard drinks per week). Over 20 years approximately 20,600 fewer deaths and 900,000 cases averted across HIV (429,200 cases), intentional injury (216,200 cases), road injury (221,500 cases), liver cirrhosis (32,400 cases) and breast cancer (1,000 cases) are estimated. Net taxation would also increase due to increases in Value Added Tax (VAT) despite reduction in excise taxation due to reduced volume sold. Retail revenue would also increase with the exact distribution of this between retailers and producers/distributers dependent on the market.

The poor would be impacted more than the rich both in terms of consumption (Q1 -7·8 vs. Q5 -3·2%) and harm reduction. Of the lives saved 56% accrue to the bottom two wealth quintiles. Alcohol expenditures would increase by around R353 billion over 20 years, with the poorest quintile contributing the smallest absolute proportion (13%) and the richest the largest (28%), however, the poor pay the most in proportion to their income. Estimated healthcare cost savings of R3.9 billion accrue to the South African government and R2.9 billion to households over 20 years, leading to 564,700 cases of Catastrophic Health Expenditure (CHE) averted. The avoidance of lost wages are estimated at R51.1 billion from the five modelled health harms.

7.1.2 Interpretation

My work suggests that MUP would be an effective policy to reduce alcohol consumption and associated harm in South Africa whilst also raising retail and tax revenue. The equity impact is complex with the poorest groups accruing the greatest health benefit, particularly amongst the heaviest drinkers, whilst also seeing the greatest increase in expenditure relative to income, although this is partially offset by reductions in health expenditures and lost wages.

7.1.3 Contribution to evidence base

My work is situated in the literature of mathematical modelling of health policies in LMICs as explored in the scoping review. I built the model using established mathematical and economic methods alongside a thorough programme of stakeholder engagement ensuring contextual relevance and potential for impact. I have drawn on the SAPM (Brennan et al., 2015) for the logic that underpins the epidemiology impact, however, the nature of the data, the alcohol harm profile, the existence of homebrew and the inclusion of ECEA capabilities make this work distinct. My thesis broadly agrees with similar work carried out for Scotland that a MUP would reduce consumption, particularly amongst poorer drinkers (Brennan et al., 2015, Holmes et al., 2014). This work contributes to the South African evidence base as the first study to link minimum unit pricing with estimates of reduced health harms disaggregated by wealth and drinker group.

My thesis also corresponds to the work carried out by Van Walbeek and Chelwa (2021) modelling the consumption impact of a MUP in South Africa. Both studies agree that the policy would reduce consumption and increase spending particularly amongst heavy drinkers although it diverges as to the extent of the impact. My thesis presents a smaller policy impact with less of a differential impact between drinker groups than Van Walbeek and Chelwa (2021). I have explored in detail the data and methods which drive these differences as part of a separate consultancy project with Professor Van Walbeek. The divergence is primarily due to different baseline prices drawn from alternative datasets (Appendix 6). In the final year of my PhD an Organisation for Economic Cooperation and Development (OECD) report has been published which estimates health impacts of MUP for South Africa at the population level (OECD, 2021). The OECD model uses international data and adjustment in relative risks to estimate the impact of the policy on 12 categories of disease of which seven are related to alcohol (alcohol dependence, cirrhosis, injuries, cancer, depression, diabetes and CVD). The MUP policy impact is simulated by borrowing data from the UK on the percentage of alcohol sold below a minimum price by drink type (beer/wine/spirits) and estimating the mean increase required. Notably the elasticities they use are much higher with the lowest at -0.41 and the highest -0.7, varying by drink type, age and mean consumption. They estimate approximately 20 life years per 100,000 and 35.08 DALYs per 100,000 annually, between 2020 – 2050. This model uses different health conditions, outcomes, pricing mechanisms and data. The focus is not on using local data and building a contextually relevant model, able to present results by subgroups of interest, but on providing evidence for 48 countries on the potential impact of a number of alternative alcohol control policies. The work does also show that MUP is highly effective in reducing alcohol related harm.

My ECEA study joins two other ECEA studies for South Africa, one modelling the impact of a sugar sweetened beverage tax (Saxena et al., 2019b) and the other a salt reduction policy (Watkins et al., 2016). Applying this methodology broadens the regressivity argument applied to pricing policies of alcohol in South Africa beyond a narrow focus on increased consumption expenditure (Marx et al., 2019). It allows for consideration of financial savings, via reduced healthcare costs and lost wages, as well as the distribution of non-financial outcomes, in this case improved health.

7.2 Strengths

7.2.1 MUP appraisal outside of a high-income country

My thesis presents the first detailed epidemiological policy appraisal model for a minimum unit pricing policy in South Africa, the first example outside of a high-income country. Previous work modelling MUP in South Africa was completed using aggregate data and only examined how price changes affect consumption without estimating harm outcomes (Van Walbeek and Chelwa, 2021). Global modelling work covering South Africa has used percentage changes in price at a population level to estimate the impact of taxation increases (Chisholm et al., 2018) and most recently MUP (OECD, 2021). In this thesis the price to consumption section performs individual level simulation and the consumption to harm section incorporates wealth and drinker group specific baseline risk and policy impact allowing for exploration of differential impact. I incorporated unrecorded alcohol via the inclusion of homebrew and assumptions around switching behaviour. This is particularly relevant to LMICs where unrecorded alcohol is generally more prevalent (Lachenmeier et al., 2021).

7.2.2 Distributional impact

I have presented the distributional impact of the policy, an aspect often neglected in the appraisal of alcohol policies (Jain et al., 2020). In a country with very high levels of income inequality, and with South Africa's history of apartheid, any pricing policy for public health will be under scrutiny for how it impacts the poorest groups. This study has presented estimates for the distribution of health outcomes as well as broader financial outcomes in order to provide decision makers with a more complex understanding of potential policy impacts.

7.2.3 Stakeholder engagement

Stakeholder engagement is recommended, though often underutilised, in modelling research for many reasons including time constraints and poor communication (Jahangirian et al., 2015, Husbands et al., 2017). My work provides an example of how stakeholder engagement can be effectively incorporated into the modelling of public health policies from inception (helping to shape the research question) through to completion (presentation and communication of results). This has led to greater impact evidenced by: feedback from government officials that my work has informed internal policy discussions; media coverage online (de Wet, 2021); a radio interview (Maytham and Gibbs, 2021); presenting my research at an Alcohol Harms Reduction Legislative Review Workshop attended by government officials in South Africa (Douglas Murray Trust, 2021); and paid consultancy work adapting the national model to the Western Cape Province (report not yet published). Spending time building relationships with stakeholders, listening and adapting the research to their questions, has been essential in producing high quality contextually relevant research and leading to these opportunities.

7.2.4 Open access model

Finally, I deliberately created the model using free, open source software, all code is available publicly on GitHub (code available here) (using a CC-BY-NC license). This means that public health analysts in South Africa can freely use and run this model without restrictions and those in other countries are free to adapt the model to their own settings.

7.3 Limitations

The discussion sections of my papers (chapters 5 and 6) describe limitations relating to data, the scope of the model, unknown impact on the unlicensed market and methodological issues relating to the ECEA. Here I explore these in more detail and also discuss the limitations of my sensitivity analysis and the impact of Covid-19.

7.3.1 Data

Firstly, surveys do not cover all alcohol purchased due to individual underestimation and lack of representativeness. Surveys miss homeless and institutionalised people, groups who have been shown to consume more (Rehm et al., 2020b, Probst et al., 2017). This implies that those who report drinking had their consumption increased too much when I combined their responses with administrative data. Dependent drinkers are not explicitly modelled, a group of particular public health concern as they suffer the most alcohol related harm. It is unlikely that the population-level elasticities used would accurately capture their responses to prices changes and risks of substitution to homebrew or more harmful alcohol not intended for human consumption would be higher.

There are also very high reported levels of abstention, as high as 82% for women. My stakeholders expressed distrust at this figure which led me to conduct sensitivity analysis varying the proportion of abstainers. Reducing the number of abstainers in the model (from 82%/45% to 67%/37% for females/males) resulted in very little change to the aggregate consumption and spend estimates but reduced the health impact from approximately 21,000 to 16,000 lives saved and approximately 900,000 to 700,000 cases saved. New methods are being developed to try to improve the accuracy of consumption estimates for South Africa. Recent work combines data from 17 South African surveys with administrative sources to estimate levels of consumption over time, however even within this highly detailed piece of work the issue of abstinence reporting remains (Cois et al., 2021).

Finding, and cleaning, pricing data that allowed me to generate real price distributions linked to both drinking patterns and wealth quintiles was one of the most time consuming parts of the modelling process. The pricing data I used comes from one locality and has a small sample. In this data the rich buy cheap alcohol as do the poor. Stakeholder's suspected there was more diversity in the price distributions than my dataset captures. As mentioned above I have completed work with Professor Van Walbeek exploring this further by inputting alternative prices (drawn from the National Income Dynamic Study (NiDS)) into my model, for the Western Cape Province (Appendix 6). This results in a higher aggregate impact of MUP and greater differential impact between heavy and moderate drinkers. It should be noted that the University of Cape Town commissioned an additional ad-hoc survey in townships in the Western Cape, in August 2021, to search for the very cheap prices reported in the NiDS data, the researchers were unable to find any.

Comparing my model with SAPM the restricted pricing data clearly led to a number of simplifications. For example I was unable to separate on and off-trade alcohol in the model, I also could not model different drink types which meant there were no price elasticities by drink type and importantly no cross-price elasticities. Research in South Africa demonstrates, as one would expect, that different drinks exhibit different price elasticities, even within categories, with the cheapest wine for example -1.08 compared to high price wine at -0.42 (Van Walbeek and Blecher, 2014). If it is the case that the cheapest drinks are more price elastic then a MUP would likely have a greater impact than I have estimated.

7.3.2 Scope

There are many outcomes which I have not been able to include due to feasibility constraints. For example I have a very limited number of health outcomes which results in an under estimation of the total health benefit and healthcare cost savings. I have also only included limited cost outcomes. This is particularly pertinent to my ECEA paper where not all health related costs were included such as traditional healers or transport costs, which may account for around 50% of the total cost incurred (Mutyambizi et al., 2019). My modelling also takes no account of harm caused to non-drinkers. In South Africa high profile examples include intimate partner violence, foetal alcohol syndrome and violence against children (Matseke et al., 2021, Cluver et al., 2020).

7.3.3 Homebrew and unlicensed outlets

The impact of MUP is made more uncertain in the South African context by the presence of homebrew and unlicensed outlets both of which lack high quality data. Homebrew is considered the most common form of unrecorded alcohol (Van Walbeek and Blecher, 2014) therefore I incorporated this into the modelling using data from the South African Demographic and Health Survey and stakeholder input. However the periods of prohibition during Covid-19 have led to reports of an increase in home brewing, for example the spike in pineapple sales as people resorted to pineapple beer (Nick Dall, 2020). The extent and longevity of this is unknown however it seems likely the alcohol industry will utilise marketing such that the trend for increasing consumption of branded alcohol continues, especially amongst young people. Homebrew has been declining for some time (Van Walbeek and Blecher, 2014) and it seems unlikely Covid-19 will reverse that trend once people can again access alcohol through the usual channels.

In South Africa there are a large number of unlicensed alcohol outlets particularly in poor townships (Parry, 2010b). Most alcohol sold in shebeens is supplied by legally manufactured formal businesses (Charman et al., 2013) and it is important to consider how MUP might operate within this context. One stakeholder, who worked previously on Western Cape government alcohol harm reduction, explained how unlicensed shebeen owners would take a wheelie bin to a licensed outlet and purchase the maximum daily allowance for personal use within law, using a bulk discount. Since it is nonsensical to enforce a MUP at a shebeen that is unlicensed, never mind how small and numerous they are, enforcement may be focused at the licensed premises who supply the shebeens. The implications for modelling consumption and harm are unclear. It may be that there is a greater impact as shebeens are forced to close, although the unlicensed sector may innovate to find ways around the legislation.

7.3.4 ECEA methodological issues

In relation to the ECEA some input variables were only available disaggregated by wealth quintile (consumption, price) and some by income quintile (healthcare utilisation, employment rates). This necessitated an assumption that they correlate but this will be imperfect. The ECEA is helpful in presenting socioeconomic gradients of health and financial outcomes but it may be problematic when comparing the increase in alcohol expenditure with savings in both health expenditures and lost wages. The increase in alcohol expenditure is far greater than the savings but as we have only included a limited number of health conditions this only provides part of the financial benefits and may be misleading.

7.3.5 Sensitivity analysis

I did not undertake probabilistic sensitivity analysis which is the most common approach in the health economic literature recommended for decision analytic models of medical interventions (Briggs et al., 2012), but instead focused on deterministic one-way analysis. My deterministic approach has limitations as it does not provide decision makers with an overall understanding of the uncertainty surrounding the model results, it does not account for correlation and non-linearities in the model and the results do not indicate how likely it is that a specific result will occur (McCabe et al., 2020).

Despite this a probabilistic approach might not be appropriate in my case due to the number of assumptions that would be required to fit a distribution to every parameter, especially challenging given the data constraints, the number of outcomes and the computational complexity leading to feasibility issues. Indeed, in a later paper Briggs et al. (2016) discusses sensitivity analysis in the context of epidemiological model structures used in the economic evaluation of non-communicable disease public health interventions and, short of suggesting good practice, they show that comparative risk assessments (a model structure which matches mine) currently focus on deterministic sensitivity analysis (Asaria et al., 2007, Trueman et al., 2010).

The Sheffield Alcohol Policy Model (SAPM) (Brennan et al., 2015), on which much of my model structure is based, also focused on varying key parameters deterministically. Drawing on Briggs et al. (2016) and Brennan et al. (2015), the approach I adopted was to focus on parameter uncertainty for a wide range of strategically selected inputs (including abstention levels, price elasticities, baseline health gradients, baseline HIV numbers, discount rates, switching behaviour, CHE thresholds, and wage rates). This has allowed me to draw out influential parameters and suggested directions for further research, for example the impact of the price elasticities on whether or not alcohol expenditure is strictly regressive.

7.3.6 Impact of Covid-19

During the pandemic the sale of alcohol was prohibited in South Africa on at least three occasions. The ban was justified by the requirement for increased hospital capacity to treat Covid-19 patients and increased policing capacity to enforce the lockdown (Rehm et al., 2020a). Following the lifting of prohibition various restrictions remained such as limited opening hours. Covid-19 will have changed alcohol consumption, alcohol related harm and the basic demography of the population. Evidence on the positive impact of the lockdown, and alcohol ban, on trauma admissions is emerging but is limited due to the lack of nationally coordinated hospital data (Barron et al., 2020, De Jong et al., 2020, Navsaria et al., 2021). My modelling results estimate policy impacts assuming Covid-19 had not happened. How accurately my model estimates the future is dependent on if, and how quickly, these variables return to pre Covid-19 levels, this is a challenge common to many policy models estimating long term harm and is acknowledged as a limitation.

However, as a result of Covid-19 and the subsequent alcohol ban the public profile of alcohol harm in South Africa was greatly increased, particularly as it relates to hospital admissions. The willingness of government to take decisive action in the pursuit of public health goals, in direct conflict with alcohol industry objectives, may signal a future relationship that is more adversarial than collaborative, as it has appeared in the past (Bertscher et al., 2018). The alcohol industry are currently bringing court cases against the government for the actions they have taken (Businesstech, 2021). Local alcohol researchers believe the Covid-19 crisis represents an opportunity to push government to introduce better alcohol control measures (Parry, 2020, Matzopoulos et al., 2020). This increases the relevance and potentially the impact of my PhD work.

7.4 Further research

Arising from sensitivity analysis and the above limitations key areas for further research are identified. These include further exploration of the equity impact of the policy via collection of improved pricing data, incorporating broader outcomes and developing the methods. In addition further research should explore the impact of the policy on dependent drinkers, the impact on homebrew and unlicensed outlets, alternative alcohol policies, and the potential for regional MUP policies within South Africa.

7.4.1 Improving the data

A high priority in this area of research is the collection of accurate transaction level purchasing data, including at shebeens, as this was a key concern of stakeholders and the sensitivity analysis indicated the critical impact of price elasticities on the results. The data should be nationally representative and include a large sample, including both on- and off-trade alcohol. This would enable the estimation of price distributions for different drink types (beer/wine/spirits) by drinker groups and wealth quintiles and allow for the estimation of own and cross-price elasticities, data more akin to that used in SAPM (Brennan et al., 2015). The collection of such data would require significant time and financial investment. It may be that such data exists within market research companies and could be purchased by Universities but I expect this would come at a very high price.

7.4.2 Expanding scope and developing methods

The model could be expanded to include all alcohol related harms rather than the five currently included, and a much broader set of financial outcomes such as care giver, traditional medicine or any primary/ambulatory care costs. High profile alcohol related harms in South Africa include intimate partner violence and foetal alcohol syndrome which could be estimated to demonstrate harm to the non-drinker, stakeholders indicated this would make an important contribution to the policy debate. As mentioned above whilst my approach to sensitivity analysis is clearly set within currently accepted methodology I would recommend future research applying probabilistic sensitivity analysis to the model, for example applying the methods used by Briggs et al. (2017) in their comparative risk assessment of the UK sugar tax.

7.4.3 Estimating the impact on dependent drinkers

I have not accounted for dependent drinkers separately within the model, only heavy drinkers. To estimate the impact on dependent drinkers further research would require an estimation of the proportion of heavy drinkers who are dependent, by subgroup, the prices they pay and their price elasticity. Should a MUP policy be implemented a programme of research including qualitative interviews with the poorest dependent drinkers and their households would be valuable. This could explore the impact on dependent drinkers and their families, in particular whether other essential purchases are displaced by the price increase. Given the income inequality in South Africa this qualitative research would also be beneficial for heavy and moderate drinkers from the poorest groups. The Scottish evaluation programme commissioned alongside the MUP policy implementation provides an example of a mixed-methods study to assess the impact of MUP on dependent drinkers (Public Health Scotland, 2018).

7.4.4 Homebrew and unlicensed premises

This remains a significant area for further research. With regards to homebrew further surveys might improve the data whilst the model could be adapted to introduce assumptions around initiation of homebrew following the policy rather than the current approach of homebrew drinkers switching more of their alcohol consumption to homebrew. Work is currently being undertaken within the Western Cape, on a research project I am a member of, to explore scenarios around the unlicensed market. A number of research questions have been raised such as the extent of the market, the various supply chains, the potential for enforcement and whether MUP would provide a disincentive for current license holders to renew their licenses if they were being undercut by the informal sector.

7.4.5 Appraisal of alternative policies

The model focused on MUP as the policy chosen by stakeholders in the first workshop, however, it could be developed to appraise alternative pricing policies, such as a volumetric tax system, or non-price based alcohol control policies such as restricting opening hours, restricting advertising and brief interventions. This would be useful both to compare effectiveness and the potential equity impact. A single distributional metric, such as a concentration index, to quantify the distribution of the health benefits could be used to compare policies. This work could also be developed to compare more explicitly the baseline health distribution, across the whole population, and the post policy health distribution, drawing on Distributional Cost-Effectiveness Methods (Asaria et al., 2016).

7.4.6 Estimating regional impacts

As with Scotland or the Northern Territory of Australia the provincial Western Cape government are exploring MUP as a policy option that sits within their legislative remit. Therefore a further research question is what would be the potential impact of a MUP applied to only one of the nine provinces within South Africa. This is work I have undertaken in collaboration with South African academics and policy professionals for the Western Cape Provincial Government. To answer this research question I used the following methods: (1) consulted with local experts on known differences in the drinking profile and health harms between the Western Cape and nationwide, including available local data sources; (2) used National Income Dynamics Study (NIDs) (which has a larger sample size than SADHS), to generate summary statistics and exploratory regressions to discover if being in the Western Cape is a significant variable in relation to whether or not an individual drinks, and to what extent; (3) explored pricing data, in particular to discover how Western Cape price distributions differ from Tshwane prices which are currently used in the model; (4) searched for data on underlying levels of health harm in the Western Cape (on a disease by disease basis e.g. HIV prevalence in the Western Cape is about half that of the national average (Health Systems Trust, 2020b); (5) used the information gained in (1) - (4) to make adjustments, using weights, combined, with Western Cape population statistics, such that the modelled population represents the Western Cape as closely as possible. As requested by funders I reviewed my model against economic modelling completed concurrently by academics at the University of Cape Town who used different pricing data and elasticity methods to estimate the consumption impact of a MUP by drinker groups. This work has been written up as a report for the Douglas Murray Trust (publication due December 2021). As part of this research project I also co-supervised three South African students compiling implementation experience of MUP and other pricing policies in Scotland, Northern Territory Australia, Russia and Botswana (publication due December 2021).

7.5 Conclusion

The work included within my thesis suggests that MUP is an effective policy option for South Africa and would impact poorer groups more than the rich both in terms of consumption reductions and health gains. The policy implication for the national South African government, or failing that for provincial governments, is to consider incorporating a MUP policy for alcohol within their alcohol harms reduction strategies as part of a package of reforms to address this significant public health challenge.

Appendix

1 Appendix 1

1.1 Specific search terms used

Web of science

TS = Topic, searches for topic terms in the following fields; title, abstract, author keywords, keywords plus.
AD = Address, searches for institution and/or place names in the Address field within a record, usually for the first named author of an article
The asterisk (*) represents any group of characters, including no character.
Cost-effectiveness will search for both cost effectiveness and cost-effectiveness, even when inside double quotation marks.

