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 policy, but high levels of income inequality raise concerns about equity impacts. 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 impact across wealth quintiles on: (i) alcohol consumption and expenditures; (ii) mortality; (iii) government healthcare cost savings; (iv) reductions in cases of catastrophic health expenditures (CHE) and household savings linked to reduced health-related workplace absence.

Results We estimate MUP would reduce consumption more among the poorest than the richest drinkers. Expenditure would increase by ZAR 353 000 million (1 US$=13.2 ZAR), the poorest contributing 13% and the richest 28% of the increase, although this remains regressive compared with mean income. Of the 22 600 deaths averted, 56% accrue to the bottom two quintiles; government healthcare cost savings would be substantial (ZAR 3.9 billion). Cases of CHE averted would be 564 700, 46% among the poorest two quintiles. Indirect cost savings amount to ZAR 51.1 billion.

Conclusions A MUP policy in South Africa has the potential to reduce harm and 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.

Key questions

What is already known?

► Alcohol pricing policies, such as taxation and minimum unit pricing (MUP), are consistently recommended by the WHO 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 extended cost-effectiveness analysis 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. 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. In South Africa, alcohol harm is wide-reaching, encompassing non-communicable diseases, injuries and infectious diseases. There are high levels of abstinence (82/46% among women/men) coupled with high levels of heavy episodic drinking among those who...
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). This taxation system results in wine and traditional beer benefitting 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 among the heaviest drinkers. 

South Africa experiences high levels of income inequality and around 45% of households were in receipt of at least one form of social grant in 2015. In addition, income-related health inequality has increased as a result of COVID-19. 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.

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 (eg, 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.

In summary, examining a broad range of effects, along both the health and financial dimensions, of pricing policies for harmful products (eg, alcohol, tobacco and sugary drinks), is absolutely essential to enable the comprehensive assessment of their equity and redistributive impact. The model used in this study was based on stakeholder engagement which shaped the choice of policy, outcomes and subgroups. This is essential to addressing a contextually defined concern for equity. ECEA provides a helpful framework for exploring equity but does not replace stakeholder engagement which may highlight the need for additional and complementary analyses that measure equity impacts in different ways for example including a broader range of outcome measures or alternative subgroups of interest.

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

**METHODS**

**General approach**

We build on a recent MUP model contextualised to South Africa that is described in great detail elsewhere. The model uses a public health epidemiological model that can be best described as a comparative risk assessment model using multistate life tables, over a 20-year time horizon. We expand this MUP model in applying the ECEA framework (figure 1), specifically this requires the addition of a number of new variables (OOP costs, mean wages, cases of catastrophic health expenditures (CHE) averted) and increased disaggregation of inputs by wealth quintile beyond that used in the original model (eg, the incorporation of healthcare utilisation rates). ECEA examines the impact of policy along both health and financial dimensions, (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 (eg, 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 (eg, wealth quintiles) so as to point to the potential equity 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 data sets and the published literature (table 1; online supplemental appendix sections 1–2).

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 (ie, 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 (US$0.76) for one standard drink (12 g of pure alcohol, ie, 330 mL beer or a 125 mL 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 on 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 preintervention 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) with each individual classified as an abstainer or drinker. Drinkers are then 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 (online supplemental appendix 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 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...
| Input                                      | Wealth quintiles (QI=poorest)* | 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                                  | R9.1 R9.1 R9.1 R11.6 R11.6     | International Alcohol Control Study (2014) adjusted for inflation to 2018 prices Gibbs et al14 |
| Occasional binge                          | R8.0 R10.0 R10.1 R13.4 R11.1   |                                             |
| Heavy                                     | R7.8 R9.7 R9.2 R10.6 R12.8     | Van Walbeek and Chelwa41 authors’ calculations (webappendix section 3) Gibbs et al14 |
| Price elasticity by drinker groups†       |                                 |                                             |
| 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  |                                             |
| Share of disease at baseline‡            |                                 |                                             |
| HIV                                       | 20% 36% 32% 9% 3%               | Authors’ calculations using GHS 2018        |
| Intentional injury road injury            | 9% 29% 26% 26% 10%              | Authors’ calculations using GHS 2018        |
| Liver cirrhosis                           | 7% 7% 22% 18% 47%              | Authors’ calculations’ using GHS 2018       |
| Breast cancer                             |                                 |                                             |
| Disease-related expenditure and utilisation |                                |                                             |
| Proportion of disease-related expenditures paid as OOP | 21% 18% 41% 56% 82% | Saxena et al.22                             |
| 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 et al.42 (webappendix section 5) |
| Trauma care utilisation rates—road injury | 18% 19% 18% 18% 22%            | Authors’ calculations using GHS 2019 data; Matzopoulos et al.42 (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)            | 6100 27 400 49 300 95 600 408 900 | Authors’ calculations using GHS 2019 data deflated to 2018 |
| Absenteeism (days per year)               |                                 |                                             |
| HIV                                       | 14 14 14 14 14                | Maffessanti and Lee-Angell43               |
| Intentional injury                        | 10 10 10 10 10                | Bola et al44                               |
| Road injury                               | 18 18 18 18 18                | Parkinson et al45                          |
during the original model development process. 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.14

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-specific and quintile-specific healthcare utilisation rates (table 1). Condition-related treatment unit cost estimates were sourced from the literature and adjusted for inflation27 (where necessary) to reach the baseline year of 2018. All future costs were discounted at 5% per year.26 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) for each wealth quintile using previously published estimates.22 28

Subsequently, FRP benefits associated with household cost savings were derived for each quintile. The measure of FRP used was the number of cases of 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.