Search topic	**Hits**
Geography	

TS=("low-resource setting*" or "resource-constrained setting*" or "resource-poor setting*" or "limited-resource setting*" or "resource-limited setting*" or Africa* or (Asia* NEAR/2 south) or (Asia NEAR/2 east) or "latin America*" or "central America*" or "south america*" or caribbean or "west indies" or "middle east") OR TS=(countr* NEAR/0 (developing or "less* developed" or "under developed" or "least-developed" or underdeveloped or "middle income" or middle-income or low-income or "low* income" or underserved or "under served" or deprived or poor*) or nation* NEAR/0 (developing or "less* developed" or "under developed" or least-developed or underdeveloped or "middle income" or middle-income or low-income or "low* income" or underserved or "under served" or deprived or poor*) or population* NEAR/0 (developing or "less* developed" or "under developed" or least-developed or underdeveloped or "middle income" or middle-income or low-income or "low* income" or underserved or "under served" or deprived or poor*) or world NEAR/0 (developing or "less* developed" or "under developed" or "least-developed" or underdeveloped or "middle income" or middle-income or low-income or "low* income" or underserved or "under served" or deprived or poor*) or econom* NEAR/0 (developing or "less* developed" or "under developed" or underdeveloped or "middle income" or middle-income or "low* income" or low-income) or low* NEAR/0 (gdp or gnp or "gross domestic" or "gross national") or lmic* or "third world" or "lami countr*" or "transitional countr*") or TS=(AFGHANISTAN or ALBANIA or ALGERIA or "AMERICAN SAMOA" or ANGOLA or ARMENIA or ARMENIAN or AZERBAIJAN or BANGLADESH or BELARUS or BYELARUS or BYELORUSSIAN or BELORUSSIA* or BELIZE or BENIN or BHUTAN or BOLIVIA or BOSNIA or "BOSNIA AND HERZEGOVINA" or HERZEGOVINA or HERCEGOVINA or BOTSWANA or BRASIL or BRAZIL or BULGARIA or "BURKINA FAS*O" or BURUNDI or URINDI or "CAPE VERDE" OR "CABO VERDE" or CAMBODIA or "KHMER REPUBLIC" or KAMPUCHEA or CAMERO* or "CENTRAL AFRICAN REPUBLIC" or CHAD or CHINA or COLOMBIA or COMOR* or "COMORO ISLANDS" or MAYOTTE or CONGO or ZAIRE or "COSTA RICA" or "COTE D'IVOIRE" or "IVORY COAST" or CUBA or DJIBOUTI or "FRENCH SOMALILAND" or DOMINICA* or "DOMINICAN REPUBLIC" or ECUADOR or EGYPT or "UNITED ARAB REPUBLIC" or "EL SALVADOR" or "EQUATORIAL GUINEA" or "ERITREA" or "ETHIOPIA" or FIJI or GABON* or GAMBIA or GEORGIA* or GHANA or GRENADA or GUATEMALA or GUINEA or GUAM or GUINEA-BISSAU or GUIANA or GUYANA or HAITI or HONDURAS or INDIA or MALDIVES or INDONESIA or IRAN or IRAQ or JAMAICA or JORDAN or KAZAKH* or KENYA or	3,461,059

KIRIBATI or KOREA or KOSOVO or KYRGYZ* or KIRGHIZ* or KIRGIZSTAN or LAO* or LEBANON or LESOTHO or BASUTOLAND or LIBERIA or LIBYA or MACEDONIA or MADAGASCAR or MALAGASY or MALAWI or MALAY* or SABAH or SARAWAK or MALDIVES or MALI or "MARSHALL ISLANDS" or MAURITANIA or "AGALEGA ISLANDS" or MEXICO or MICRONESIA or "MIDDLE EAST" or MOLDOV* or MONGOLIA or MONTENEGRO or MOROCCO or IFNI or MOZAMBIQUE or MYANMA* or BURMA or NAMIBIA or NEPAL or "NETHERLANDS ANTILLES" or NICARAGUA or NIGER* or "NORTHERN MARIANA ISLANDS" or PAKISTAN or "PAPUA NEW GUINEA" or PARAGUAY or PERU or PHI*LIP*INES or RUSSIA* or R*ANDA or SAMOA* or "NAVIGATOR ISLAND*" or "SAO TOME" or SENEGAL or SERBIA or MONTENEGRO or "SIERRA LEONE" or "SOLOMON ISLANDS" or SOMALIA or "SOUTH AFRICA" or "SOUTH SUDAN" or "SRI LANKA" or "S* LUCIA" or "ST. VINCENT AND THE GRENADINES" or SUDAN or SURINAM* or SWAZILAND or SYRIA* or TAJIKISTAN or TADZHIK* or TADJIKISTAN or TANZANIA or THAILAND or "TIMOR-LESTE" or TOGO* or TONGA or TUNISIA or TURKEY or TURKMEN* or TUVALU or UGANDA or UKRAINE or UZBEK* or VANUATU or VENEZUELA or VIETNAM or "VIET NAM" or "WEST BANK" or YEMEN or ZAMBIA or ZIMBABWE or RHODESIA) *Indexes=SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, BKCI-S, BKCI-SSH, ESCI, CCR-EXPANDED, IC Timespan=All years*	
Health	
TS=("global health" or "health equity" or "public health" or mortality or morbidity or death or disease or conditions or illnesses or "quality adjusted life year" or "disability adjusted life year") OR AD=(health or hlth) Indexes=SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, BKCI-S, BKCI-SSH, ESCI, CCR-EXPANDED, IC Timespan=All years	11,119,929
Equity	
TS=(equit* or equality or fair* or inequalit* or inequit* or distibution* or "financial risk protection" or socioeconomic or Gini or Lorenz or "social justice" or poverty or “health disparit*”) Indexes=SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, BKCI-S, BKCI-SSH, ESCI, CCR-EXPANDED, IC Timespan=All years	719,321
Modelling	

TS=("extended cost-effectiveness" or "distributional cost-effectiveness" or "equity-effectiveness model" or "cost-effectiveness" or "cost utility" or "cost benefit" or "economic model*" or "return on investment" or "simulation model*") Indexes=SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, BKCI-S, BKCI-SSH, ESCI, CCR-EXPANDED, IC Timespan=All years	197,156
Decision/policy making	
TS=(polic* or decision-mak* or decision-support or decision-process or decision-aid* or implement* or impact or priorit* or "health-facility strengthening" or appraisal or evaluation) or AD=(policy) *Indexes=SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, BKCI-S, BKCI-SSH, ESCI, CCR-EXPANDED, IC Timespan=All years*	6,500,256
1 AND 2 AND 3 AND 4 AND 5 English language only	659 637

Imported into endnote on 01/02/2021, 637 articles.

Scopus

Keyword search: TITLE-ABS-KEY search, where KEY includes author keywords and controlled indexed terms in searched databases.
Scopus automatically searches plural versions of words, as well as US-UK spelling variations.
Punctuation is ignored: heart-attack or heart attack return the same results
If the phrase is contained within double quotation marks then it searches for a loose/approximate phrase i.e. cost-effectiveness and cost effectiveness will return the same results. If using braces it will return the exact phrase (World health Organisation, 2019a)
*= can be any number of letters or none

Search	**Hits**
Geography	

TITLE-ABS-KEY("low-resource setting*" or "resource-constrained setting*" or "resource-poor setting*" or "limited-resource setting*" or "resource-limited setting*" or Africa* or (Asia* W/2 south) or (Asia W/2 east) or "latin America*" or "central America*" or "south america*" or caribbean or "west indies" or "middle east") OR TITLE-ABS-KEY((countr* or nation* or population* or world) W/0 (developing or "less* developed" or "under developed" or "least-developed" or underdeveloped or "middle income" or "middle-income" or "low-income" or "low* income" or underserved or "under served" or deprived or poor*)) OR TITLE-ABS-KEY(econom* W/0 (developing or "less* developed" or "under developed" or underdeveloped or "middle income" or middle-income or "low* income" or low-income)) OR TITLE-ABS-KEY(low* W/0 (gdp or gnp or "gross domestic" or "gross national")) OR TITLE-ABS-KEY(lmic* or "third world" or "lami countr*" or "transitional countr*") OR TITLE-ABS-KEY(AFGHANISTAN or ALBANIA or ALGERIA or "AMERICAN SAMOA" or ANGOLA or ARMENIA or ARMENIAN or AZERBAIJAN or BANGLADESH or BELARUS or BYELARUS or BYELORUSSIAN or BELORUSSIA* or BELIZE or BENIN or BHUTAN or BOLIVIA or BOSNIA or "BOSNIA AND HERZEGOVINA" or HERZEGOVINA or HERCEGOVINA or BOTSWANA or BRASIL or BRAZIL or BULGARIA or "BURKINA FAS*O" or BURUNDI or URINDI or "CAPE VERDE" OR "CABO VERDE" or CAMBODIA or "KHMER REPUBLIC" or KAMPUCHEA or CAMERO* or "CENTRAL AFRICAN REPUBLIC" or CHAD or CHINA or COLOMBIA or COMOR* or "COMORO ISLANDS" or MAYOTTE or CONGO or ZAIRE or "COSTA RICA" or "COTE D'IVOIRE" or "IVORY COAST" or CUBA or DJIBOUTI or "FRENCH SOMALILAND" or DOMINICA* or "DOMINICAN REPUBLIC" or ECUADOR or EGYPT or "UNITED ARAB REPUBLIC" or "EL SALVADOR" or "EQUATORIAL GUINEA" or "ERITREA" or "ETHIOPIA" or FIJI or GABON* or GAMBIA or	4,896,347

GEORGIA* or GHANA or GRENADA or GUATEMALA or GUINEA or GUAM or GUINEA-BISSAU or GUIANA or GUYANA or HAITI or HONDURAS or INDIA or MALDIVES or INDONESIA or IRAN or IRAQ or JAMAICA or JORDAN or KAZAKH* or KENYA or KIRIBATI or KOREA or KOSOVO or KYRGYZ* or KIRGHIZ* or KIRGIZSTAN or LAO* or LEBANON or LESOTHO or BASUTOLAND or LIBERIA or LIBYA or MACEDONIA or MADAGASCAR or MALAGASY or MALAWI or MALAY* or SABAH or SARAWAK or MALDIVES or MALI or "MARSHALL ISLANDS" or MAURITANIA or "AGALEGA ISLANDS" or MEXICO or MICRONESIA or "MIDDLE EAST" or MOLDOV* or MONGOLIA or MONTENEGRO or MOROCCO or IFNI or MOZAMBIQUE or MYANMA* or BURMA or NAMIBIA or NEPAL or "NETHERLANDS ANTILLES" or NICARAGUA or NIGER* or "NORTHERN MARIANA ISLANDS" or PAKISTAN or "PAPUA NEW GUINEA" or PARAGUAY or PERU or PHI*LIP*INES or RUSSIA* or R*ANDA or SAMOA* or "NAVIGATOR ISLAND*" or "SAO TOME" or SENEGAL or SERBIA or MONTENEGRO or "SIERRA LEONE" or "SOLOMON ISLANDS" or SOMALIA or "SOUTH AFRICA" or "SOUTH SUDAN" or "SRI LANKA" or "S* LUCIA" or "ST. VINCENT AND THE GRENADINES" or SUDAN or SURINAM* or SWAZILAND or SYRIA* or TAJIKISTAN or TADZHIK* or TADJIKISTAN or TANZANIA or THAILAND or "TIMOR-LESTE" or TOGO* or TONGA or TUNISIA or TURKEY or TURKMEN* or TUVALU or UGANDA or UKRAINE or UZBEK* or VANUATU or VENEZUELA or VIETNAM or "VIET NAM" or "WEST BANK" or YEMEN or ZAMBIA or ZIMBABWE or RHODESIA)	
Health	
TITLE-ABS-KEY("global health" or "health equity" or "public health" or mortality or morbidity or death or disease or conditions or illnesses or "quality adjusted life year" or "disability adjusted life year") OR AFFIL(health or hlth)	17,122,519
Equity	
TITLE-ABS-KEY(equit* or equality or fair* or inequalit* or inequit* or distibution* or stratified or "financial risk protection" or socioeconomic or Gini or Lorenz or Kakwani or “social justice” or poverty)	1,190,598
Modelling	

TITLE-ABS-KEY("extended cost-effectiveness" or "distributional cost-effectiveness" or "equity-effectiveness model" or "cost-effectiveness" or "cost utility" or "cost benefit" or "economic model*" or "return on investment" or “simulation model*”)	
Decision/policy-making	
TITLE-ABS-KEY(polic* or decision-mak* or decision-support or decision-process or decision-aid* or implement* or impact or priorit* or "health-facility strengthening" or appraisal or evaluation) or AFFIL(policy)	17,314,297
1 AND 2 AND 3 AND 4 AND 5 Limit to english	2158 2092

Ovid MEDLINE

Ovid MEDLINE Ovid MEDLINE(R) and Epub Ahead of Print, In-Process & Other Non-Indexed Citations and Daily 1946 to January 29, 2021 * can mean any number of characters or zero characters # stands for one character within a word Cost-effectiveness will return the same results as cost effectiveness even within " " Note: be careful with "" in medline they need to be straight ones, I found problems when copying in from googledocs, I had to redo all of the quotation marks.			
		MeSH subject headings/Custom search **Explode all subject headings and click include all subheadings**	**Hits**
Geography			
	1	exp africa/ or caribbean region/ or cuba/ or dominica/ or dominican republic/ or grenada/ or haiti/ or jamaica/ or saint lucia/ or "saint vincent and the grenadines"/ or central america/ or latin america/ or exp mexico/ or exp south america/ or asia, central/ or russia/ or cambodia/ or timor-leste/ or indonesia/ or laos/ or malaysia/ or myanmar/ or philippines/ or thailand/ or vietnam/ or bangladesh/ or bhutan/ or india/ or afghanistan/ or iran/ or iraq/ or jordan/ or lebanon/ or syria/ or turkey/ or yemen/ or nepal/ or pakistan/ or sri lanka/ or china/ or mongolia/ or albania/ or "bosnia and herzegovina"/ or bulgaria/ or kosovo/ or "macedonia (republic)"/ or moldova/ or montenegro/ or "republic of belarus"/ or serbia/ or ukraine/ or fiji/ or papua new guinea/ or vanuatu/ or samoa/ or tonga/	1063338
	2	("low-resource setting*" or "resource-constrained setting*" or "resource-poor setting*" or "limited-resource setting*" or "resource-limited setting*" or Africa* or "latin America*" or "central America*" or "south america*" or caribbean or "west indies" or "middle east").mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]	414411
	3	((countr* or nation* or population* or world) adj (developing or "less* developed" or "under developed" or "least-developed" or underdeveloped or "middle income" or "middle-income" or "low-income" or "low* income" or underserved or "under served" or deprived or poor*)).mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]	917
	4	(econom* adj (developing or "less* developed" or "under developed" or underdeveloped or "middle income" or middle-income or "low* income")).mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]	238
	5	(low* adj (gdp or gnp or "gross domestic" or "gross national")).mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]	265
	6	(lmic* or "third world" or "lami countr*" or "transitional countr*").mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]	9257

	7	(AFGHANISTAN or ALBANIA or ALGERIA or “AMERICAN SAMOA” or ANGOLA or ARMENIA or ARMENIAN or AZERBAIJAN or BANGLADESH or BELARUS or BYELARUS or BYELORUSSIAN or BELORUSSIA* or BELIZE or BENIN or BHUTAN or BOLIVIA or BOSNIA or “BOSNIA AND HERZEGOVINA” or HERZEGOVINA or HERCEGOVINA or BOTSWANA or BRASIL or BRAZIL or BULGARIA or “BURKINA FAS#O” or BURUNDI or URINDI or CAMBODIA or “KHMER REPUBLIC” or “KAMPUCHEA or CAMERO* or “CAPE VERDE” OR “CABO VERDE” or “CENTRAL AFRICAN REPUBLIC” or CHAD or CHINA or COLOMBIA or COMOR* or “COMORO ISLANDS” or MAYOTTE or CONGO or ZAIRE or “COSTA RICA” or “COTE D'IVOIRE” or “IVORY COAST” or CUBA or DJIBOUTI or “FRENCH SOMALILAND” or DOMINICA* or ECUADOR or EGYPT or ”UNITED ARAB REPUBLIC” or “EL SALVADOR” or “EQUATORIAL GUINEA” or ERITREA or ETHIOPIA or FIJI or GABON* or GAMBIA or GEORGIA* or GHANA or GRENADA or GUATEMALA or GUINEA or GUAM or GUINEA-BISSAU or GUIANA or GUYANA or HAITI or HONDURAS or INDIA or MALDIVES or INDONESIA or IRAN or IRAQ or JAMAICA or JORDAN or KAZAKH* or KENYA or KIRIBATI or KOREA or KOSOVO or KYRGYZ* or KIRGHIZ* or KIRGIZSTAN or LAO* or LEBANON or LESOTHO or BASUTOLAND or LIBERIA or LIBYA or MACEDONIA or MADAGASCAR or MALAGASY or MALAWI or MALAY* or SABAH or SARAWAK or MALDIVES or MALI or “MARSHALL ISLANDS” or MAURITANIA or “AGALEGA ISLANDS” or MEXICO or MICRONESIA or “MIDDLE EAST” or MOLDOV* or MONGOLIA or MONTENEGRO or MOROCCO or IFNI or MOZAMBIQUE or MYANMA* or BURMA or NAMIBIA or NEPAL or “NETHERLANDS ANTILLES” or NICARAGUA or NIGER* or “NORTHERN MARIANA ISLANDS” or PAKISTAN or PANAMA or “PAPUA NEW GUINEA” or PARAGUAY or PERU or PHI#LIP#INES or RUSSIA* or R#ANDA or SAMOA* or “NAVIGATOR ISLAND*” or “SAO TOME” or SENEGAL or SERBIA or MONTENEGRO or “SIERRA LEONE” or “SOLOMON ISLANDS” or SOMALIA or “SOUTH AFRICA” or “SRI LANKA” or “S* LUCIA” or “ST. VINCENT AND THE GRENADINES” or SUDAN or SURINAM* or SWAZILAND or SYRIA* or TAJIKISTAN or TADZHIK* or TADJIKISTAN or TANZANIA or THAILAND or TIMOR-LESTE or TOGO* or TONGA or TUNISIA or TURKEY or TURKMEN* or TUVALU or UGANDA or UKRAINE or UZBEK* or VANUATU or VENEZUELA or VIETNAM or “VIET NAM” or “WEST BANK” or YEMEN or ZAMBIA or ZIMBABWE or RHODESIA)**.ti,ab.**	1356719
	8	Combine 1 - 7 with OR	1993557
Health			
	9	(health* or medical or hospital or clinic* or treatment or "public health" or mortality or morbidity or death or disease or conditions or illnesses).mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]	15206767
Equity			

	10	exp Social Justice/ or exp Health equity/ or exp Socioeconomic factors/ or exp Health status disparities/ or exp Healthcare disparities/ or exp Poverty/ or exp Health Services Accessibility/ or exp Universal Coverage/	579145
	11	(equit* or equality or fair* or inequalit* or inequit* or distibution* or "financial risk protection" or socioeconomic or Gini or Lorenz or "social justice" or poverty).mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]	424848
	12	10 or 11	765072
Modelling			
	13	exp Models, economic/ or exp Cost-benefit analysis/	92673
	14	("extended cost-effectiveness" or "distributional cost-effectiveness" or "equity-effectiveness model" or "cost-effectiveness" or "cost utility" or "cost benefit" or "economic model*" or "return on investment" or “simulation model*”).mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]	116,606
	15	13 or 14	142157
Decision or policy making			
	16	Exp Decision making/ or exp Policy making/ or exp Public policy/ or exp Health policy/ or exp Policy/ or exp Decision support techniques/ or exp Decision making, exp organisational/ or exp Health priorities/ or exp Health care rationing/	464424
	17	(polic* or decision-mak* or decision-support or decision-process or decision-aid* or implement* or impact or priorit* or "health-facility strengthening" or appraisal or evaluation).mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]	3608996
	18	16 or 17	3772601
	19	8 AND 9 AND 12 AND 15 AND 18 English language only	1523

Ovid Embase

Ovid Embase **Embase 1974 to 2021 January 29** **ID: scharrlib** * can mean any number of characters or zero characters # stands for one character within a word Cost-effectiveness will return the same results as cost effectiveness even within “ ” Note: be careful with “” in ovid they need to be straight ones, I found problems when copying in from googledocs, I had to redo all of the quotation marks.

		Emtree subject headings/Custom search Explode all subject headings and click include all subheadings	Hits
Geography			
	1	("low-resource setting*" or "resource-constrained setting*" or "resource-poor setting*" or "limited-resource setting*" or "resource-limited setting*" or Africa* or "latin America*" or "central America*" or "south america*" or caribbean or "west indies" or "middle east").mp. [mp=title, abstract, heading word, drug trade name, original title, device manufacturer, drug manufacturer, device trade name, keyword, floating subheading word, candidate term word]	469757
	2	((countr* or nation* or population* or world) adj (developing or "less* developed" or "under developed" or "least-developed" or underdeveloped or "middle income" or "middle-income" or "low-income" or "low* income" or underserved or "under served" or deprived or poor*)).mp. [mp=title, abstract, heading word, drug trade name, original title, device manufacturer, drug manufacturer, device trade name, keyword, floating subheading word, candidate term word]	1241
	3	(econom* adj (developing or "less* developed" or "under developed" or underdeveloped or "middle income" or middle-income or "low* income")).mp. [mp=title, abstract, heading word, drug trade name, original title, device manufacturer, drug manufacturer, device trade name, keyword, floating subheading word, candidate term word]	280
	4	(low* adj (gdp or gnp or "gross domestic" or "gross national")).mp. [mp=title, abstract, heading word, drug trade name, original title, device manufacturer, drug manufacturer, device trade name, keyword, floating subheading word, candidate term word]	382
	5	(lmic* or "third world" or "lami countr*" or "transitional countr*").mp. [mp=title, abstract, heading word, drug trade name, original title, device manufacturer, drug manufacturer, device trade name, keyword, floating subheading word, candidate term word]	10989

Free text	6	(AFGHANISTAN or ALBANIA or ALGERIA or "AMERICAN SAMOA" or ANGOLA or ARMENIA or ARMENIAN or AZERBAIJAN or BANGLADESH or BELARUS or BYELARUS or BYELORUSSIAN or BELORUSSIA* or BELIZE or BENIN or BHUTAN or BOLIVIA or BOSNIA or "BOSNIA AND HERZEGOVINA" or HERZEGOVINA or HERCEGOVINA or BOTSWANA or BRASIL or BRAZIL or BULGARIA or "BURKINA FAS#O" or BURUNDI or URINDI or CAMBODIA or "KHMER REPUBLIC" or KAMPUCHEA or CAMERO* or "CAPE VERDE" or "CABO VERDE" or "CENTRAL AFRICAN REPUBLIC" or CHAD or CHINA or COLOMBIA or COMOR* or "COMORO ISLANDS" or MAYOTTE or CONGO or ZAIRE or "COSTA RICA" or "COTE D'IVOIRE" or "IVORY COAST" or CUBA or DJIBOUTI or "FRENCH SOMALILAND" or DOMINICA* or ECUADOR or EGYPT or "UNITED ARAB REPUBLIC" or "EL SALVADOR" or "EQUATORIAL GUINEA" or ERITREA or ETHIOPIA or FIJI or GABON* or GAMBIA or GEORGIA* or GHANA or GRENADA or GUATEMALA or GUINEA or GUAM or GUINEA-BISSAU or GUIANA or GUYANA or HAITI or HONDURAS or INDIA or MALDIVES or INDONESIA or IRAN or IRAQ or JAMAICA or JORDAN or KAZAKH* or KENYA or KIRIBATI or KOREA or KOSOVO or KYRGYZ* or KIRGHIZ* or KIRGIZSTAN or LAO* or LEBANON or LESOTHO or BASUTOLAND or LIBERIA or LIBYA or MACEDONIA or MADAGASCAR or MALAGASY or MALAWI or MALAY* or SABAH or SARAWAK or MALDIVES or MALI or "MARSHALL ISLANDS" or MAURITANIA or "AGALEGA ISLANDS" or MEXICO or MICRONESIA or "MIDDLE EAST" or MOLDOV* or MONGOLIA or MONTENEGRO or MOROCCO or IFNI or MOZAMBIQUE or MYANMA* or BURMA or NAMIBIA or NEPAL or "NETHERLANDS ANTILLES" or NICARAGUA or NIGER* or "NORTHERN MARIANA ISLANDS" or PAKISTAN or PANAMA or "PAPUA NEW GUINEA" or PARAGUAY or PERU or PHI#LIP#INES or RUSSIA* or R#ANDA or SAMOA* or "NAVIGATOR ISLAND*" or "SAO TOME" or SENEGAL or SERBIA or MONTENEGRO or "SIERRA LEONE" or "SOLOMON ISLANDS" or SOMALIA or "SOUTH AFRICA" or "SRI LANKA" or "S* LUCIA" or "ST. VINCENT AND THE GRENADINES" or SUDAN or SURINAM* or SWAZILAND or SYRIA* or TAJIKISTAN or TADZHIK* or TADJIKISTAN or TANZANIA or THAILAND or TIMOR-LESTE or TOGO* or TONGA or TUNISIA or TURKEY or TURKMEN* or TUVALU or UGANDA or UKRAINE or UZBEK* or VANUATU or VENEZUELA or VIETNAM or "VIET NAM" or "WEST BANK" or YEMEN or ZAMBIA or ZIMBABWE or RHODESIA).mp. [mp=title, abstract, heading word, drug trade name, original title, device manufacturer, drug manufacturer, device trade name, keyword, floating subheading word, candidate term word]	2427052
	7	1 or 2 or 3 or 4 or 5 or 6	2687336
Health			
	8	("global health" or "health equity" or "public health" or mortality or morbidity or death or disease or conditions or illnesses or "Quality adjusted life year" or "Disability adjusted life year").mp. [mp=title, abstract, heading word, drug trade name, original title, device manufacturer, drug manufacturer, device trade name, keyword, floating subheading word, candidate term word]	11709106
Equity			
	9	exp Health equity/ or exp health care disparity/ or exp health disparity/ or exp social justice/ or exp socioeconomics/	434898

	10	(equit* or equality or fair* or inequalit* or inequit* or distibution* or "financial risk protection" or socioeconomic or Gini or Lorenz or "social justice" or poverty).mp. [mp=title, abstract, heading word, drug trade name, original title, device manufacturer, drug manufacturer, device trade name, keyword, floating subheading word, candidate term word]	365824
	11	9 or 10	675118
Modelling			
	12	exp economic model/ or exp economic evaluation/	316208
	13	("extended cost-effectiveness" or "distributional cost-effectiveness" or "equity-effectiveness model" or "cost-effectiveness" or "cost utility" or "cost benefit" or "economic model*" or "return on investment" or “simulation model*”).mp. [mp=title, abstract, heading word, drug trade name, original title, device manufacturer, drug manufacturer, device trade name, keyword, floating subheading word, candidate term word]	276377
	14	12 or 13	352587
Decision or policy making			
	15	exp Decision making/ or exp Policy/ or exp Public policy/ or exp Health care policy/	663738
	16	(polic* or decision-mak* or decision-support or decision-process or decision-aid* or implement* or impact or priorit* or "health-facility strengthening" or appraisal or evaluation).mp. [mp=title, abstract, heading word, drug trade name, original title, device manufacturer, drug manufacturer, device trade name, keyword, floating subheading word, candidate term word]	13826708
	17	15 or 16	13826770
		7 AND 8 AND 11 AND 14 AND 17 Limited to english	3067 2998

1.2 Table of extended cost-effectiveness analysis and cost-effectiveness analysis included papers

Panel A: Extended cost-effectiveness analysis			
Author and year	**Health problem**	**Policy**	**Country**
Assebe et al. (2020)	Malaria	Vaccination and healthcare provision	Ethiopia
Essue et al. (2020)	Cataracts	Healthcare provision	Vietnam
Johansson et al. (2015)	Pneumonia	Vaccination	Ethiopia
Johansson et al. (2017)	Mental ill health	Healthcare provision	Ethiopia
Loganathan et al. (2016)	Rotavirus	Vaccination	Malaysia
Megiddo et al. (2016)	Epilepsy	Healthcare provision	India
Megiddo et al. (2018)	Pneumonia	Vaccination	India
Mishra et al. (2018)	Cancer	Pricing policies	India, Indonesia, Bangladesh, Philippines, Vietnam, Armeia, China, Mexico, Turkey, Brazil, Columbia, Thailand, Chille
Nandi et al. (2016)	Neonatal complications	Healthcare provision	India
Nandi et al. (2017)	Diarrhoea	Improving water and sanitation infrastructure	India
Olson et al. (2016)	Road traffic injury	Road safety legislation	Vietnam
Postolovska et al. (2018)	Tobacco related mortality	Pricing policies	Armenia
Raykar et al. (2016)	Mental ill health	Healthcare provision	India
Salti et al. (2016)	Tobacco related mortality	Pricing policies	Lebanon
Saxena et al. (2019a)	Multiple health conditions	Pricing policies	Philippines
Saxena et al. (2019b)	Diabetes	Pricing policies	South Africa
Shrime et al. (2016a)	Cancer	Healthcare provision	Uganda
Shrime et al. (2016b)	Multiple health conditions	Healthcare provision	Ethiopia
Shrime et al. (2019)	Neonatal complications	Healthcare provision	Malawi
Verguet et al. (2013)	Rotavirus	Vaccination	India and Ethiopia

Verguet et al. (2015a)	Tobacco related mortality	Pricing policies	China
Verguet et al. (2015b)	Tuberculosis	Healthcare provision	India
(Verguet et al., 2016b)	Multiple health conditions (Diarrhoea and Pneumonia)	Vaccination	Ethiopia
Verguet et al. (2017a)	Postnatal complications	Increasing female educational level	Niger and India
Verguet et al. (2017b)	Tobacco related mortality	Pricing policies	China
Watkins et al. (2016)	Cardiovascular Disease	Food legislation	South Africa
Wu et al. (2019)	Tobacco related mortality	Pricing policies	Vietnam
Wu et al. (2020)	Tobacco related mortality	Pricing policies	India
Panel B: Cost-effectiveness analysis			
Author and year	**Health problem**	**Policy**	**Country**
Anderson et al. (2019)	Rotavirus	Vaccination	Democratic Republic of Congo (DRC), Kenya, Zambia, Zimbabwe
Anderson et al. (2020)	Rotavirus	Vaccination	Nigeria
Basu et al. (2019)	Cardiovascular Disease	Healthcare provision	South Africa
Carrera et al. (2012)	Infant malnutrition	Healthcare provision	Ethiopia, Mali, Niger, Rwanda, Uganda, Benin, Ghana, Kenya, Nigeria, South Africa, Zimbabwe, Bangladesh, (Punjab) Pakistan, Philippines, Vietnam
Fiedler et al. (2000)	Infant malnutrition	Food fortification	Philippines
James et al. (2019)	Tobacco related mortality	Pricing policies	Columbia
Levin et al. (2015)	Cancer	Vaccination	China
Nugent et al. (2017)	Hypertension	Healthcare provision	Bangladesh
Olsen et al. (2021)	Pneumonia	Healthcare provision	Ethiopia
Pecenka et al. (2015)	Rotavirus	Vaccination and healthcare provision	Ethiopia

Pillarisetti et al. (2017)	Multiple health conditions	Improving living conditions	India
Plessow et al. (2016)	Infant malnutrition	Pricing policies	India
Rasella et al. (2018)	Multiple health conditions	Healthcare provision	Brazil
Rheingans et al. (2012)	Rotavirus	Vaccination	26 countries (focus on 8: Bangladesh, DR Congo, Ethiopia, India, Kenya, Niger, Nigeria, Uganda)
Rheingans et al. (2014)	Rotavirus	Vaccination	India
Rheingans et al. (2018)	Rotavirus	Vaccination	Lao
Segovia et al. (2020)	Obesity	Pricing policies	Ecuador
Tobe et al. (2016)	Neonatal complications	Screening	China
Vecino-Ortiz and Arroyo-Ariza (2018)	Obesity	Pricing policies	Columbia
Verguet et al. (2015c)	Multiple health conditions	Vaccination and healthcare provision	Ethiopia
Waters et al. (2013)	Pneumonia	Healthcare provision	Nigeria, Egypt, Bangladesh, Cambodia and Peru
Wieser et al. (2018)	Infant malnutrition	Pricing policies	Pakistan
Zhang et al. (2016)	Cancer	Vaccination	China

2 Appendix 2

2.1 Ethical approval

Original approval from ScHARR ethics committee

The University Of Sheffield.

Approved: 04/12/2018

Naomi Gibbs
Registration number: 170128818
School of Health and Related Research
Programme: Wellcome Trust PhD

Dear Naomi

PROJECT TITLE: PhD: Economic modelling of alcohol pricing policies in South Africa, with a focus on equity: Expert interviews and workshops.
APPLICATION: Reference Number 023357

On behalf of the University ethics reviewers who reviewed your project, I am pleased to inform you that on 04/12/2018 the above-named project was **approved** on ethics grounds, on the basis that you will adhere to the following documentation that you submitted for ethics review:

- University research ethics application form 023357 (dated 03/12/2018).
- Participant information sheet 1052221 version 2 (03/12/2018).
- Participant information sheet 1052222 version 2 (03/12/2018).
- Participant consent form 1052219 version 2 (03/12/2018).
- Participant consent form 1052220 version 2 (03/12/2018).

If during the course of the project you need to deviate significantly from the above-approved documentation please inform me since written approval will be required.

Yours sincerely

Jennifer Burr
Ethics Administrator
School of Health and Related Research

Approval of amendment to ScHARR ethics committee

The University Of Sheffield.

School Of Health And Related Research.

ScHARR

Charlotte Claxton
Ethics Committee Administrator
Regent Court
30 Regent Street
Sheffield S1 4DA

01 April 2020

Telephone: +44 (0) 114 222 5446
Email: c.claxton@sheffield.ac.uk

Project title: Economic modelling of alcohol pricing policies in South Africa with a focus on equity
Reference Number: 023357

Dear Naomi,

Thank you for submitting the above amended research project for approval by the ScHARR Research Ethics Committee. On behalf of the University, I am pleased to inform you that the project with changes was approved.

If during the course of the project you need to deviate significantly from the documents you submitted for review, please inform me since written approval will be required.

Yours sincerely

C.E. Clax

Charlotte Claxton
On behalf of the ScHARR Research Ethics Committee

Original approval from SAMRC

HUMAN RESEARCH ETHICS COMMITTEE

30 May 2019

Ms Naomi Gibbs
Alcohol, Tobacco and Other Drug Research Unit
SAMRC Cape Town

Dear Ms Gibbs

Protocol ID:	EC005-4/2019
Protocol title:	Economic modelling of alcohol pricing policies in South Africa with a focus on equity
Meeting date:	27 May 2019

Thank you for your application to the Committee, which was discussed at the April 2019 meeting, and your responses dated 22 and 29 May 2019. I am pleased to inform you that ethics approval is now granted for the study.

Please note that the approval is valid for 1 year, i.e. from 27 May 2019 to 26 May 2020. Any changes to the research protocol must be submitted as an amendment. Any adverse events must be reported within 48 hours. Any protocol deviations have to be reported.

Wishing you well with your research.

Yours sincerely

Prof Danie du Toit
Chairperson: SAMRC Human Research Ethics Committee

Members present at the meeting: Prof D du Toit (Chairperson), Ms S Behardien, Adv J Early, Dr H Etheredge, Prof A Kengne, Ms M Ledwaba, Prof C Lombard, Dr AG Loxton, Mr G Makanda, Prof C Wiysonge, Dr W Zembe

Amendment approval for the November workshop 2019 from SAMRC

SAMRC advancing life

HUMAN RESEARCH ETHICS COMMITTEE

10 October 2019

Ms Naomi Gibbs
Alcohol, Tobacco and Other Drug Research Unit
SAMRC Cape Town

Dear Ms Gibbs

Protocol ID:	EC005-4/2019
Protocol title:	Economic modelling of alcohol pricing policies in South Africa with a focus on equity
Meeting date:	26 September 2019

Thank you for your application to the Committee for an amendment, submitted on 5 September 2019. The Committee granted ethics approval for the amendment, with the recommendation that the informed consent forms should be sent out before the conference to allow possible participants time to decide whether they want to participate; and that the emails with study outcomes be sent as BCC so that names are kept confidential.

Wishing you well with your research.

Yours sincerely

Prof Danie du Toit
Chairperson: SAMRC Human Research Ethics Committee

Members present at the meeting: Prof D du Toit (Chairperson), Ms S Behardien, Adv J Early, Dr H Etheredge, Ms M Ledwaba, Dr A Loxton, Mr G Makanda, Dr E Nicol, Dr W Zembe

Amendment approval for the May online workshop

HUMAN RESEARCH ETHICS COMMITTEE

9 April 2020

Ms Naomi Gibbs
Alcohol, Tobacco and Other Drug Research Unit
SAMRC Cape Town

Dear Ms Gibbs

Protocol ID:	EC005-4/2019
Protocol title:	Economic modelling of alcohol pricing policies in South Africa with a focus on equity
Meeting date:	March 2020

Thank you for your application to the Committee for an amendment, submitted on 28 February 2020 and updated on 31 March 2020 (neither amendment form was dated). The Committee thanked you for following their recommendations. The Committee approved the proposed webinar, as submitted on 31 March 2020 as an alternative due to lockdown situations, with two comments: 1. Will participants be reimbursed for the bandwidth they use? 2. How will the researchers now ensure that enough or relevant people participate in the workshop? There is no information on what the minimum number of people/relevant clusters must be to make the workshop successful.

Yours sincerely

Prof Danie du Toit
Chairperson: SAMRC Human Research Ethics Committee

Members present at the meeting: : Prof D du Toit (Chairperson), Ms S Behardien, Adv J Early, Dr H Etheredge, Ms M Ledwaba, Prof C Lombard, Dr A Loxton, Dr W Zembe

2.2 Detailed table of stakeholders

Policy makers and government
National Government: Ministry of finance/treasury Department of Social Development Department of Agriculture Department of Trade and Industry Department of Health Forum of South African Director Generals – Chaired by Director General in The Presidency Inter-ministerial Committee on Substance Abuse (IMC) National Council of Provinces Committee on Economic and Business Development National Agriculture Marketing Council (NAMC) Provincial governments (9 provinces) Elected officials – including the Premier Department of economic affairs and tourism Western Cape provincial Liquor Board Western Cape Liquor Authority
Public
Drinkers Friends and families of drinkers Victims of alcohol related crimes Taxpayers Those employed by the alcohol industry
Civil society organisations
DG Murray Trust Soul City Foundation for Alcohol Related Research (FARR) Congress of South African Trade Unions Sustainable Livelihoods Foundation NCD Alliance
Practitioners and professionals
Substance abuse treatment/prevention practitioners

HIVV treatment practitioners SA national council on alcoholism and drug dependence
Lobby groups
FEDHASA national trade association for hotel, guesthouses, restaurants and caterers South Africans Against Drunk Driving Health promotion development foundation network South African Alcohol Policy Alliance (SAAPA) Free Market Foundation
Media
Tiso Blackstar (publisher, broadcaster, retailer) South African Broadcasting Corporation (SABC) eTV (privately owned free to aid TV channel) Multichoice (video entertainment and internet company) Health e-News (South African Health News Service) Advertising Media Forum (AMF) Advertising Medial Association of South Africa Oglivy (Marketing and advertising company)
International public health bodies
World Health Organisation (WHO) Global Alcohol Policy Alliance (GAPA) WHO regional office for Africa
Research community
Local academics involved n pricing policies of alcohol in South Africa Medical Research Council, South Africa School of Economics, University of Cape Town University of Witswatersrand Private research consultancies Genesis Analytics Economic Modelling Solutions DNA Economics Econex (company commissioned by South African Breweries) Econometrix

National and international academics engaged in alcohl research from any of the following disciplines: Policy analysis and management Social policy Health policy Public health Health economics Geography Mental health and addiction Psychology Psychiatry Development studies Medicine Epidemiology Law (licensing)
Private business
Networks/Associations The South African liquor trade association The South African Breweries Industry Association for Responsible Alcohol use (ARA) SA wine Industry Information and Systems NPC (SAWIS) South African Liquor Brand Owners Association (SALBA) South African Taverner's Association Association for alcohol responsibility and education (AWARE) International trade associations Suppliers Specific companies include; SABMiller, Brandhouse and Distell, Pernod Ricard, Heineken, DIAGEO, KWV, Edward Snell & CO., Vinpor. Retail South Africa Leisure, Tourism and Hospitality Association (SALTA) Consumer Goods Council of South Africa Major chain stores (Pick n Pay, Woolworths, Massmart, Shoprite Checkers) Smaller outlets

Outlets in townships
Employers in all sectors concerned with productivity impact of alcohol
Licensing lawyers

2.3 Interview questions

Interview questions

Alcohol harm and policy

• What evidence are you aware of relating to alcohol harm in South Africa?

• What are the high profile policy issues in relation to alcohol-related harms in South Africa currently?

Pricing and MUP

• What do you know about how alcohol excise taxes are structured in South Africa?

• How effective do you think alcohol excise taxes in South Africa are in reducing alcohol-related harms?

• Are there barriers or conditions that make this difficult?

• Are there ways in which strategies to increase the price of alcohol in South Africa could be strengthened?

• What do you know about Minimum Unit Pricing of alcohol? (If nothing, then I will give a brief explanation)

• Do you think minimum unit pricing could work in South Africa? And why?

Equity

• How is equity conceptualised in South Africa?

• Would you find it useful to see an alcohol pricing policy model that incorporated a concern for equity? If so, how?

Next steps

• Is there anything you think it is important for me to know/consider about alcohol policy and research in South Africa?

• Would you or your colleagues be interested in attending a workshop in November 2019 to inform the development of an equity informed alcohol pricing model?

• Do you know of anyone else who might be interested in the work that I am doing or who could provide useful inputs? Would you be happy to ask their permission to give me their contact details?

2.4 Workshop one: event plan

2.4.1 Project background and objectives

This PhD project aims to build an economic model for alcohol pricing policies in South Africa. It will link price change to change in consumption and change in consumption to health (at least). The model will demonstrate the differential impact of the policy between subgroups of interest.

Objective one: To map out the problem of alcohol harm in South Africa, conceptual model.

Objective two: To establish the list of possible policy options to be modelled

Objective three: To establish the list of possible subgroups of interest

Objective four: To establish the outcome domains, and items, which are of interest

2.4.2 Broad plan

The first section of the workshop will develop an understanding of the problem and the boundaries of the model

The second section of the workshop will consider the choice of policy, subgroups and outputs to make the model as relevant as possible to the current debate in South Africa.

Event team: Naomi Gibbs, Professor Parry, Administrative support provided by SA-MRC

Timings: Workshop activities 2 hours and 45 minutes. (Roughly 9am – 12pm, with 15 minute float for starting late or overrunning)

Room set up: Small tables to enable groups of three/four to work comfortably together. Estimating I will need four separate tables.