Finally, 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.29

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. First, we removed the wealth gradient from the price elasticity estimates using −0.40 to −0.22, and −0.18 for moderate, occasional binge and heavy drinkers, respectively. Second, we used alternative price elasticities estimated by Van Walbeek and Blecher30 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 −0.75.30 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 US$ using the exchange rate at 2018 of R13.2 per US$.31 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 savings.
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  | 4100   | 7400   | 4000   | 3800   | 1400   |
| 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)      | R2900   | R200   | R300   | R700   | R1200  | R500   |
| Government healthcare cost savings (ZAR million) | R3900   | R600   | R1200  | R1000  | R1000  | R1100  |
| Cases of CHE averted | 564 700 | 176 700| 82 000 | 115 900| 153 800| 36 400 |
| Annual indirect cost savings (ZAR million)       | R51 100 | R4700  | R11 600| R8400  | R11 800| R14 700|

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.

CHE, Catastrophic health expenditures; OOP, out-of-pocket; QI, poorest wealth quintile; QV, richest wealth quintile; ZAR/R, South African Rand.

RESULTS
First, 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 2). 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.

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 (US$26 700 million). The poorest would contribute the lowest proportion (about 13%), while the richest the largest (around 28%) of the expenditures (figure 2). 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 (US$0.22 billion) and government cost savings of approximately ZAR 3.9 billion (US$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 2).

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 2).

Finally, the savings in indirect costs were estimated at ZAR 51 100 million (US$3900 million). There is generally a positive gradient across the quintiles driven by both the increasing labour participation and increasing wage rate (figure 2).

Sensitivity analyses
A key driver for the results is the price elasticities. We explored two alternative scenarios. First, 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). Second, 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 3).

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 3).

Finally, 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 3).

**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 US$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. Importantly, FRP benefits would be large with CHE cases averted concentrated between quintiles I and IV. Indirect cost savings of ZAR 51100 million (US$3900 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 with 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 among women (82%). Non-drinkers will experience benefits from a reduction in others’ drinking via reductions in intimate partner violence, fetal alcohol syndrome and other forms of crime and violence, 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 (ie, 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. 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

| Table 3 Key results for the sensitivity analyses (over a 20-year time horizon) |
|--------------------------|------------------|----------------|------------------|------------------|------------------|------------------|
| 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 | 22600 | 4100 | 7400 | 4000 | 3800 | 1400 |
| 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 | 18717 | 1500 | 6500 | 4400 | 4500 | 1800 |
| 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 | 52400 | 11800 | 18400 | 10600 | 8300 | 3400 |
| 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) | 564700 | 176700 | 82000 | 115900 | 153800 | 36400 |
| 25% | 401300 | 50200 | 81900 | 115700 | 153600 | 0 |
| 40% | 401300 | 50200 | 81900 | 115700 | 153600 | 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 | R4700 | R11 600 | R8400 | R11 800 | R14 700 |
| Indirect cost savings using minimum wage applied across all quintiles | R20 700 | R4100 | R7200 | R4100 | R3800 | R1500 |

Deaths averted and CHE cases averted rounded to the nearest hundred.
Financial outcomes rounded to the nearest hundred million.
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 wage by quintile versus minimum wage across the quintiles. QI, poorest wealth quintile; QV, richest wealth quintile; ZAR/R, South African Rand.
particularly affect the healthcare system, such as alcohol-related trauma admissions in South Africa.36

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. This aligns broadly with international evidence (from both modelling studies and empirical evaluation) which suggests limited regressive effects, or in some cases financial gains from reduced consumption expenditure, for the poorest groups.11 37 38 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 benefits 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 (eg, alcohol being considered as one sole commodity).14 Second, our modelling only included five of over 30 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.39 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.40 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 (eg, 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. 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.

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Data availability statement Data may be obtained from a third party and are not publicly available. All data sources used in the model are listed in the web appendix. Data may be obtained from a third party and are not publically available.

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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:

\[
\text{Price elasticity of demand}_{ij} = \frac{\frac{\text{new consumption}_{ij} - \text{baseline consumption}_{ij}}{\text{consumption}_{ij}}}{\frac{\text{new price}_{ij} - \text{baseline price}_{ij}}{\text{baseline price}_{ij}}}, \quad (A1)
\]

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 (Q1=poorest; Q5=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* led to 100% for Q1, which was unrealistic. Hence, we replaced this 100% value with the rate from “any condition” for Q1.
As for liver cirrhosis, we used the utilisation rates corresponding to “any condition” (from the General Household Survey\textsuperscript{8} 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\textsuperscript{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:

$$utilisation_{adj,qi} = \frac{utilisation_{q_i}}{\left(\sum_{q=1}^{5} utilisation_{q_i}\right)/5} \times multiplier, \quad (A.2)$$

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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Supplementary Webappendix

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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 (2015)
                    | 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.
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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.

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\[
\text{Price elasticity of demand}_{ij} = \frac{\text{new consumption}_{ij} - \text{baseline consumption}_{ij}}{\text{consumption}_{ij}} \times \frac{\text{new price}_{ij} - \text{baseline price}_{ij}}{\text{baseline price}_{ij}}, \quad (A1)
\]

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 (Q1=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\(^8\) led to 100% for Q1, which was unrealistic. Hence, we replaced this 100% value with the rate from “any condition” for Q1.*
As for liver cirrhosis, we used the utilisation rates corresponding to “any condition” (from the General Household Survey\(^8\) 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\(^1\)) 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   | 1,851,600              | Violence                              | 757,200         | 0.41                |
| and self-harm            |                        |                                       |                 |                     |

**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:

\[
utilisation_{adj,qi} = \frac{utilisation_{qi}}{\sum_{j=1}^{n} utilisation_{qj}/5} \times \text{multiplier}, \quad (A.2)
\]

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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