2.4.3 Detailed agenda

	Timing	**Objective**	**Activity**	**Resources**
Arrivals	Pre-event 8:30 – 9:05	Get everyone to sign consent forms	• Welcome people • Ask them to sign consent form and take participant information sheet.	Desk with • pens • consent forms

			• Ask them to complete sign in sheet and give them R100	• participant information sheets • sign in sheet • money • stickers for names
Welcome	5 minutes 9:05 – 9:10	Welcome everyone and outline the plan for the day	CP welcomes everyone and introduces NG, NG outlines the plan for the day including objectives and timings of activities.	• Laptop • Projector • presentation.
Introductions	15 minutes 9:10 – 9:25	Understand the expertise in the room	Introductions: name, organisation and role. Also ask them, "what is your interest in the topic?"	
Background to the research	10 minutes 9:25 – 9:35	To provide the participants with knowledge of the research project	NG to present some sort of graphic about the research process, including the different components of the research, and crucially how the stakeholder engagement shapes it at different points. Emphasise the stakeholders as much as possible. Use the visualisation.	• Laptop • Projector • presentation
Developing an understanding of	40 minutes	To develop an understanding of the	NG to present the conceptual model (a diagram mapping out the problem of alcohol in South	• laptop, • projector • presentation

the problem – the conceptual model	9:35 – 9:40 NG presents 9:40 – 10:00 small groups annotate the picture 10:00 – 10:15 one person per group feeds back to the whole group	problem of alcohol in South Africa. This will provide context in which the research will sit. It will highlight areas which are new or require further research.	Africa). This will be presented on a projector. NG then explains the objective and the exercise. Participants will be split into groups of three or four, sat around tables. Each will be given an A1 sheet with the conceptual model of alcohol harm in South Africa. Questions to guide the review will be provided on the projector and printed out. NG circulates to ensure people are happy with what they are doing. Each group will then feedback. The paper will be handed in for analysis. During whole group discussion admin support note taking in particular picking up any points of difference or consensus.	• Printed out diagram of alcohol harm in South Africa • Felt tip pens in a range of colours
Break 10:15 – 10:30	**15 minutes (during the break NG to write up all the outcomes that have been captured during the conceptual modelling onto two flipcharts, one for health outcomes, one for non-health)**			
Policies of interest	20 minutes	To establish what are the key alcohol pricing	NG to outline current tax system in South Africa and any pricing policies that exist (create some	• Flipchart • pens

	10:30 – 10:40 NG presents 10:40 – 10:50 discussion *(I think this one might well run over)*	policies to be included within the model.	slides). Talk about multiple policies that have been considered elsewhere. Give examples such as: tax sugar drinks same as flavoured fruit beverages to spirit. Tax sorghum beer, MUP, excise tax across the board. Ask people to have small group discussion for 5 minutes. Go around the room asking the small groups for their responses. *If all three groups have fed back and we have any time left then encourage a group discussion around what policy is realistic, what might be the population reaction.*	Put up key points for group one, group two, group three as they are feeding them back. Make sure you ask about what is realistic (i.e. implementable).
Sub-populations of interest	20 minutes 10:50 – 11:10	To establish key sub-populations of interest	Free for all group discussion on what subgroups it is most important to include in the model. Given this work is interested in trying to model not only the mean impact but also its distribution the subgroups will be important for demonstrating the differential impact of the policy.	• flipchart • pens

			Depending on group size this discussion could occur in one group or smaller groups but I would need help capturing the conversation from Charles. I think at this point two groups might be reasonable. Decide on the day. NG stands at the front jotting down key subgroups of interest as they arise on a large flipchart.	
Outputs	20 minutes 11:10 – 11:30	To establish outcome domains, both health and non-health.	NG to present potential outcomes (actually these should come from the earlier conceptual modelling session). I could add some that are not on there. Two pieces of flipchart paper. One piece for health outcomes and one for non-health outcomes (financial risk protection, crime, productivity). Group discussion, NG to ask the room for what is missing, there may not be any missing as they	• Stickers for the voting • Pre prepared flipchart paper with list of outcomes • Flipchart pens • Blue tack to stick up the paper

			have already had a chance to input into this. Write them up on the two flipchart pages as they are suggesting them. Until the room reaches saturation point. Voting: Once we have saturated all of the outcomes present everyone with 3 dots. Ask them to stick their dots against the outputs they think are the most important. Explain that it is necessary to prioritise! Also mention that differential impact will be an important part of the modelling process and will be examined in more detail in the second workshop. The subgroups and outcomes strongly shape this but there will be further methodological decisions for the stakeholders to input into.	
Summary and next steps	15 minutes 11:30 – 11:45	To thank everyone and invite them to input into the next workshops	Give everyone an opportunity to say one sentence, whatever they think is important to say about the work. Gives everyone a voice (Advice from Clara from SA workshop she attended).	• Post it notes of two different colours.

			NG thanks everyone for their time. Informs there will be a workshop outputs summary sent to everyone (unless they would prefer not to receive it) and invite to the following workshops, the next one will look in more detail at methods used to illustrate equity and the final will present model results and discuss next steps. NG to invite feedback on the workshop (post-its, one thing that worked, one thing that did not work). Ask people to stay for lunch	
Networking lunch – 30 minutes				

2.5 Feedback from workshop one

Things to do differently
• More time, more ideas and thoughts could be cultivated with a little more time • Keep finding important decision makers to come to these things • Maybe we should show street address so people don't get lost getting here • Consider social disruption effects
Things that worked well
• Good. Very helpful. • That was very good workshop and interesting • Everything that was presented here was great. Looking forward to work together • Framing of tax system and pricing helped with understanding • Good to bring various groups in. Place to reflect on issues and possibilities. Well done! • Great conversation, liked your responsiveness to change the agenda • Good facilitation and organisation. Helpful in mapping the causal relationships between policy and societal factors and outcomes • Everything was good especially: you had a great energy, flexibility when Aadeliah suggested a change in the flow, to delay the group work (Prof Parry), well organised, liked group work. • Very helpful to have all these players together discussing policy options – thinking through alcohol harms and ways to address it • Well prepared, ethically thorough, good absorption of input. • A systematic approach to engage on the issues. Small group interactions. • Interactive and well organised with well-defined outcomes targeted

2.6 Workshop two: online event plan

2.6.1 Project background and objectives

This PhD project aims to build an economic model for alcohol pricing policies in South Africa. It will link price change to change in consumption and change in consumption to health. The model will demonstrate the differential impact of the policy between subgroups of interest.

1. Discussion of progress so far - gathering input on assumptions and data
2. Presentation of some preliminary results
3. Discussion on how to present final model results and communication strategy

2.6.2 Broad plan

Event team: Naomi Gibbs, Prof Charles Parry

Timings: Workshop activities 2 hours. (Roughly 09:00 – 11.00)

Expected attendance: 12 – 15 people

People will have been sent the consent form and participant info sheet in advance. They will not have been given the link for the online workshop unless they have signed the consent form. The online workshop will be delivered in blackboard.

2.6.3 Detailed agenda

	Timing	Objective	Activity
Arrivals	Pre-event 08:30 – 09:00	Get everyone connected to the online workshop and able to hear.	This may be a challenge. Everyone will be provided with instructions. I will have completed a trial run with Charles and Aadielah in advance.

Welcome	5 minutes 09:00 – 09:05	Welcome everyone and outline the plan for the session	NG explains the functionality of the software, i.e. how to make a comment/ask a question etc. NG outlines the plan for the online workshop, including objectives and timings of activities. Explain how feedback will be elicited through google forms which they will be required to fill in at various points.
Introductions	15 minutes 09:05 – 09:20	Understand who is on the online workshop	CP briefly welcomes everyone and introduces himself and NG. NG goes through the list and asks people to give their name and organisation, whether they were at the first workshop, what is your interest in the topic
Recap of workshop one	10 minutes 9:20 – 9:30 NG presentation	To provide the participants with a brief background to the research project and outputs from workshop one.	NG to recap the last session's outputs. Emphasise the stakeholders as much as possible. Use the visualisation. Also share the most recent evidence regarding minimum pricing globally.

Price to consumption model: Part 1	10 minutes 09:30 – 09:40 NG presents	Understanding where the baseline consumption estimates come from. Explain how the pricing data has been arrived at and why. Outline some key assumptions and modelling choices.	NG to present the model progress focusing on consumption, price and elasticity estimates. NG always linking the work done to the direction given in workshop one.
Price to consumption model: Part 2	10 minutes 09:40 – 09:50 Everyone fills in the form	Gather feedback from stakeholders on key modelling choices.	Ask people to click link to google form and fill in. If anyone is struggling the will be emailed a word version for them to complete and email back afterwards.
Consumption to harm model: Part 1	10 minutes 09:50 – 10:00 NG presents	To provide progress on consumption to harm part of the model	NG presents the progress made in modelling consumption to harm part of the model.
Consumption to harm model: Part 2	10 minutes 10:00 – 10:10 Everyone fills in the form	Gather feedback from stakeholders on key modelling choices.	Ask people to click link to google form and fill in. If anyone is struggling the will be emailed a word version for them to complete and email back afterwards.

Tea break (10 minutes)			
Some preliminary results	15 minutes 10:20 – 10:35 NG present	To give stakeholders some initial results to gather interest and provide transparency	Present the first preliminary results with a caveat that this has not all been finalised.
How to present model results	10 minutes 10:35 – 10:45 5 minutes – NG explains the exercise 5 minutes – everyone completes the exercise	To gather input for a communication strategy for the results.	NG to outline some key points around differential input NG to outline a few of the communication channels which are possibilities. Then ask them to fill in another form which relates to their context. So give an example from mine as a PhD student. Who/Why/What/How Give an example (see slides)

Summary and next steps	10 minutes 10:45 – 10:55	To thank everyone and invite them to the next event.	Give everyone an opportunity to say one sentence, whatever they think is important to say about the work. Gives everyone a voice. Go down the list one at a time. NG thanks everyone for their time particularly in such difficult circumstances. Informs there will be a workshop outputs summary sent to everyone (unless they would prefer not to receive it) and invite to the final workshop, the next one will be more of a presentation of results where we might want to invite people more broadly. NG to invite feedback on the workshop via email.
Close of meeting 11am			

2.7 Stakeholder communication exercise results

Who do we want to communicate with?	**Why do we want to communicate with them?**	**What is the key message we want to communicate?**	**How do we practically do this? (examples: online articles, interactive online web tools, one page policy briefing, presenting in person, emails)**
Academics, policymakers, civil society, etc..	move the debate forward given how powerful the results are	MUP works, and might work well in SA	Opeds, radio, tv...
Policy makers	to change the alcohol policy	Higher price saves government expenses.	policy briefs, presentation in person, articles in respected journals.
Policy makers, media	This is a critical moment to influence policy. Demonstrating that the poor benefit is very powerful.	as above	policy briefings, interactive online tools
Those who make spending decisions in the household, bystanders who can stop their friends from drinking too much	To reduce spend, to encourage them to stop their friends from drinking	The more you drink, the more lives you put in danger, including your own	Culturally sensitive mass media campaigns, edutainment (is there evidence on what has worked in similar contexts?)

Media	To influence public opinion	a) That government should consider MUP in its strategy to reduce alcohol harms, b) that MUP influences behaviour of heaviest drinkers, c) that it saves lives of poorest who are currently bedrock of the consumer market for making profits of beer industry and low end wine and spirit producers & distributors	Press releases, twitter tweets, articles in fora such as The Conversation & Bhekisisa Health
Policy Makers	To set policy with most desirable impact		one page policy briefing and presenting in person
Government, the public, civil society organisations	It's how we influence policy and how we influence community level interventions	The cost burden of alcohol is far greater than what the industry provides to the state. Minimum unit pricing is the intervention that is mostly likely to be effective as a first step to building stronger policy and regulation instruments that decrease the burden of alcohol on the state and our society.	All these examples are useful. Lobbying will be the most effective however.
Regulators	To enhance policy formulation	Price measures are important in harm reduction	Policy briefing
Policy makers	influence policy choices	improved quality of life and health, lives gained, influencing spending towards beneficial/ life enhancing choices	interactive online, policy briefs, articles

Appropriate government ministries (Trade and Industry, Finance, Social Development?, Health, etc)	They can make a difference, i.e. implement policy	A MUP (with an increase in the excise tax) will have positive fiscal and health effects	All of the above. A "saturation bombing" strategy. Also, align yourself with a credible NGO in the public health space. They should have a reputation of being balanced and reasonable, but clearly distant from the industry
Policy makers, retailers and the public	Requires obtaining a critical mass of buy-in	Individual and societal harms can be reduced without an adverse impact to retail traders on the lower end (my understanding is that it is likely retailers would increase their profits?)	Infographic heavy online articles, policy briefs and presenting to policy making and retail outlet forums
We want to communicate with policy makers, retailers, consumers, interest groups, and community orgainsations	We want to reduce alcohol harms to alcohol consumers, families, and those affected by alcohol use.	Who is affected most by the change in MUP. And the impact that it has on lives and costs to society. Impact on government revenue; presumably to be used to mitigate the negative impacts of alcohol. Disincentives to consume alcohol.	Online articles, online interactive web, policy briefings. Academic is also important. But in the end action is needed and that would lie with the policymakers. Also consultation with roleplayers (public at large, civics, consumers of alcohol, families etc) as buy-in is important.
Policy-makers, civil society, police, prosecution	To influence policy and practice.	Reduce harm.	It depends on the target and the setting.

Government first then media opinion makers (who seem to be heavily influenced by industry)	Government to implement policy confidently based on evidence; opinion makers who claim to offer anti-government 'balance' in media but actually present industry argument. Evidence is necessary but not sufficient to change policy; government must be convinced and be able to present the arguments for the benefit of society, despite individual inconvenience. Must also raise addicts getting help (when prices increase!)	for the sake of SA health and safety, we need to drink less and in patterns that are moderate, for the sake of ourselves, our partners (esp women), innocent others (children, roadusers, students etc) - we are not banning alcohol but reducing access (through price like sugar tax) - not a new strategy - see 'sin taxes'. state and society must stop subsidising liquor industry (costs to health system, to crime which impacts on econ, like productivity and less aggression all round!)	all the above - have a multi-prong coms strategy starting with Cabinet, down to parliament and in all provinces and the bring the Mayors in) then media must report on all this. academic journals NB plys social media too

2.8 Workshop three: event plan

2.8.1 Project background and objectives

This PhD project aims to build an economic model for alcohol pricing policies in South Africa. It will link price change to change in consumption and change in consumption to health. The model will demonstrate the differential impact of the policy between subgroups of interest. Objectives for the final workshop were:

1. Explanation of minimum unit pricing
2. Brief overview of methods
3. Presentation of results
4. Discussion of results

2.8.2 Broad plan

Event team: Naomi Gibbs, Prof Charles Parry, Colin Angus (to provide broader context and answer questions where appropriate)

Timings: Workshop activities 1.5 hours. (Roughly 10:00 – 11.30)

Expected attendance: 15 - 20 people

People will not need to sign a consent form or participant information sheet. No data is being collected from participants.

The webinar will be delivered in blackboard.

2.8.3 Detailed agenda

	Timing	Objective	Activity
Arrivals	Pre-event 9:50 – 10:00	Get everyone connected to the webinar and able to hear	People asked to join 10 minutes in advance so we are able to start promptly at 10am.

Welcome	5 minutes 10:00 – 10:05	Welcome everyone and outline the plan for the session	NG explains the functionality of the software, i.e. how to make a comment/ask a question etc. Explain the session will not be recorded. NG outlines the plan for the session, including objectives and timings. CP gives an introduction focusing on the current policy context and the working relationship with Sheffield Alcohol Research Group.
Background to research	5 minutes 10:05 – 10:10 NG presents		NG to present the background to the research including the project overview slide presented at every workshop to date.
Explanation of minimum unit pricing	5 minutes 10:10 – 10:15	To make sure all new policy attendees have a basic understanding of the policy in order to understand results but also for the discussion.	NG to give a brief explanation of minimum pricing
Brief overview of methods	10 minutes 10:15 – 10:25 NG presents	To give a lay conceptual overview of the model	NG presents a conceptual framework for how the modelling process works

Presentation of results	20 minutes 10:25 – 10:45	Present the main research findings	NG to present the headline results findings, including polls to maintain attention.
Tea break (5 minutes)			
Discussion of results	10:50 – 11:30 40 minutes	Give participants an opportunity to discuss results and future research directions	Three stakeholders who had attended workshops one and two gave five minute reflections on the research. They were given the following questions: • What are your reflections on the research that has just been presented? • What are the next steps or remaining questions to be addressed? NG responds to any important points raised by discussants and then facilitates general discussion.
Close of meeting 11:30 am			

2.9 One page policy brief

Minimum Unit Pricing of Alcohol in South Africa

This policy brief is based on a published paper: "Effects of minimum unit pricing for alcohol in South Africa across different drinker groups and wealth quintiles: a modelling study"
http://bmjopen.bmj.com/cgi/content/full/bmjopen-2021-052879

Problem

South Africa experiences high levels of alcohol related harm across non-communicable disease, infectious disease and injury

Higher levels of harm from alcohol are experienced by the poor particularly for infectious disease such as HIV

How does minimum pricing work?

Minimum unit pricing legislates for a retail floor price dependent on the alcohol content of the drink

It does not replace a tax system but works alongside it

A R10 minimum unit price would mean a 750ml bottle of 5% beer could not be sold for less than R25. A 750 ml bottle of 12.5% wine could not be sold for less than R62.5

The policy targets the cheapest alcohol, often drunk by the heaviest drinkers

What are the estimated benefits of a R10 MUP to South Africa?

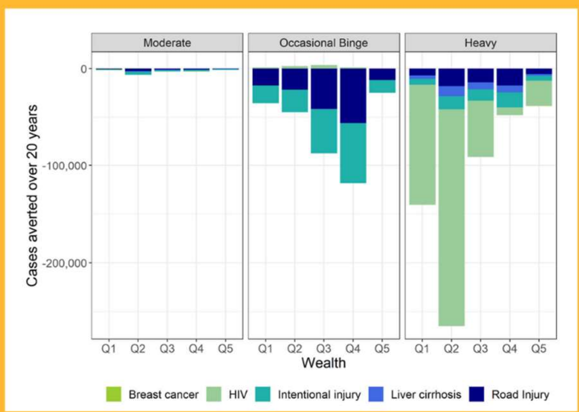
We estimate a 4.4% decrease in alcohol consumption

We estimate 20,585 fewer deaths and 900,332 fewer cases of alcohol attributable HIV, intentional injury, road injury, liver cirrhosis and breast cancer, over the next 20 years

Poorer drinkers are estimated to reduce their consumption the most

Amongst heavy drinkers 86% of the lives saved accrue to the bottom three wealth quintiles.

We estimate increases in retail and tax revenue



To find out more please contact:
Naomi Gibbs at n.gibbs@sheffield.ac.uk or Prof. Charles Parry at charles.parry@mrc.ac.uk

3 Appendix 3

3.1 Multipliers for intentional injury and road injury

South African research giving trauma numbers from 1999 was used in combination with iHME data to estimate the multiplier between prevalence and hospital admissions (Matzopoulos et al., 2006).

Category in iHME	Prevalence iHME 1999	Category in survey in paper	Number of cases	Multiplier from prevalence to hospital visit
Transport injuries	1,566,017.43	Traffic	302,872	0.19
Unintentional injuries	3,392,764.13	Other injuries	416,449	0.12
Interpersonal violence and self-harm	1,851,637.90	Violence	757,180	0.41

3.2 Script file library

The model is split into two. Price to consumption and consumption to harm. Each have their own R project. Within each R project are three folders: inputs, intermediate and outputs.

In the price to consumption R project the inputs folder contains two further folders and R projects, one for the SADHS data and one for the IAC data as there was so much data wrangling to do and inter relation between them, for example creating an ordered choice model for wealth in SADHS and using it to predict wealth in IAC data. Three of the outputs from the SADHS and IAC R projects are saved into the inputs folder for the price to consumption model.

In the consumption to harm R project the inputs folder contains a further folder for the General Household Survey data

Price to Consumption	
R Project: SADHS	
Script: SADHS wrangling	• Selecting variables from female, male and household SADHS datasets and bringing them together. Renaming and categorising variables as needed, tidying the data. • Compute new variables to provide annual consumption estimates. • Adjusting annual estimates to take into account the frequency questions as well as the 7 day recall (applies to both mean and peak measures). • Creating the heavy_bing_mod categories. • Changing the weights so that the population represents 2018 population. • Visualising the distribution of drinkers using pie charts Save the data as "SADHS.Rda" (this saves it only within the SADHS project)
Script: shift_consumption	• Bring in SADHS data • This is where I do the gamma shift. I create a gamma distribution using 80% of Euromonitor data of recorded sales for 2018. Fit a gamma to the survey data. Work out the difference between the percentiles and uplift everyone's individual consumption by that amount. • I do this without including homebrew and then uplift homebrew by the same percentage shift • There is also a peak model fitted within this script file to relate peak drinking to mean drinking plus age band, sex and whether or not they state that they drink 5 or more. The model has been labelled peak_model • I also recalculate the proportions of heavy_binge_mod after the shift and visualise on pie charts again.

	Save the model as “peak_model.Rda” Save the files as “base_consumption.Rda” (these are saved within the inputs folder for price to consumption R project as well as the SADHS project)
Script: predicting wealth	• This script is to generate a model (ordered choice model) which approximates the wealth quintiles. Saves the model so it can be used to predict wealth quintiles in the IAC dataset. Save the model as “model_wealth.Rda” (this is saved in the SADHS R project)
R Project: IAC project	
Off-trade prices	
IAC_price_alcopop_off	Check all prices and adjust as necessary Calculate ppml Calculate number of standard drinks in 6 months Save as “off_rtd.Rda”
IAC_price_beer_off	Check all prices and adjust as necessary Calculate ppml Calculate number of standard drinks in 6 months Save as “off_beer.Rda”
IAC_price_cider_off	Check all prices and adjust as necessary Calculate ppml Calculate number of standard drinks in 6 months Save as “off_cider.Rda”
IAC_price_labeer_off	Check all prices and adjust as necessary Calculate ppml Calculate number of standard drinks in 6 months Save as “off_labeer.Rda”
IAC_price_spirits_off	Check all prices and adjust as necessary Calculate ppml Calculate number of standard drinks in 6 months Save as “off_spirit.Rda”
IAC_price_stout_off	Check all prices and adjust as necessary Calculate ppml

	Calculate number of standard drinks in 6 months Save as “off_stout.Rda”
IAC_price_wine_off	Check all prices and adjust as necessary Calculate ppml Calculate number of standard drinks in 6 months Save as “off_wine.Rda”
On-trade prices	
IAC_price_alcopop_on	Check all prices and adjust as necessary Calculate ppml Calculate number of standard drinks in 6 months Save as “on_rtd.Rda”
IAC_price_beer_on	Check all prices and adjust as necessary Calculate ppml Calculate number of standard drinks in 6 months Save as “on_beer.Rda”
IAC_price_cider_on	Check all prices and adjust as necessary Calculate ppml Calculate number of standard drinks in 6 months Save as “on_cider.Rda”
IAC_price_labeer_on	Check all prices and adjust as necessary Calculate ppml Calculate number of standard drinks in 6 months Save as “on_labeer.Rda”
IAC_price_spirits_on	Check all prices and adjust as necessary Calculate ppml Calculate number of standard drinks in 6 months Save as “on_spirit.Rda”
IAC_price_stout_on	Check all prices and adjust as necessary Calculate ppml Calculate number of standard drinks in 6 months Save as “on_stout.Rda”
IAC_price_wine_on	Check all prices and adjust as necessary Calculate ppml Calculate number of standard drinks in 6 months Save as “on_wine.Rda”
Bringing it all together	
prices_together	Bring in all the above files and bind together Inflate prices to 2018 Adjust off-trade wine prices Categorise drinkers into drinker groups

	Bring in model_wealth in order to predict wealth groups Create drinker and wealth groups combined Calculate mean prices Calculate new mean prices under different minimum price scenarios Save price changes dataframe to use in price to consumption model
5. R Project: model_pc **3.2.1**	
Script: model_pc **3.2.2**	• The model script brings in the three R files from the inputs folder: base_consumption data, and the price_changes (mean price under different policy options) and peak_model • Joins consumption and price changes together by heavy/binge/mod drinker type categories. • An elasticity matrix is then manually created and this is then also joined to the dataframe. • Consumption is calculated following a change in mean price • Expenditure is calculated at each level • Change in expenditure is calculated • Homebrew is added back into the model • Change in consumption is calculated • Total litres drink at each scenario is calculated • Peak drinking is estimated • Industry and government revenue are calculated Save the data as "consumption_scenarios.Rda" (saved into outputs in price to consumption model and saved into inputs in consumption to harm model)

Consumption to harm	
R Project: GHS 2018	
Script: prev by quintile	• This script takes the GHS data and applies the ordered choice wealth model created in SADHS to allocate everyone into a wealth quintile. • It then calculates percentage share of disease burden between the wealth quintiles for HIV, road, intentional injury and cancer. Road and intentional injuries were combined to create one injury category. Liver cirrhosis is also using injury gradients in the base case. Save the data as "prev_wealthquintile.Rda" (saved in the inputs folder for ch R project)

R Project: model_ch	
Script: rr_and_pifs	• Brings in "inputs/consumption_scenarios.Rda". • Creates relative risks for each drinking for each consumption level for every health outcome included. For example rr_ii_R5 would be the relative risk at a R5 minimum price for intentional injury. • It then calculates potential impact fractions for every policy for every health outcome. Grouped by sex, wealth and drinker type. The sample was not large enough to also do it by age. • It also summarises total risk within each sex, wealth and drinker group. These are then transformed into proportions so that they can be taken forward and use to distribute baseline prevalence between the groups. Save the data as "intermediate/pif_ii_Rda" (for every health outcome) Save the data as "intermediate/rr_drinker_type.Rda"
Script: **allocating_wealth_quintile**	• Load "consumption_scenarios.Rda" and the population data for 2018 from an excel file in the inputs folder. • This code distributes the 2018 data into sex/wealth/drinker types using the proportions from the SADHS data, resulting in a very long file. save the data as "intermediate/males_2018.Rda" save the data as "intermediate/females_2018.Rda"
Script: baseline_probabilities	• Brings in 2018 aggregate data on mortality and cases from the health inputs data excel file in inputs folder • Brings in 2018 aggregate data on population, also an excel file in inputs folder, which includes probability of death at each age from iHME life tables from 2017 (they were not available by single year of age for 2018) • Brings in prev_wealthquintile.Rda saved into inputs folder from GHS data (see above). • Brings in SADHS consumption scenarios data so population proportions can be calculated • Brings in data on risk by drinker type from rr_and_pifs script file above • Step one: Using SADHS data calculate the proportion of the population within each wealth quintile • Step two: allocates deaths and cases between the quintiles using prev_wealthquintile proportions • Step three: Using SADHS data calculate the proportion of the population within each drinker category within each wealth quintile • Step four: allocate deaths and cases between the drinker types using rr_drinker type proportions • Step five: Apply the proportions from step three to the population to get the population within each category • Step six: divide deaths/cases in each category by population in each category to get baseline probabilities

	save the data as "intermediate/baseline_probabilities.Rda"
Script: policy_scenario_probabilities	load("females_2018.Rda") load("males_2018.Rda") load("baseline_probabilities.Rda") load("pif_hiv.Rda") load("pif_ii.Rda") load("pif_road.Rda") load("pif_liver.Rda") load("pif_bcancer.Rda") • Pifs are matched to the 2018 population by sex, drinker type and wealth. • Risk of mortality from other causes is calculated. • Prob of death under each price scenario is calculated by multiplying the probability of death by the pifs • Prob of having the disease (as opposed to death) is calculated in the same way using the same pifs • Data is arranged by age, and a reduced dataframe is selected which includes, age, starting population, wealth, drinker type and all the probabilities for prev and deaths. • Rename pop_wealth_drinker as pop_t0. save the data as "intermediate/female_population.Rda" save the data as "intermediate/male_population.Rda"
Script: model_ch	• Load the prepared populations, female_population and male_population from the intermediate file. • The population is projected forward 20 years, by sex and wealth and drinker type, for each pricing scenarios. • Lives are added up at the end of the 20 years for each policy scenario • The new populations at each scenario level are saved. • These are then multiplied by the relevant probability of disease to get the prevalence of each disease at each policy level save the data as "outputs/results_mortality.Rda" save the data as "outputs/results_prevelance.Rda" save the data as “intermediate/prev_base_f.Rda” for all policies for males and females. This will be used in cost modelling

Script: **visualising_morb_mort_results**	• load("outputs/results_mortality.Rda") • load("outputs/results_prevelance.Rda") • prepare the data to feed into a plot • run various plots save the data as tiff files in the outputs folder
Script: **health_costs**	• load("intermediate/prev_base_f.Rda") for all policies for males and females. • Create net prev by taking base away from each policy scenario. • Calculate costs for each year, using 5% discount rate, also taking account of the multiplier between prev and receiving treatment • Combine costs
Script: **crime_costs**	• Bring in the consumption_scenarios from price to consumption. • Use alcohol attributable fractions and percentage cost of GDP which is crime related allocate a percentage of the GDP to each of the three crime costs • Calculate percentage change in consumption • Apply the percentage decrease in consumption to a decrease in crime cost

3.3 Script file library for ECEA

Price to Consumption	
R Project: SADHS	
Script: SADHS wrangling	• Selecting variables from female, male and household SADHS datasets and bringing them together. Renaming and categorising variables as needed, tidying the data. • Compute new variables to provide annual consumption estimates. • Adjusting annual estimates to take into account the frequency questions as well as the 7 day recall (applies to both mean and peak measures). • Creating the heavy_bing_mod categories. • Changing the weights so that the population represents 2018 population. • Visualising the distribution of drinkers using pie charts Save the data as "SADHS.Rda" (this saves it only within the SADHS project)
Script: shift_consumption	• Bring in SADHS data

	- This is where I do the gamma shift. I create a gamma distribution using 80% of Euromonitor data of recorded sales for 2018. Fit a gamma to the survey data. Work out the difference between the percentiles and uplift everyone's individual consumption by that amount. - I do this without including homebrew and then uplift homebrew by the same percentage shift - There is also a peak model fitted within this script file to relate peak drinking to mean drinking plus age band, sex and whether or not they state that they drink 5 or more. The model has been labelled peak_model - I also recalculate the proportions of heavy_binge_mod after the shift and visualise on pie charts again. Save the model as "peak_model.Rda" Save the files as "base_consumption.Rda" (these are saved within the inputs folder for price to consumption R project as well as the SADHS project)
Script: predicting wealth	This script is to generate a model (ordered choice model) which approximates the wealth quintiles. Saves the model so it can be used to predict wealth quintiles in the IAC dataset. Save the model as "model_wealth.Rda" (this is saved in the SADHS R project)
R Project: IAC project	
Script: IAC wrangling	- Bringing in the IAC dataset and creating some variables for total consumption and percentage split between the different beverage categories (redundant at the moment). - Changing variable to match the SADHS variables for use in the model to predict wealth quintiles. Save the file as "IAC_dk.Rda" (this is just for the drinker density plots) Save the file as "IAC_demographics.Rda" (this is for the wealth modelling) Files only saved within the IAC R project
Script: IAC_price_beer_on **3.3.1**	Prices calculated per ml for beer in the on trade. This is repeated for all on and off trade drinks and each one is saved as an R data file. Save the data as "on_beer.Rda" (for every drink, on and off trade within the IAC R project)

Script: prices_october_2020 3.3.2	• Brings all the on and off trade prices for every drink and puts them into one dataframe. • Brings in wealth model from SADHS R project • Then it increases all prices by inflation to 2018. • Brings in the IAC_demographics.Rda created in wrangling. • Creates drinker categories (heavy/binge/mod). Visualises drinker type price distributions. • Then applies minimum prices R5, R10, R15. Changes the distribution and then computes mean price for new distribution. • Generates wealth quintiles using predictions from the regression model created in SADHS. Save the file as: "prices.Rda" (full file with all demographics and all prices, saved only in the IAC R project) Save the file as "price_changes.Rda" (includes only the rows (heavy/binge/mod) and four prices one for each policy scenario, saved in the price to consumption R project in the inputs folder)
6. R Project: model_pc 3.3.3	
Script: adjusting_elasticities	• This file adjusts the elasticities using the wealth gradient
Script: model_pc 3.3.4	• The model script brings in the three R files from the inputs folder: base_consumption data, and the price_changes (mean price under different policy options) and peak_model • Joins consumption and price changes together by heavy/binge/mod drinker type categories. • An elasticity matrix is then manually created and this is then also joined to the dataframe. • Consumption is calculated following a change in mean price • Expenditure is calculated at each level • Change in expenditure is calculated • ECEA ONLY – increase in spend over 20 years is calculated. • Homebrew is added back into the model • Change in consumption is calculated • Total litres drink at each scenario is calculated • Peak drinking is estimated • Industry and government revenue are calculated Save the data as "consumption_scenarios.Rda" (saved into outputs in price to consumption model and saved into inputs in consumption to harm model)
Script: regressivity	• Calculates how strictly regressive the policy is by comparing change in spend with income by quintile

Consumption to harm	
R Project: GHS 2018	
Script: prev by quintile	• This script takes the GHS data and applies the ordered choice wealth model created in SADHS to allocate everyone into a wealth quintile. • It then calculates percentage share of disease burden between the wealth quintiles for HIV, road, intentional injury and cancer. Road and intentional injuries were combined to create one injury category. Liver cirrhosis is also using injury gradients in the base case. Save the data as "prev_wealthquintile.Rda" (saved in the inputs folder for ch R project)
R Project: model_ch	
Script: rr_and_pifs	• Brings in "inputs/consumption_scenarios.Rda". • Creates relative risks for each drinking for each consumption level for every health outcome included. For example rr_ii_R5 would be the relative risk at a R5 minimum price for intentional injury. • It then calculates potential impact fractions for every policy for every health outcome. Grouped by sex, wealth and drinker type. The sample was not large enough to also do it by age. • It also summarises total risk within each sex, wealth and drinker group. These are then transformed into proportions so that they can be taken forward and use to distribute baseline prevalence between the groups. Save the data as "intermediate/pif_ii_Rda" (for every health outcome) Save the data as "intermediate/rr_drinker_type.Rda"
Script: **allocating_wealth_quintile**	• Load "consumption_scenarios.Rda" and the population data for 2018 from an excel file in the inputs folder. • This code distributes the 2018 data into sex/wealth/drinker types using the proportions from the SADHS data, resulting in a very long file. save the data as "intermediate/males_2018.Rda" save the data as "intermediate/females_2018.Rda"
Script: baseline_probabilities	• Brings in 2018 aggregate data on mortality and cases from the health inputs data excel file in inputs folder • Brings in 2018 aggregate data on population, also an excel file in inputs folder, which includes probability of death at each age from iHME life tables from 2017 (they were not available by single year of age for 2018)

	• Brings in prev_wealthquintile.Rda saved into inputs folder from GHS data (see above). • Brings in SADHS consumption scenarios data so population proportions can be calculated • Brings in data on risk by drinker type from rr_and_pifs script file above • Step one: Using SADHS data calculate the proportion of the population within each wealth quintile • Step two: allocates deaths and cases between the quintiles using prev_wealthquintile proportions • Step three: Using SADHS data calculate the proportion of the population within each drinker category within each wealth quintile • Step four: allocate deaths and cases between the drinker types using rr_drinker type proportions • Step five: Apply the proportions from step three to the population to get the population within each category • Step six: divide deaths/cases in each category by population in each category to get baseline probabilities save the data as "intermediate/baseline_probabilities.Rda"
Script: **policy_scenario_probabilities**	load("females_2018.Rda") load("males_2018.Rda") load("baseline_probabilities.Rda") load("pif_hiv.Rda") load("pif_ii.Rda") load("pif_road.Rda") load("pif_liver.Rda") load("pif_bcancer.Rda") • Pifs are matched to the 2018 population by sex, drinker type and wealth. • Risk of mortality from other causes is calculated. • Prob of death under each price scenario is calculated by multiplying the probability of death by the pifs • Prob of having the disease (as opposed to death) is calculated in the same way using the same pifs • Data is arranged by age, and a reduced dataframe is selected which includes, age, starting population, wealth, drinker type and all the probabilities for prev and deaths. • Rename pop_wealth_drinker as pop_t0. save the data as "intermediate/female_population.Rda" save the data as "intermediate/male_population.Rda"
Script: model_ch	• Load the prepared populations, female_population and male_population from the intermediate file.

<table>
<tr><td></td><td>

The population is projected forward 20 years, by sex and wealth and drinker type, for each pricing scenarios.
Lives are added up at the end of the 20 years for each policy scenario
The new populations at each scenario level are saved.
These are then multiplied by the relevant probability of disease to get the prevalence of each disease at each policy level

save the data as "outputs/results_mortality.Rda"
save the data as "outputs/results_prevelance.Rda"
save the data as “intermediate/prev_base_f.Rda” for all policies for males and females. This will be used in cost modelling
</td></tr>
<tr><td>Script:
visualising_morb_mort_results</td><td>

load("outputs/results_mortality.Rda")
load("outputs/results_prevelance.Rda")
prepare the data to feed into a plot
run various plots

save the data as tiff files in the outputs folder
</td></tr>
<tr><td>Script:
health_costs_ECEA</td><td>

load(“intermediate/prev_base_f.Rda”) for all policies for males and females.
Create net prev by taking base away from each policy scenario.
Create utilisation variables for each quintile for each disease/injury
Create healthcare cost variables, uprated to 2018 where necessary
Create a function to calculate costs, using 5% discount rate.
Calculate costs dataframes
Create function to sum costs over 20 year run
Sum costs and combine into one dataframe
Allocate costs as either borne by the individual (oop) or by the government (govt)

save the data as “intermediate/results_costs.Rda”
</td></tr>
<tr><td>Script:
financial_risk_protection
(CHE averted)</td><td>

Bring in the results_costs data
Create a variable that assigns an income level to each quintile, then take 10% of it, also 25% and 40%
Compare the income with the oop from the disease area. If oop greater than 10% of income then count the prevalence for that group. If not then set at zero. This counts all of the cases of CHE averted.
Sum and visualise

</td></tr>
<tr><td>indirect_costs_ECEA
(productivity and absenteeism)</td><td>

Bring in the results_costs data
Create income variable for each wealth quintile
Create new variables to calculate productivity loss at 6% over 20 years using discount rate of 5%. Sum them.
Create daily wage variable
Create new variables to calculate absenteeism loss by multiplying days loss by lost income by prev of disease
Sum and visualise

</td></tr>
</table>

4 Appendix 4

This is the appendix which accompanies the published paper: Effects of minimum unit pricing for alcohol in South Africa across different drinker groups and wealth quintiles: a modelling study. It is published online and has been inserted in its published format.

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Supplementary Material

Price to consumption

Our model starts by estimating mean and peak alcohol consumption at current alcohol prices at the individual level. The proportion of alcohol consumption which is homebrew is also estimated. This process utilised both alcohol frequency questions and seven day recall questions asked in the same survey. As survey data significantly underreports consumption we calibrate these estimates to market research data using statistical methods established in the literature [1-3]. Following the shift of mean consumption, peak consumption is re-estimated using a simple regression model created at baseline. We categorise drinkers into three exhaustive and mutually exclusive groups; moderate (less than 15 standard drinks per week); occasional binge (less than 15 drinks per week but more than 5 on one occasion); and heavy (15 or more drinks per week). A standard drink in South Africa is currently 15ml or 12 grams of pure ethanol. We compute a regression model for wealth quintiles using the South African Demographic and Health Survey (SADHS) data and use it to predict wealth quintiles in the International Alcohol Control (IAC) dataset to generate price distributions for wealth and drinker groups. Alcohol is treated as one commodity due to data constraints.

1. Estimating baseline consumption using South African Demographic and Health Survey (SADHS)

The SADHS survey asked the following questions:

Table 1: Survey questions

Survey	**Alcohol questions** **[answers]**
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]

Process of adjusting the SADHS estimates

Drinkers were categorised by their drinking frequency and by whether or not they had reported any drinking in the last seven days.

Table 2: Frequency of alcohol consumption responses

Drinking occasion frequency	count	Reported drinks in last 7 days	Reported zero drinks in last 7 days
5 or more days a week	293	266	27 (6 binge, 21 drinker)
1-4 days per week	668	565	103 (29 binge, 74 drinker)
1-3 days per month	1163	799	364 (all drinkers)
less often than once a month	1187	404	783 (all drinkers)
NA	7025		

Readjusting those with a seven day drinking pattern (pink numbers)

The pink numbers are respondents who say they only drink 1 -3 days per month or less often than once a month but have drunk in the last 7 days. If this were multiplied by 52 it would be an overestimate. Therefore, we assumed for those that drink 1-3 days per month we have captured their one drinking week in the month and multiply by 12 to get their annual consumption. There are 799 people in this category. We assumed for those who drink less often than once a month but who did drink in the last week we have caught their one drinking week that occurs every two months. We multiplied by six, to get the annual figure. There are 404 people in this category. The yellow numbers do not require adjustment as respondents report drinking every week and have a seven day drinking pattern.

Readjusting those without a seven day drinking pattern but who say they drink (blue and red numbers)

For those with a drink frequency of five or more days per week we used the mean standard drinks for drinkers who reported the same frequency but who do have a seven day pattern, there are 27 people that this applies to (blue).

For those with a drink frequency of 1 – 4 days per week we used the mean standard drinks for drinkers who report the same frequency but who do have a seven day pattern, there are 103 people in this group (blue).

For those with a drink frequency of 1 – 3 days per month we used the mean adjusted annual drinks (adjusted in 2.2.1.3.1) of the equivalent frequency group who did report a drinking pattern. There are 364 drinkers in this group (red).

All of the above estimates were computed for sex and binge drinking subgroups.

For those with a drink frequency of less than once per month we used the mean adjusted annual drinks (adjusted in 2.2.1.3.1) of the equivalent frequency group who did report a drinking pattern. This is computed for subgroups based on sex and binge drinking. There are 783 people in this group (red)

Process of adjusting peak drinks

Using the same process as above we applied a peak drink to those observations without one. As an additional check we validated that all those reporting binge drinking had a peak drink at minimum of 5.

Comparing the adjusted SADHS data with the estimates using only 7 day recall as expected prevalence of drinking increases and per capita estimates reduce (Table 6). The prevalence estimates are now broadly similar to the NiDs and GISAH estimates (Table 3).

Table 3: Comparing adjusted with unadjusted statistics

	Prevalence of drinking		**Sample size: drinkers**	**Annual litres of alcohol - per capita**			**Annual litres of alcohol - Just drinkers**		
	Female	Male		Total	Female	Male	Total	Female	Male
SADHS (7 day recall only) Population weights applied	9.3%	32.7 %	n = 1949 (report drinks in the 7 day recall) females = 571 males = 1378	2.2	0.65	4.5	10.6	6.54	12.2
SADHS adjusted (7 day recall plus adjustments based on frequency questions) Population weights applied	18%	54%	n = 3311 females = 1125 males = 2186	1.65	0.50	3.4	5.0	2.59	6.25

Figure 1: Density plot of female drinkers before and after the shift

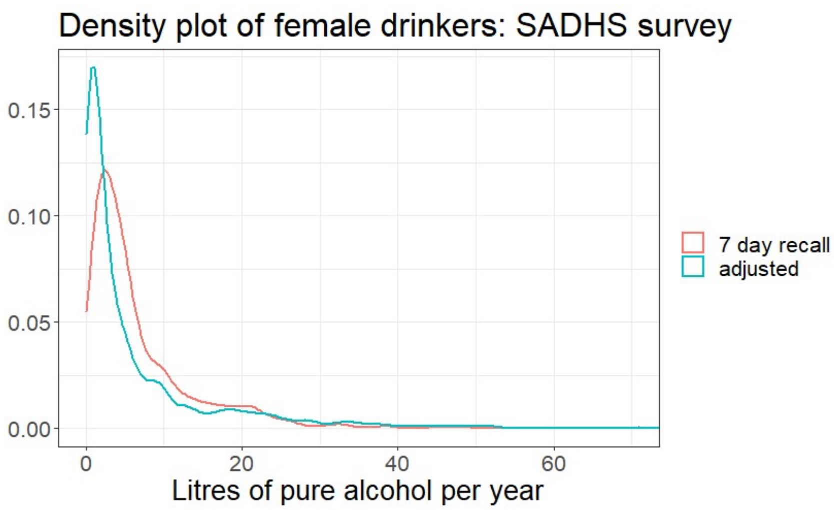
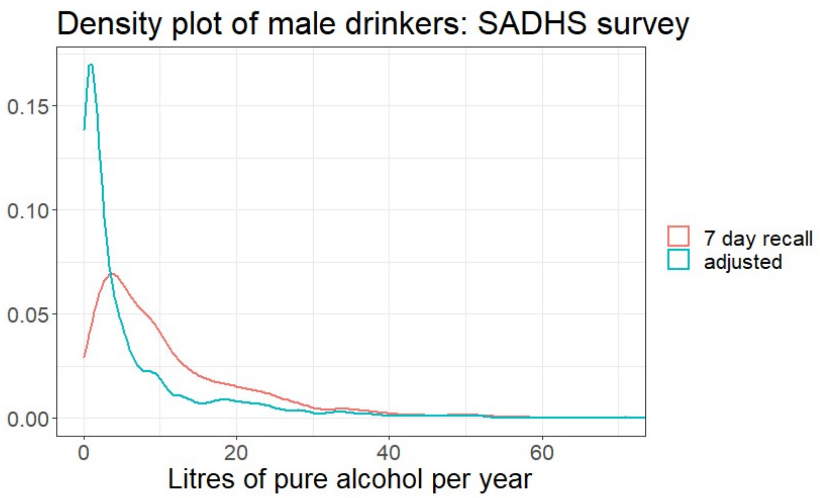


Figure 2: Density plot of male drinkers before and after the shift



Incorporating the frequency data into the seven day recall moves the distribution towards the left (Figures 1 and 2). This is logical as the sample will now include those drinkers who stated that they drink but did not record any for the last seven days, it also adjusted down those who claim to drink less than weekly but who did recall drinks for the last seven days. This pattern gives some confidence in the dataset and utilises the strengths of capturing heavy drinking well and including occasional drinkers.

2. Uplifting consumption

Surveys provide important data about drinking patterns within the population but total consumption estimates are far smaller than that indicated by administrative sources [4]. As this is a global phenomenon there are established statistical calibration methods in the academic literature. The steps are broadly as follows:

- compute the ratio between survey and sales per capita consumption (known as coverage)
- use this ratio to adjust the mean for each subpopulation of interest
- use the new mean to estimate an associated standard deviation based on a published relationship, estimated using regression on a large global dataset [2]

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

- use the new mean and standard deviation to generate the shape and rate parameters and fit a gamma distribution

This method relies on three assumptions. Firstly that the sales data accurately reflects per capita consumption. Secondly, that the true proportion of abstainers has been captured by the survey, and finally that under-estimation of consumption is the same across all population groups.

Two additional key limitations have been identified with regards to this method. Firstly, there is no empirical evidence that under-coverage is distributed as implied by the shifts needed to fit the adjusted consumption to the gamma. Secondly, that shifting consumption to a gamma can artificially reduce the long tail of heavy drinkers [3]. To address the second point a proposed method is to fit a gamma distribution to the survey and for each percentile of the distribution calculate the percentage consumption increase and apply these percentage shifts to the corresponding percentile of the survey data.

The following steps outline, in detail, how we calibrated the SADHS dataset to Euromonitor figures:

- First a cap was applied to all drinkers of 68 litres of alcohol per year or 150 grams of alcohol per day. As the model includes long term effects (20 years) the cap is needed as a higher level of alcohol cannot be sustained in the long term [5]. This cap impacted one woman and ten men. Of this small group only two men drunk both homebrew and recorded alcohol and so their total consumption was reduced to 68 litres and then split into recorded and homebrew using their previous percentage split.

- Survey coverage level was calculated as the difference between total per capita consumption recorded in the SADHS survey and per capita consumption using Euromonitor recorded sales data for 2018. 80% of the sales data is used to account for spillage, stockpiling and tourist consumption. This sales figure was then increased to take account of the 4.15% of total alcohol consumed in the SADHS survey reported as homebrew (representing unrecorded alcohol in the model). The comparison of total consumption according to the survey and the adjusted official sales data was used to calculate a coverage of 27%.

- For female and male subgroups the mean litres of alcohol was adjusted by the multiplication factor. This adjusted mean was used to estimate an associated standard deviation based on a previously established relationship between the two. These were then used to fit a "shifted" gamma distribution (maintaining the cap of 68 litres), calculated for male and females separately.

- A gamma distribution was fitted to the original sample of drinkers, by sex, and percentiles were taken across this and the shifted distribution. Percentage differences in consumption were calculated. These increases were then applied to the percentiles of the original survey sample.

- Each individual's total consumption was split into homebrew and recorded alcohol using the original percentage split (this assumes underreporting is equal across homebrew and recorded alcohol).

- Results were compared visually and via a table (Table 7 and Figures 8 and 9). There is a small difference between the two methods, more visible for males than females. It appears adjusting by percentiles only makes a difference at the extremes, lowering the left hand peak slightly but also falling below the Gamma shifted distribution after 60 litres of alcohol per year for men meaning there is a smaller number of the very high drinkers.

The percentile adjusted distribution was used for the main model base on expert opinion.

Table 4: Comparing pre and post shift data

Females – litres of alcohol per year	Mean	Min	Max
SADHS Survey data (weighted mean and capped)	2.57	0.09	68
Gamma fitted to survey (difference due to weights)	2.50	0.09	68
Gamma shift	10.78	1	68
Adjusting each percentile (weighted mean)	10.74	0.5	68

Males – litres of alcohol per year			
SADHS Survey data (weighted mean and capped)	6.13	0.09	68
Gamma fitted to survey (difference due to weights)	5.6	0.09	68
Gamma distribution shifted	18.55	1	68
Adjusting each percentile (weighted mean)	19.2	0.5	68

Figure 3: Comparing distributions pre and post shift females

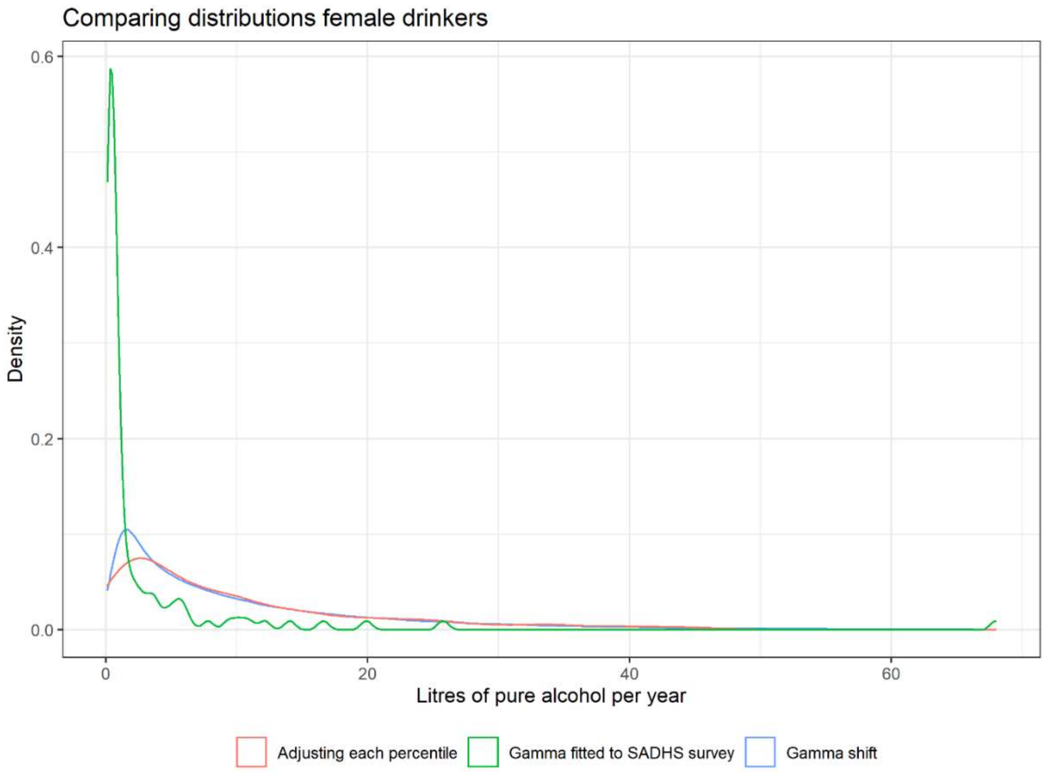
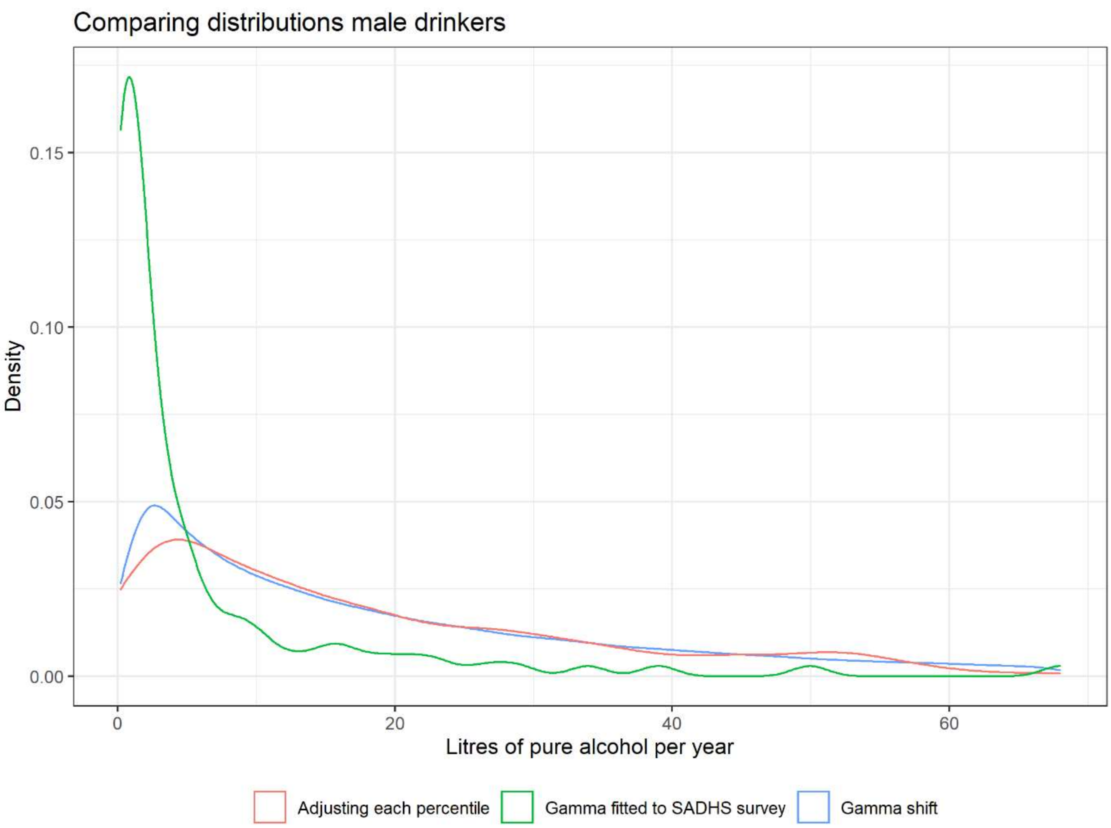


Figure 4: Comparing distributions pre and post shift males



3. Uplifting peak consumption

Peak drinking measures the highest number of drinks consumed on a single drinking occasion and therefore relates to intoxication which is associated with harms such as road injury, interpersonal violence and self-harm. Following the method used in the Sheffield Alcohol Policy Model [6], the following linear regression model was fitted, for all drinkers, to the non-shifted SADHS data, relating peak drinking to mean consumption, age and sex.

$$peak_{ij}(SADHS) = \beta_0 + \beta_1 \times ageband + \beta_2 \times sex$$

The model was used to compute fitted values for the non-shifted data. The model assumes there is a linear relationship between peak and mean consumption, the magnitude of which is allowed to vary by age and sex.

After the mean consumption was shifted as above the corresponding new peak consumption was computed using the following formula:

$$peak_{ij}(shifted) = \mathrm{peak}_{ij}(SADHS) \times \left(\frac{E(peak_{ij}(shifted))}{E(peak_{ij}(SADHS))}\right)$$

The linear relationship between mean and peak estimated from the SADHS survey is maintained for the shifted mean and peak consumption, this assumes individuals under reported peak and mean consumption by the same magnitude. The method also assumes the prediction error for the model is of the same magnitude for all levels of consumption.

The predictions were checked to ensure that peak estimates were not below mean daily drinking. There were 88 people (out of the 3311 drinkers) for whom this was true. These people had their peak drinking increased to match their mean daily drinking.

4. Wealth quintiles

In order to match wealth groups between the two datasets an ordered choice model was created using SADHS data with wealth quintile (1 – 5) as the dependent variable, using the MASS package in R [7]. Wealth groups were chosen as the best available measure to capture socioeconomic status that allowed us to match between the SADHS and IAC dataset. Although income was asked in the IAC dataset many of the respondents refused to answer resulting in a very small sample.

All the variables that were common across the two datasets were included in the initial model, these were not just asset ownership but also age, sex, educational level and population group (race). Stepwise regression was performed using the step.AIC function. This chooses the best variables to include by running the regression with all variables in and then taking one out and computing a goodness of fit measure (the AIC). If the goodness of fit measure is improved then that model is preferred, it runs this for many models until it finds the model with the highest AIC. This method resulted in the selection of the following variables: age, sex, population group, education level, car, landline, electricity, fridge, computer, radio, tv. The only variable it removed was mobile phone which fitted anecdotally with conversations we had with stakeholders in South Africa regarding how much poorer people prioritise mobile phones.

The goodness of fit matrix evaluates the success of the model, comparing the closeness of the predicted and observed outcome (Table 5). The model never predicts the poorest as the richest or the richest as the poorest.

Table 5: Goodness of fit matrix

		Prediction				
		Poorest	Poorer	Middle	Richer	Richest
Actual	Poorest	1300	593	196	9	0
	Poorer	299	975	744	192	17
	Middle	62	612	1042	595	26
	Richer	5	236	763	818	244
	Richest	0	10	108	422	1068

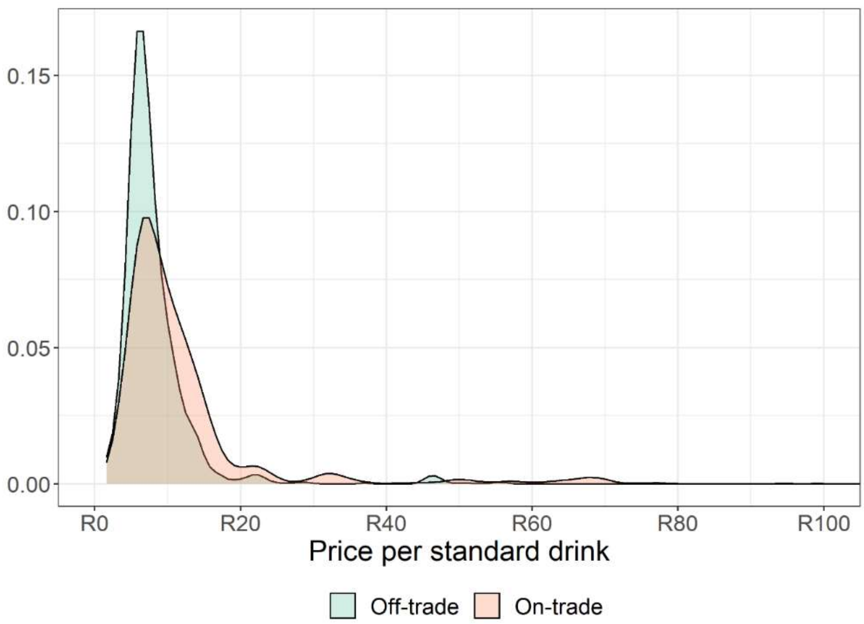
5. International Alcohol Control Study 2014 for prices

The IAC dataset provides prices by drinking location by beverage, by container size and also asks whether the individual binge drinks, demographic data is also collected. The survey asked for the price in Rands by location, for example they ask for the price of a beer paid at a pub for each container size. There are 17 drinking locations (12 on trade and 5 off trade) and 12 drink types. On-trade is where the alcohol is consumed on the premises it is purchased (e.g. hotels, restaurants, pubs), off-trade is where the alcohol is consumed off the premises it was purchased at (e.g. supermarket or bottle store).

Prices were disaggregated by population subgroups rather than by drink type (wine/beer/spirits etc). This was consistent with the South Africa specific price elasticities which were calculated for drinker groups whilst treating alcohol as a single commodity. The IAC respondents were categorised into drinker groups using the definitions above. Each price was weighted by the number of units (e.g. bottles, glasses, cans) sold, the container size of those units and the number of drinking occasions in 6 months (Figure 5). Every price observation was validated using data from the South African Consumer Price Index. Prices were increased to 2018 to account for inflation.

Figure 5: Distribution of off-trade and on-trade prices, standard drink is 15ml or 12grams of pure ethanol.

On-trade is where the alcohol is consumed on the premises it is purchased (e.g. hotels, restaurants, pubs), off-trade is where the alcohol is consumed off the premises it was purchased at (e.g. supermarket or bottle store).



The off-trade wine prices were adjusted using data from the South Africa Wine Industry Statistics [8] who report the proportions of still wine sold (which makes up 93% of total volume of wine sold) in the off-trade in 2018 that falls within different price bands, this data was used to adjust downwards the off-trade wine (Table 6). The price observations were sorted in ascending order and a cumulative volume variable created. The price closest to the 49th percentile was then adjusted down to R3.74 and all prices below adjusted using the same proportion. The prices at the very bottom were adjusted so they could not go below R2.50. The same adjustment process was applied to each of the four groups.

Table 6: Price distribution for off-trade wine

Retail price per litre of wine for 2018	Price per standard drink (15ml) assuming 12% abv	Cumulative percentage of total still wine sold at price SAWIS data	Cumulative percentage of IAC data for off-trade wine pre-adjustment	Cumulative percentage of IAC data for off-trade wine post-adjustment
Less than R30	Less than R3.75	49%	33%	51%
> R30 – R48	> R3.75 – R6	82%	60%	83%
> R48 - R72	> R6 – R9	89%	77%	89%
> R72 - 108	> R9 – R13.5	95%	89%	95%
> R108	> R13.5	100%	100%	100%

As the Tschwane prices were collected in one locality, they were validated against national data sources. Beer is by far the most popular drink, accounting for over 50% of the alcohol sold so beer prices are critical. We accessed data from the South Africa Consumer Price Index for January 2020 to compare the Gauteng province (where Tshwane is located) with other provinces. Beer, which accounts for over 50% of alcohol sold in South Africa, Guateng is at R13.76 for a 330ml can. The average across the eight prices listed above is R13.66 which is very close to Guateng's price, therefore we assume the same price distributions across the whole of South Africa.

Finally, prices were validated with all stakeholders including individuals resident in townships who could provide anecdotal evidence relating to cheap alcohol available at shebeens.

6. Base prices by subgroup

All IAC drinkers were now categorised by drinker type and by wealth quintile (Table 7). Wealth quintile was predicted using the ordered choice model created using the SADHS data. Drinkers in the lowest wealth quintile appear the least likely to drink in moderation leaving a very small sample size (this is not weighted by number of drinks). It is therefore not possible to create price distributions for all 15 categories.

Table 7: Count of IAC price observations and respondents within each category

	Moderate obs (individuals)	Occasional Binge obs (individuals)	Heavy obs (individuals)
Poorest	2 (2)	29 (23)	35 (24)
Poorer	8 (8)	23 (18)	28 (20)
Middle	11 (11)	132 (90)	88 (40)
Richer	23 (20)	95 (59)	60 (30)
Richest	93 (68)	135 (93)	101 (50)

The mean price for each of these drinker categories demonstrates there is wealth gradient (Table 8).

Table 8 Mean price of standard alcoholic drink (15ml of pure alcohol) for each subgroup

	Moderate	Occasional Binge	Heavy
Poorest	R6.79	R7.97	R7.78
Poorer	R9.43	R10.0	R9.65
Middle	R10.2	R10.1	R9.23
Richer	R11.3	R13.4	R10.6
Richest	R11.7	R11.1	R12.8

In order to ensure adequate sample size the poorest/poorer/middle and richer/richest categories were aggregated for moderate drinkers (Table 9). This represents the final group of prices used in the model.

Table 9 Mean price of standard alcoholic drink (15ml of pure alcohol) within each subgroup

	Moderate	Occasional Binge	Heavy
Poorest	R9.13	R7.97	R7.78
Poorer	R9.13	R10.0	R9.65
Middle	R9.13	R10.1	R9.23
Richer	R11.6	R13.4	R10.6
Richest	R11.6	R11.1	R12.8

7. Adjusting the elasticities

The starting point for elasticities -0.4, -0.22 and -0.18 for moderate, occasional binge and heavy drinkers respectively [9]. We adjusted these elasticities to incorporate an income gradient using -0.86 and -0.5 elasticity for low and high socioeconomic status [10]. To remain on the conservative side we will count the bottom two quintiles as low SES and the top three as high.

Table 10: Elasticities by wealth and drinker group

Drinker type	Q1	Q2	Q3	Q4	Q5
Moderate	-0.53	-0.53	-0.31	-0.31	-0.31
Occasional binge	-0.29	-0.29	-0.17	-0.17	-0.17
Heavy drinkers	-0.24	-0.24	-0.14	-0.14	-0.14

8. Individual spend, tax and retail revenue

Alcohol consumption expenditure

The total retail spend at baseline, and each scenario, was computed by adding up all the individual spends multiplied by their population weights. When the SADHS consumption estimates were shifted to calibrate to market research data only 80% of the consumption figure was used to take account of spillage, stockpiling and tourism, but the 20% of alcohol remains in the headline sales revenue. Therefore to make it comparable we estimate the total sales revenue by increasing the modelled alcohol consumption revenue by 1.25 (100/80).

Government revenue, VAT, excise tax and retail revenue

The following steps outline how we computed government and retail revenue:

- Calculate VAT by assuming 15% of the base retail spend is VAT
- Import 2018 base excise tax from Treasury Budget Report [11]
- Calculate total volume consumed of alcohol at all four scenarios (baseline/R5/R10/R15)
- Calculate the percentage change in volume from baseline for each of the three policies
- Apply the percentage change in volume to base excise tax (we assume a fixed ratio between volume and excise tax)
- Calculate retail revenue by: spend - vat - excise tax

It is likely this is a conservative approach to modelling excise tax revenue as generally the cheaper alcohol, which this policy targets, generates a lower proportion of excise tax than the more expensive, so we can consider this a lower band on the excise tax revenue.

Consumption to harm

9. Relative risks

Relative risks were calculated for each of the health outcomes of interest at baseline, and each policy scenario using published relative risk equations [12,13]. The same relative risk equations are used for morbidity (or prevalence) and mortality. HIV risk is derived from a stepped function for mean drinking differing by socioeconomic status, intentional injuries and road injury from a continuous function of mean drinking differing by whether the individual binge drinks, liver cirrhosis and breast cancer from a continuous function of mean drinking, for breast cancer this is only for females (Table 11).

Table 11: Relative risk equations used

Health Condition	**Relative risk Current drinkers**	**Relative risk former drinkers**	**ICD-10 codes**
HIV	Low SES $RR = 2.99$ if x > 61/49 grams per day (males/females) $RR = 1.94$ if x > 0 $RR = 1$ otherwise Higher SES $RR = 1.54$ if x > 61/49 grams per day (males/females) $RR = 1$ otherwise	RR = 1	B20-24
Intentional Injuries **(self-harm and interpersonal violence)**	Drinkers $RR = \exp(00199800266267306\,.x)$ Heavy episodic drinkers (HED) $RR = \exp(00199800266267306\,.x + 0.647103242058538)$	RR = 1	ICD-10 codes: X60 – Y09 Y35 –36 Y870 Y871
Road Injury **(pedestrian, cyclist, motorcyclist, motor vehicle, other road)**	Drinkers $RR = \exp(0.00299550897979837\,.x)$ Heavy episodic drinking $RR = \exp(0.00299550897979837\,.x + 0.959350221334602)$	RR = 1	V01–04, V06, V09–80, V87, V89, V99
Breast Cancer	Females only $RR = \exp(0.01018\,.x)$	RR = 1	C50
Liver	if x <= 1 $1 + x.\exp((\beta_1 + \beta_2).\sqrt{\frac{1 + 0.1699981689453125}{100}})$ If x > 1 $\exp((\beta_1 + \beta_2).\sqrt{\frac{x + 0.1699981689453125}{100}})$	RR = 3.26 for both females and males	K70, K74

	Female b1 = 2.351821 b2 = 0.9002139 Male b1 = 1.687111 b2 = 1.106413		
x = grams of alcohol consumed per day among current drinkers HED = drinking 60 grams or more on one drinking occasion			

10. Potential impact fractions

Potential impact fractions (PIFs) were calculated by dividing relative risk under each policy by relative risk at baseline. These incorporated population weights and were computed by sex *(i)*, wealth group *(j)* and drinker group *(k)*.

$$PIF_{ijk} = \frac{\text{relative risk}_{ijk}\ \text{(policy)}}{\text{relative risk}_{ijk}\ \text{(baseline)}}$$

11. Socioeconomic gradients of ill health

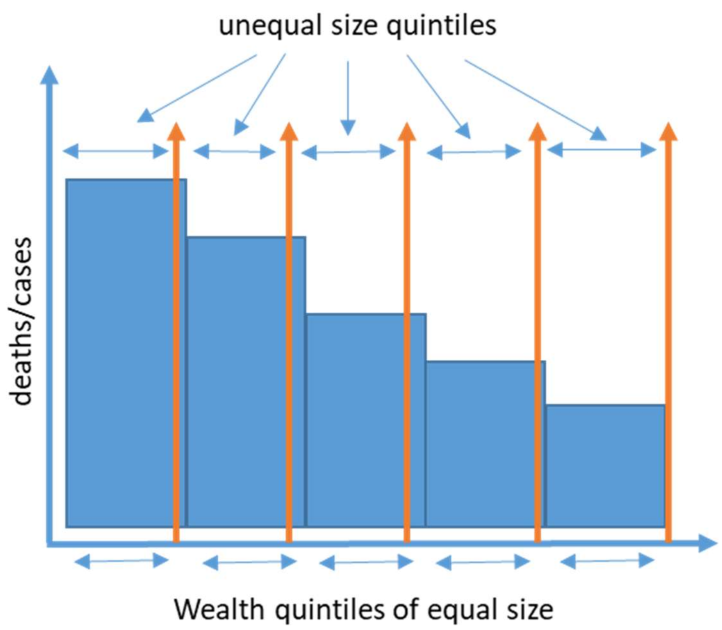
Health outcomes in South Africa are not evenly distributed throughout the population, with the poor often bearing a higher burden of disease, depending on the illness. Data analysis was carried out using General Household Survey (GHS) data for 2018. The ordered choice regression model computed previously, using SADHS data, was applied to the GHS data to split the survey population into wealth quintiles compatible with the foundational dataset (SADHS). Percentage within each wealth quintile with the disease was computed (Table 12). Liver cirrhosis was not one of the health conditions included in the survey and breast cancer was not specifically included although the broader category of cancer was. Sensitivity analysis was carried out using alternative gradients.

Table 12: Raw count of General Household Survey data 2018

	poorest	**poorer**	**middle**	**richer**	**richest**
15+ raw count (648 NAs)	4966	11462	14396	9633	7630
HIV raw count percentage	395 0.08	684 0.06	614 0.04	155 0.02	41 0.005
Intentional injuries* raw count percentage	11 0.002	30 0.0027	24 0.0018	11 0.0012	3 0.0002
Road injuries raw count percentage**	7 0.0016	26 0.0022	22 0.0016	32 0.0033	13 0.00015
Cancer raw count percentage	2 0.00038	27 0.0012	41 0.0026	27 0.0029	68 0.008
nb: percentages within each quintile were calculated incorporating the survey weights * gunshot wounds; severe trauma due to violence, assault, beating; intentional poisoning; accidental poisoning; fire and burn; crime related injury – left out sports related, disability related and other ** motor vehicle -occupant, motor vehicle – pedestrian, bicycle related					

12. Distributing baseline deaths and cases and calculating probabilities

The deaths/cases (which come disaggregated by sex) at baseline is split between the five wealth quintiles using the GHS data to account for the socioeconomic gradient, as explained above. However, a preparatory step was necessary as the proportions of the population (using the SADHS proportions) in each quintile were not perfectly equal, for example for Q1, Q2, Q3, Q4, Q5 corresponded to 0.19, 0.19, 0.20, 0.21, 0.21 for females and 0.19, 0.20, 0.21, 0.20, 0.21 for males. The probability of death was calculated for each quintile first by assuming the population was split into quintiles of equal size. The total deaths/cases for each quintile using the SADHS proportions was then calculated by applying the relevant probability of death/cases for that part of the quintile which overlapped with the underlying equally sized quintile. This concept can be best illustrated on a graph.



$$Number_{cases}(SADHS_{Q1}) = Pop_{SADHSQ1} \times Prob_{Equal}$$

$$Number_{cases}(SADHS_{Q2}) = (Pop_{EqualQ1} - Pop_{SADHSQ1}) \times Prob_{EqualQ1} + (Pop_{SADHSQ1} + Pop_{SADHS} - Pop_{EqualQ1}) \times Prob_{Equal}$$

$\ldots.\,and\ so\ on$

The existence of relative risk equations implies that the baseline mortality/morbidity will also not be distributed equally between drinker groups, one would expect a higher proportion of the baseline cases to exist amongst heavy drinkers, followed by occasional binge, moderate then abstainers. In order for the baseline mortality/morbidity to vary by drinker group the total risk, for each disease, is calculated for each drinker group group, by sex and wealth quintile. The proportional share of risk between drinker groups is then calculated and used to distribute the mortality/morbidity, which has already been assigned to each quintile, between each drinker group within that quintile.

The model uses iHME data for deaths and cases of disease and population statistics (Statistics South Africa) from 2018. Life tables to get the probability of death by single year of age were only available for 2017 from iHME so these were used. The 2018 population is split proportionally into the sex/wealth/drinker groups using the SADHS proportions.

The probability of death for each disease is calculated for the baseline scenario and taken away from overall probability of death for each single year of age given in the life table to give a probability of death from non-modelled causes. This probability of death from non-modelled causes remains constant at every policy scenario. The probability of death from the five diseases of interest then vary according to the policy level and the corresponding potential impact fraction.

We model counterfactual population structure (i.e. in the absence of the policy) over 20 years, starting from 2018 using current population estimates from Statistics South Africa, plus birth projections for 2020 to 2023 and assume current age-, sex- and wealth-specific mortality rates remain constant [14]. Birth cohorts for years beyond 2023 are not modelled as they would not have reached the age at which we model alcohol consumption (15+) within the time horizon.

We create multistate life tables in which the population faces a probability of mortality for each of the five disease/injury conditions and for other cause mortality each year. This approach allows us to simulate prevalence of and mortality from multiple diseases simultaneously, assuming diseases are independent of one another. The model generates alternative population impact fractions (as above) for baseline and for each policy scenario. Using the relevant population impact fraction and rerunning the multistate life table enables a calculation of the difference between baseline and the policy.

13. Baseline health and lagged health impact

HIV, road injuries and intentional injuries realise the full impact of the reduction in drinking immediately whereas the health impact on liver cirrhosis and breast cancer are subject to lags in the effect, meaning the reduced drinking does not translate to a reduced health risk immediately [15]. Breast cancer 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 (Appendix part 9).

The life tables for the 20 year time horizon are saved for each of the policy scenarios. They are then used in combination with the probability of having the disease and the potential impact fraction under each policy, to estimate the number of cases.

HIV, road injuries and intentional injuries realise the full impact of the reduction in drinking from the first year of the drinking reduction whereas liver cirrhosis and breast cancer are subject to lags in the effect. 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 (Table 13).

Table 13: Modelled time-lags by condition – proportion of overall change in risk experienced in each year following a change in consumption (Holmes et al., 2012)

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

14. Hospital multipliers and costs

The prevalence of disease/injury at each policy scenario for each year of the 20 year time horizon was multiplied by the proportion who would then go on to receive hospital treatment (Table 14) and the relevant hospital cost applied (Table 15). The costs taken from the literature were increased by inflation where necessary to reach the baseline year of 2018. Future costs were discounted at 5% as recommended by the Department of Health in the guidelines for pharmacoeconomic submissions [16]. All sources were sense checked with a South African stakeholder with health economics expertise.

Table 14: Estimated multiplier from population prevalence to hospital admission

Condition	Multiplier (cases in population who go on to receive healthcare treatment)	Source
HIV	0.62	UNAIDS estimates that 62% of people living with HIV in 2018 in South Africa were on treatment [17]
Intentional Injury	0.41	Survey estimating trauma admissions [18] combined with iHME data from the same year to predict multipliers.
Road injury	0.19	Survey estimating trauma admissions [18] combined with iHME data from the same year to predict multipliers.
Liver Cirrhosis	0.5	Paper on liver cirrhosis in sub-Saharan Africa suggests 50% of patients are admitted to hospital with end-stage liver disease [19].
Breast Cancer	0.75	All studies found estimate what proportion present with late stage breast cancer (51%) but not what proportion never receive hospital treatment [20]. Therefore an estimate of 0.75 is used.

Table 15: Hospital costs and sources

Condition	Cost per patient	Source
HIV	R 3,318.62 (2017/18)	This is the annual cost. Taken from a systematic literature review of per patient costs of HIV services in South Africa [21]. There are many different levels of treatment, this cost is only for first-line treatment, so this is conservative.
Intentional Injury	R58,928 (2013)	This retrospective case note review included 143 violence related emergency hospital admissions from January to March 2013. Average inpatient stay was 9.8 days with treatments including emergency surgery, intensive care and resuscitation beds on admission [22].
Road injury	R56,592.17 (2012)	A prospective cohort study followed 100 patients admitted following a Road traffic injury between late 2011 and early 2012 at Edendale Hospital Pietermartizburg [23].
Liver Cirrhosis	R2,967 (2018)	50% multiplier used above comes from paper suggesting 50% of liver cirrhosis patients get admitted to hospital with end stage liver disease. Treatment for end stage liver disease includes A specific study on liver cirrhosis was not found so general costs have been used from the district health baromenter. Expenditure per patient day equivalent

		(district hospitals) was R2967 (average taken from across the 9 provinces). This assumes just one patient day. Conservative. [24]
Breast Cancer	Early stage R14,915 Late stage R16,869 (2015)	This retrospective case review included 200 women at a government hospital in South Africa. The average cost is different depending on whether they were diagnosed at an early (56%) or late (44%) stage [25].

15. Sensitivity Analysis

Parameter	Central estimate	Alternative plausible values	Rationale	Results
Price elasticities	-0.53 moderate Q1, Q2 -0.31 moderate Q3, Q4, Q5 -0.29 occasional binge Q1, Q2 -0.17 occasional binge Q3, Q4, Q5 -0.24 heavy Q1, Q2 -0.14 heavy Q3, Q4, Q5			Central estimates Consumption - 4.40% Spend 18.09 % Lives saved 20,585 Cases saved 900,332
		Scenario 1 -0.40 moderate -0.22 occasional binge -0.18 heavy	Scenario 1 Applies estimates based only on drinker type, removing any wealth gradient.	Scenario 1 Consumption - 4.50% Spend 17.86% Lives saved 18,717 Cases saved 825,935
		Scenario 2 -0.5 for high income drinkers (applied to quintiles 3, 4, 5) -0.86 for low income drinkers (applied to quintiles 1,2 to be conservative)	Scenario 2 Estimates using NIDs data for two subsets of the population, the top 50% and bottom 50% of households by total household expenditure [10].	Scenario 2 Consumption - 14.16% Spend 5.4% Lives saved 52,419 Cases saved 2,331,362
		Scenario 3 -0.8	Scenario 3 Van Walbeek and Blecher [10] literature review of South African specific price elasticities found Selvanathan and Selvanathan [26] estimated -0.8 which corresponds closely to price elasticity estimates for beer (-0.8), wine (-0.9) and spirits (-0.9) produced by SALBA (2010).	Scenario 3 Consumption - 17.96% Spend 0.1 % Lives saved 64,494 Cases saved 2,891,284

Proportion of abstainers in the population	82% female non-drinkers 45% male non-drinkers	67% female non-drinkers 36% male non-drinkers	Stakeholders have indicated scepticism about the prevalence of non-drinking reported in SADHS (and all alcohol studies). Currently the model only adjusts the consumption of those who report anything at all. We will increase the survey weightings of drinkers in the SADHS so that 67% of females do not drink and 36% of males. Based on a South African study which used both surveys and biomarkers [27].	Central estimates Consumption - 4.40% Spend 18.09 % Lives saved 20,585 Cases saved 900,332 Alternative scenario Consumption - 4.48% Spend 17.77% Lives saved 15,616 Cases saved 678,929
HIV baseline estimates	iHME 2018 estimates female 77,499 deaths 4,772,473 cases male 70,186 deaths 2,799,754 cases	Thembisa 2018 estimates female 35,487 deaths 4,542,677 cases male 36,345 deaths 2,578,747 cases	Stakeholders highlighted the difference between GBD estimates and local estimates for HIV deaths. The Thembisa model was built by local academics and is used by UNAIDs [28].	Central estimates Lives saved 20,858 Cases saved 900,332 HIV lives saved 10,229 HIV cases averted 429,205 Alternative scenario Lives saved 16,086 Cases saved 907,930 HIV lives saved 5,486 HIV cases averted 423,850
Socioeconomic gradients of ill health	HIV Q1 (poorest) – 20% Q2 – 36% Q3 – 32% Q4 – 9% Q5 – 3% Intentional Injury/Road Injury/Liver Cirrhosis Q1 – 9% Q2 – 29%	Scenario 1 Changing the liver cirrhosis gradient to match the one used for breast cancer	Scenario 1 Stakeholders indicated that for long-term conditions like cirrhosis wealthier groups could well be over-represented in SA. They suggested sensitivity analysis by applying values for a condition that is less concentrated amongst the poor.	Central estimates Liver cirrhosis lives saved/cases averted Q1 133 / 3,528 Q2 432 / 11,298 Q3 295 / 7,801 Q4 288 / 7,639 Q5 82 / 2,158 Scenario 1

	Q3 – 26% Q4 – 26% Q5 – 10% Breast cancer Q1 – 7% Q2 – 7% Q3 – 22% Q4 – 18% Q5 – 47%	Scenario 2 HIV Q1 (poorest) – 25% Q2 – 22% Q3 – 20% Q4 – 18% Q5 – 14% Intentional injury/ Road injury/Liver cirrhosis Q1 – 20% Q2 – 20% Q3 – 19% Q4 – 20% Q5 – 22% Breast cancer Q1 (poorest) – 21% Q2 – 21% Q3 – 20% Q4 – 19% Q5 – 18%	Scenario 2 Recent data from another South African survey is used to provide plausible alternative socioeconomic gradients across all the conditions used in the model [29].	Liver cirrhosis lives saved/cases averted Q1 95 / 2509 Q2 104 / 2722 Q3 235 / 6203 Q4 200 / 5316 Q5 359 / 9563 Central estimates aggregate lives saved / cases averted Q1 4,088 / 176,663 Q2 7,375 / 313,360 Q3 4000 / 177,604 Q4 3,759 / 167,934 Q5 1,364 / 64,771 Scenario 2 aggregate lives saved / cases averted Q1 2,858 / 127,516 Q2 5,246 / 225,067 Q3 5,758 / 255,667 Q4 3,153 / 139,2253 Q5 3,969 / 197,191
Discount rates for costs	5% discount rate	Scenario 1 0% discount rate	Discount rate was changed to 0%	Central estimate Health costs saved R6.88 billion Scenario 1 Health costs saved

				R11.10 billion
Homebrew switching	30%	Scenario 1 0% Scenario 2 100%	The assumption that drinkers will make up 30% of the reduction in drinking recorded alcohol with homebrew comes from consultation with the stakeholders at workshop two. To test the importance of this assumption on the results a null impact and a 100% impact are introduced. 100% would mean that any homebrew drinkers will not receive any positive health impacts from the policy as all of their reduction in recorded alcohol will be replaced with homebrew alcohol.	Central estimate Consumption - 4.40% Lives saved 20,585 Cases saved 900,332 Scenario 1 Consumption - 4.56% Lives saved 21,479 Cases saved 937,507 Scenario 2 Consumption - 4.03 % Lives saved 19,156 Cases saved 844,471

16. Healthcare cost savings by quintile

Table 16: Health care costs for each of the three policy scenarios split by wealth quintile

	Q1	Q2	Q3	Q4	Q5
R5 MUP					
HIV	-R0.01	-R0.07	-R0.04	-R0.03	-R0.01
Intentional injury	R1.41	R5.22	R5.42	R12.8	R7.72
Road injury	R0.71	R2.73	R2.80	R6.39	R3.82
Liver cirrhosis	R0.02	R0.12	R0.11	R0.27	R0.14
cancer	R0.00	R0.00	R0.01	R0.05	R0.15
R10 MUP					
HIV	R162.00	R291.00	R71.10	R8.72	R33.3
Intentional injury	R495.57	R801.23	R1150.94	R1487.35	R369.03
Road injury	R232.98	R399.34	R520.70	R658.80	R163.64
Liver cirrhosis	R3.03	R9.64	R6.62	R6.45	R1.86
cancer	R0.30	R0.22	R0.80	R0.93	R1.75
R15 MUP					
HIV	R403.19	R618.29	R190.50	R79.85	R64.67
Intentional injury	R1136.23	R2029.50	R2558.09	R2350.20	R1014.96
Road injury	R536.83	R1013.46	R1173.35	R1080.17	R4618.76
Liver cirrhosis	R7.42	R23.50	R17.60	R15.20	R4.51
cancer	R0.76	R0.65	R2.24	R2.30	R4.65

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5 Appendix 5

This is the appendix which accompanies the publication format paper: Equity impact of minimum unit pricing of alcohol on household health and finances among rich and poor drinkers in South Africa

Supplementary Webappendix

of

Equity impact of minimum unit pricing of alcohol on household health and finances in rich and poor drinkers in South Africa

by

N.K. Gibbs, C. Angus, S.Dixon, C.D.H. Parry, P.S. Meier, M.K. Boachie, S. Verguet

In this supplementary webappendix, we report on the detailed inputs and assumptions that were used in the application of our minimum unit pricing (MUP) policy model, for which we heavily drew from the previously published analysis by Gibbs et al. (2021) (1).

1. Description of the data sources used for the comprehensive policy model

We detail in Figure A1 below all the data sources used for the comprehensive policy model, expanded from a previously published figure by Gibbs et al. (2021)(1).

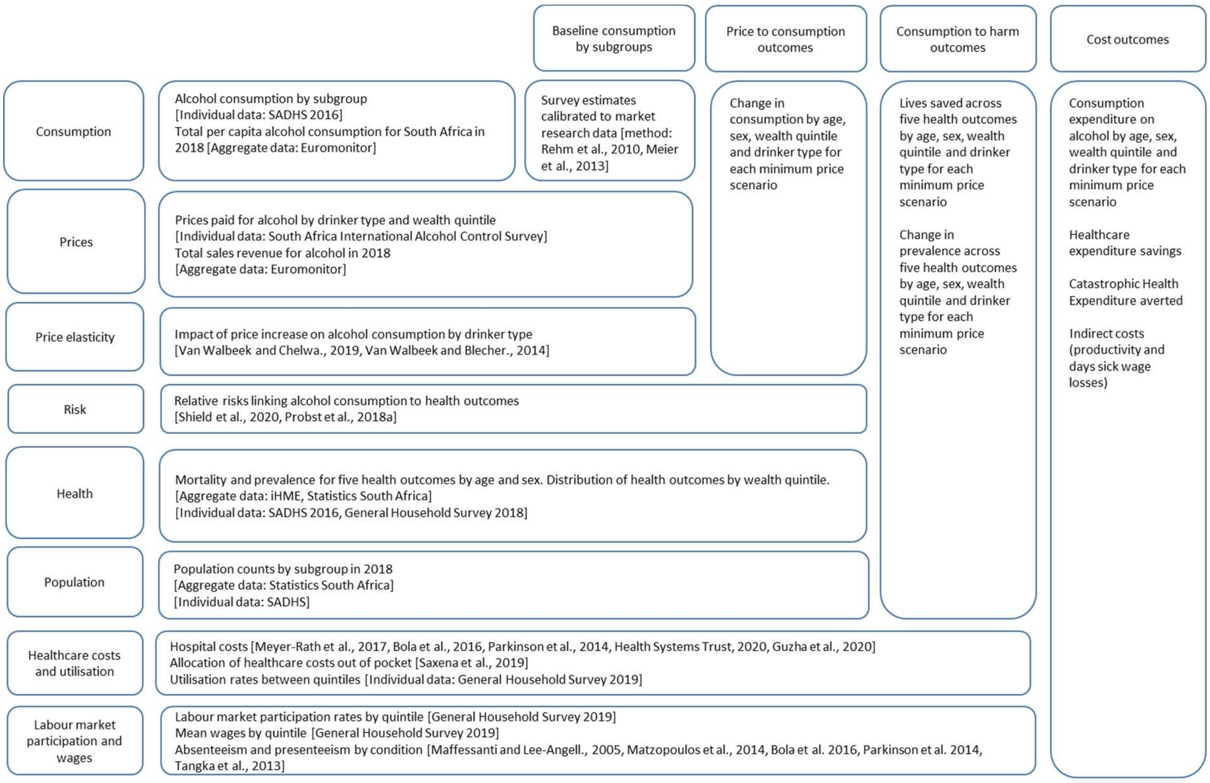

Figure A1. Detailed display of all the data sources used in the comprehensive policy model expanded in our study via extended cost-effectiveness analysis methods. Original source: Gibbs et al. (2021) (licensed under Creative Commons Attribution (CC BY 4.0)). (1)

2. Disease-related expenditures and data sources

We report in Table A1 below the inputs used for the estimation of disease- and injury-related expenditures, along with the corresponding data sources. All costs were adjusted to the year 2018.

Condition	Unit cost, per patient	Source
HIV	ZAR 3,319 (2017/18)	Meyer-Rath, van Rensburg (2). Conservative assumption of annual cost for first-line treatment.
Intentional injury	ZAR 58,928 (2013)	Bola, Dash (3).
Road injury	ZAR 56,592 (2012)	Parkinson, Kent (4).
Liver cirrhosis	R2,967 (2018)	Health Systems Trust (5). Conservative assumption of one patient day.
Breast cancer	Early stage: ZAR 14,915 Late stage: ZAR 16,869 (2015)	Guzha, Thebe (6).

Table A1. Inputs used for the estimation of disease- and injury-related expenditures, along with corresponding data sources. Note: for the unit cost per patient, the corresponding year is given in parentheses.

3. Adjusting the elasticities

The elasticities used in the original model were -0.40, -0.22 and -0.18 for moderate, occasional binge and heavy drinkers, respectively (7). We adjusted these elasticities to incorporate an income gradient using -0.86 and -0.50 elasticity for low and high socioeconomic status (SES) (8). To remain on the conservative side we considered the bottom two quintiles as low SES and the top three quintiles as high SES.

Drinker type	QI	QII	QIII	QIV	QV
Moderate	-0.53	-0.53	-0.31	-0.31	-0.31
Occasional binge	-0.29	-0.29	-0.17	-0.17	-0.17
Heavy drinkers	-0.24	-0.24	-0.14	-0.14	-0.14

Table A2. Price elasticities of demand for alcohol used in the comprehensive policy model.

4. Price shifting and elasticities

To simulate a minimum unit price (MUP) policy, each price distribution was changed so that any prices less than ZAR10 was moved up to exactly ZAR10, prices at or above ZAR10 per standard drink were left unchanged. This allowed the calculation of a new mean price and percentage change in mean price for each wealth/drinker group.

This conservative assumption assumes the industry response is to leave prices above the threshold unchanged: evidence of this was found in Scotland (9). However, if the price of products above the MUP level also increases, then the policy would be more effective, albeit somewhat less targeted.

The price change faced by different groups will depend on their purchases at baseline (before MUP policy). For example, groups who bought less of their alcohol below the threshold will experience less of a price increase.

Following the percentage change in price and using the appropriate elasticity enable the calculation of the new consumption levels in response to the change in prices created by the MUP policy. The price elasticity of demand can be written as follows:

$$\text{Price elasticity of demand}_{ij} = \frac{\frac{\text{new consumption}_{ij} - \text{baseline consumption}_{ij}}{\text{consumption}_{ij}}}{\frac{\text{new price}_{ij} - \text{baseline price}_{ij}}{\text{baseline price}_{ij}}}, \qquad \text{(A1)}$$

where i is drinker group and j is wealth quintile.

5. Health services utilisation rates

In this section, we detail the assumptions used for the healthcare utilisation rates for each of the five diseases and injuries examined in our study, by wealth quintile (QI=poorest; QV=richest).

HIV/AIDS

Using data from the General Household Survey (GHS) 2019 (10), we calculated quintile-specific utilisation rates by using the question on whether a respondent consulted a health worker as a result of illness in the last 30 days prior to the survey and HIV status. The overall figure (average) was 68% which compares well with the UN estimate of 70% of HIV patients on treatment (11).

QI	QII	QIII	QIV	QV
63.1%	71.4%	69.4%	60.5%	89.5%

Table A3. Healthcare utilisation rates used for HIV/AIDS across wealth quintiles.

Cancer/liver cirrhosis

The 2019 General Household Survey (10) provides data on those with cancer, but not breast or any specific cancer. Given that breast cancer ranks number one among all cancers in South Africa (12), we estimated that 0.3% would be the prevalence rate for breast cancer in 2019 based on the 2019 General Household Survey. Applying a similar approach used to obtain the HIV/AIDS utilisation rates (see immediately above), we estimated the number of breast cancer patients on treatment with the following quintile-specific estimates (Table A4).

QI	QII	QIII	QIV	QV
52.2%	55.7%	50.3%	67.7%	89.1%

Table A4. Healthcare utilisation rates used for cancer across wealth quintiles. Note: our original estimation with the 2019 General Household Survey[9] led to 100% for QI, which was unrealistic. Hence, we replaced this 100% value with the rate from “any condition” for QI.

As for liver cirrhosis, we used the utilisation rates corresponding to “any condition” (from the General Household Survey[9] questionnaire) as there were no other specific healthcare utilisation rate variables that could be identified (Table A5).

QI	QII	QIII	QIV	QV
52.2%	54.5%	53.5%	53.4%	63.2%

Table A5. Healthcare utilisation rates used for liver cirrhosis across wealth quintiles.

Intentional injury/road injury

The general healthcare utilisation rates (as calculated above in Table A5) were adjusted to account for how population prevalence of injury would translate to trauma admissions for either intentional or road injury. We used South African research documenting trauma admissions (from 1999; Matzopoulos et al. 2006[11]) combined with Global Burden of Disease (GBD) data (from the same year) (13) to derive a correspondence multiplier between prevalence and hospital admissions (Table A6).

Category in GBD	Prevalence (IHME 1999)	Category in Matzopoulos et al. (2006)	Number of cases	Estimated multiplier
Transport injuries	1,566,000	Traffic	302,900	0.19
Unintentional injuries	3,392,800	Other injuries	416,400	0.12

Interpersonal violence and self-harm	1,851,600	Violence	757,200	0.41

Table A6. Estimated correspondence multiplier between injury prevalence and admissions to hospital.

The estimated multipliers (Table A6) were then used to adjust the general healthcare utilisation rates (Table A5) in the following manner:

$$utilisation_{adj,qi} = \frac{utilisation_{qi}}{(\sum_{q=1}^{5} utilisation_{qi})/5} \times multiplier\ , \quad (A.2)$$

the results of which are reported in Table A7.

	QI	QII	QIII	QIV	QV
Road injury	0.18	0.19	0.18	0.18	0.22
Intentional violence	0.39	0.40	0.40	0.40	0.47

Table A7. Healthcare utilisation rates used for road injury and intentional violence, across wealth quintiles.

6. Absenteeism

In this section, we detail the assumptions made for the computation of absenteeism, that it the number of work days lost due to each of the five conditions examined in our study.

HIV/AIDS

A report by a South African insurance company states that those who have been diagnosed with HIV and who are being treated take 1,392 days (due to illness and treatment) out of 36,022 working days (14). Assuming a total of 252 working days in a year, this would equate to 14 work days lost per year.

Liver cirrhosis

Data taken from Matzopoulos et al. (2014) (15) stated that absenteeism rates averaged 2.3% in workers earning ZAR1,000 or less per month, and 1.3% in workers earning ZARR10,000 to 15,000 per month. The number of working days in South Africa per year is 252 days (16). We have therefore assumed 6 work days lost per year for the quintile I and 3 days lost per year for quintiles II, III, IV, and V.

Intentional injury and road injury

Here, the estimates of work days lost relate to the days spent in hospitalization due to these injuries. We drew corresponding estimates from microcosting studies on hospital costs (3, 4).

Breast cancer

Unfortunately, specific estimates for a South African setting (reviewing the published literature), or from a similar low- and middle-income country setting, could not be identified. Therefore, as a proxy, we extracted estimates from a US study corresponding to 6.1 work days lost per year (17).

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6 Appendix 6

Comparing South African MUP models

Comparing the University of Cape Town and Sheffield Models

This report has presented two different approaches to modelling the impact of Minimum Unit Pricing on alcohol for the Western Cape, based on previously published models for South Africa (Van Walbeek and Chelwa, 2021, Gibbs et al., 2021). The models both estimate that an MUP would be effective in reducing consumption of alcohol; however, they do not align on the magnitude of this effect or on the relative impact by drinker group. The UCT model suggests that the impact will be far greater for heavy drinkers in relative as well as absolute terms. The Sheffield model (Gibbs et al., 2021) suggests that although the absolute reduction will be greatest for heavy drinkers, in percentage terms they are the least impacted.

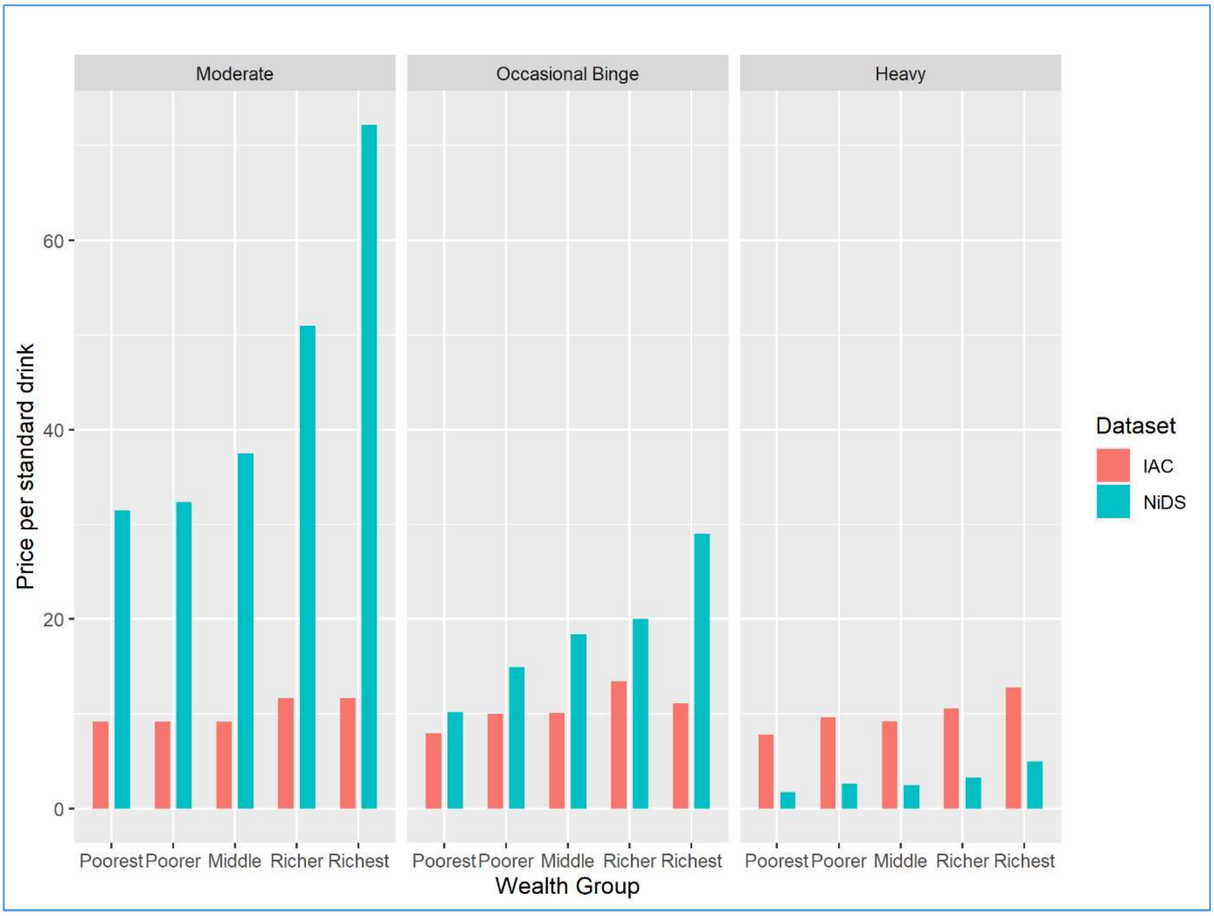
Both models use very similar elasticities to drive the policy impact but there are two differences, one of data and one of methods, which produce the different estimates. The first and most important is the pricing data used in the model. The UCT model uses the National Income Dynamic Study (NiDS) to estimate prices by taking a monthly estimate of alcohol expenditure and dividing it by a monthly estimate of consumption generated through quantity/frequency questions. These values are self-reported by respondents to the NiDS questionnaires. The Sheffield model uses price distributions for wealth and drinker groups using actual price data linked to individual drinking from the International Alcohol Control Study (IAC) survey 2014/2015 completed in the metropolitan district of Tshwane. The IAC asked for highly detailed data about prices in both on- and off-trade locations and took into account container size, drink type, and number of drinks purchased. We can see the difference in the estimated baseline prices between the two datasets (Table appendix 6.1, Figure 6.1). Grieve Chelwa provided the NiDS prices, which use income quintiles to proxy wealth quintiles owing to data constraints. The NiDS prices are far lower for heavy drinkers than the IAC prices, while the moderate drinkers, and to some extent binge drinkers, report far higher prices in the calibrated IAC data. In summary, the NiDS prices suggest a far bigger differential between the prices paid by drinker type and so are likely to show a much higher differential impact, such that the price elasticities (which are lower for heavier drinkers) are outweighed.

Table appendix 6.1: Comparing IAC and NiDs estimated price per standard drink

	Moderate	**Occasional Binge**	**Heavy**
IAC prices			

Q1	R9	R8	R8
Q2	R9	R10	R10
Q3	R9	R10	R9
Q4	R12	R13	R11
Q5	R12	R11	R13
NiDS prices			
Q1	R32	R10	R2
Q2	R32	R15	R3
Q3	R38	R18	R3
Q4	R51	R20	R3
Q5	R72	R29	R5
Prices rounded to the nearest Rand IAC prices are calibrated to CPI and SAWIS data NiDs prices computed using drinker categories to match the Sheffield model			

Figure appendix 6.1: Mean price per standard drink at baseline



The second key difference between the models is the method used to apply the elasticities. There are two methods – the arc/midpoint approach (Parkin, 2019) and the standard econometric approach. The arc method is argued to be more appropriate where price changes are very large and to effectively reduce the impact of these very large changes on consumption. The UCT model features very large price increases for heavy drinkers (e.g. a 200% price increase for a Q1 heavy drinker under a R5 MUP) and so it applies the arc method, whereas the price increases faced by drinkers in the Sheffield model are estimated to be considerably smaller (e.g. a 0.2% price increase for a Q1 heavy drinker under a R5 MUP) and uses the standard approach. The impact of this difference is to reduce the extent to which alcohol consumption decreases with MUP in the UCT model.

There are additional data and methodological differences, such as the Sheffield model breaking down prices and elasticities and consumption by wealth as well as by drinker group, as this links with baseline harm essential for the epidemiological part of the model, which we will not expand on here. We also draw our underlying consumption estimates from different datasets.

Table appendix 6.2 Price elasticities applied in the model

	Q1	Q2	Q3	Q4	Q5
Sheffield Model					
Moderate	-0.53	-0.53	-0.31	-0.31	-0.31
Occasional binge	-0.29	-0.29	-0.17	-0.17	-0.17
Heavy	-0.24	-0.24	-0.14	-0.14	-0.14
UCT Model					
Moderate	-0.45	As for Q1	As for Q1	As for Q1	As for Q1
Intermediate	-0.35				
Occasional binge	-0.22				
Heavy	-0.18				

In order to investigate how much influence the price inputs have on the results, we used the NiDS estimates of baseline prices, generated by Grieve Chelwa (Table appendix 6.2) and re-ran the Sheffield Model to compare the results.

Comparison of results

As the UCT model focuses on consumption impact, and not harm, this is the focus of our comparison. We compare results for a R5 and an R8 MUP projected for the Western Cape Province only (Table 3). The UCT model gives higher impacts and a more differential effect between drinkers than the Sheffield model. However, when we substitute the NiDS prices into the Sheffield model, the heavy drinkers see a much greater reduction in their consumption, as we would expect. On the other hand, moderate drinkers see very little impact on their consumption as they buy alcohol well above the MUP threshold.

Table appendix 6.3 also highlights the impact of the arc method as opposed to the point estimate method, with the arc method somewhat decreasing the large impacts. It is also possible to see that the alternative methods increase the difference in results as the level of MUP increases.

Table appendix 6.3: Comparison of Western Cape results between the UCT Model and the Sheffield Model with IAC prices and with NiDS prices

	Moderate-drinking households	**Intermediate drinking households**	**Occasional heavy drinking households**	**Regular heavy-drinking households**
R5 MUP				
UCT model	-0.6%	-4.6%	-4.4%	-15.7%
Sheffield model	-0.4%	-	-0.2%	-0.1%
Sheffield model using NiDS prices	-0.2%	-	-0.6 %	-16.2%
R8 MUP				
UCT model	-1.8%	-10.0%	-6.7%	-19.8%
Sheffield model	-3.7%	-	-1.7%	-1.8%
Sheffield model using NiDS prices	-0.5%	-	-1.6%	-38.1%

Future direction

It is important to note that both models agree that MUP is an effective policy to reduce alcohol consumption, and therefore harm, in South Africa and, in particular, in the Western Cape province. The magnitude of the impact varies and the relative impact between drinker group also varies, but even in the Sheffield Model (with IAC prices) the greatest reduction in alcohol consumption in absolute terms accrues to heavy drinkers, who then go on to accrue the greatest health benefits. It is possible that the UCT model represents an upper bound for effectiveness and the Sheffield model a lower bound, and that we should expect the real impact to be somewhere in between the two. As the biggest difference between the two models arises from uncertainty around the prices that people pay for alcohol, we would strongly recommend that improved pricing data be collected alongside consumption data, ideally in a way that allows for the wealth and drinking level of the respondent to be taken into account, so that we can truly understand the differential impact of this policy.

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