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Impact of minimum unit pricing on alcohol-related hospital outcomes: systematic review

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ABSTRACT

Objective To determine the impact of minimum unit pricing (MUP) on the primary outcome of alcohol-related hospitalisation, and secondary outcomes of length of stay, hospital mortality and alcohol-related liver disease in hospital.

Design Databases MEDLINE, Embase, Scopus, APA Psycinfo, CINAHL Plus and Cochrane Reviews were searched from 1 January 2011 to 11 November 2022. Inclusion criteria were studies evaluating the impact of minimum pricing policies, and we excluded non-minimum pricing policies or studies without alcohol-related hospital outcomes. The Effective Public Health Practice Project tool was used to assess risk of bias, and the Bradford Hill Criteria were used to infer causality for outcome measures.

Setting MUP sets a legally required floor price per unit of alcohol and is estimated to reduce alcohol-attributable healthcare burden.

Participant All studies meeting inclusion criteria from any country

Intervention Minimum pricing policy of alcohol

Primary and secondary outcome measures

Results 22 studies met inclusion criteria; 6 natural experiments and 16 modelling studies. Countries included Australia, Canada, England, Northern Ireland, Ireland, Scotland, South Africa and Wales. Modelling studies estimated that MUP could reduce alcohol-related admissions by 3%–10% annually and the majority of real-world studies demonstrated that acute alcohol-related admissions responded immediately and reduced by 2%–9%, and chronic alcohol-related admissions lagged by 2–3 years and reduced by 4%–9% annually. Minimum pricing could target the heaviest consumers from the most deprived groups who tend to be at greatest risk of alcohol harms, and in so doing has the potential to reduce health inequalities. Using the Bradford Hill Criteria, we inferred a 'moderate-to-strong' causal link that MUP could reduce alcohol-related hospitalisation.

Conclusions Natural studies were consistent with minimum pricing modelling studies and showed that this policy could reduce alcohol-related hospitalisation and health inequalities.

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STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ This review focused on the impact of minimum unit pricing on alcohol-related hospital burden.
⇒ It included modelling studies alongside empirical studies on minimum pricing.
⇒ It searched for official reports and documents not published in the literature.
⇒ Limitations included the heterogeneity of study methodologies which precluded meta-analyses.

INTRODUCTION

Alcohol misuse is the seventh leading risk factor for both death and disability-adjusted life years globally.[1] In Ireland, alcohol-related hospital discharges are increasing and cost the healthcare system €1.5 billion annually (approximately 7% of the healthcare budget).[2] Given the widespread consumption of alcohol and resulting harms, alcohol policies could have a meaningful impact on reducing these harms. This review focuses on minimum unit pricing (MUP), which is an alcohol policy that sets a legally required 'floor price' per measure of alcohol. MUP has been proposed to reduce alcohol-related healthcare burden and to benefit the heaviest alcohol consumers, who drink the cheapest alcohol and tend to be at greatest risk of alcohol harms.[3] This differs from general alcohol taxation which levies a tax on all alcoholic beverages and can be undermined by retailers selling cheap alcoholic beverages at below cost price and transferring price increases onto premium alcoholic beverages or non-alcoholic products.[4]

Minimum pricing has been employed for decades in certain provinces in Canada by state-owned alcohol monopolies, as well as in several former Soviet Union countries such as Armenia, Belarus, Kyrgyzstan, Moldova, Russia, Ukraine and Uzbekistan.[5] In Canada, alcohol policies are more complex and vary across the 13 jurisdictions. British Columbia and Ontario have minimum prices per litre of alcohol regardless of beverage strength which are periodically reviewed but not indexed to inflation. Saskatchewan and Manitoba have minimum prices adjusted by alcohol strength (alcohol by volume) for specific beverages, which in practice are similar to MUP in the UK and Australian jurisdictions, although not as unitary.[6 7] In particular, Saskatchewan has had minimum pricing for an extended time frame which makes it relevant for comparisons with MUP studies in the literature.

On 1 May 2018, Scotland became the first country to enact MUP (£0.50 per eight grams of alcohol) via public health legislation for all alcoholic beverages, followed by the Northern Territory, Australia in October 2018, Wales in 2020 and Ireland in 2022.[8] On 4 January 2022, Ireland overcame legislative and lobbying barriers[9] and introduced a €1.00 MUP (£0.67 UK MUP) per standard drink or 10 g of alcohol. MUP has yet to be enacted in Northern Ireland and England despite initial support from the UK coalition government.

Since the 1980s, alcohol policy research has advanced with the advent of statistical models and methods for studying policy effects.[10] Much of this MUP work came from modelling studies which used country-specific alcohol pricing, consumption and health harms data to estimate policy effects. Alcohol-related conditions are typically categorised into four groups: 'acute' or 'chronic', and '100% related' or 'partially related' conditions, which are adapted from meta-analyses and global burden of disease (GBD) studies,[11] and tend to be underestimated in the observational studies upon which these GBD studies are based.[12] Partially related conditions are ones in which alcohol is a cofactor but is not necessary for the development or progression of the condition and examples range from injuries to cancers.

Few studies have evaluated the impact of MUP specifically on alcohol-related hospital burden and inpatient outcomes, and the results of such studies have not been collectively reviewed in the literature. The aim of this paper is to provide a comprehensive review and discussion on this topic.

METHODS

Search strategy and selection criteria

This systematic review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidance.[13] The Population, Intervention, Comparison, Outcome framework was used to include a population from any country, minimum pricing intervention, comparisons pre-introduction and post-introduction of minimum pricing, and the primary outcome of alcohol-related hospitalisation, and secondary outcomes of hospital length of stay, hospital mortality, or inpatient alcohol-related liver disease (ALD) outcomes. Exclusion criteria were studies that did not report an evaluation of a minimum pricing policy or inpatient outcomes, or did not test a hypothesis or generate new knowledge (eg, editorials or protocols). Two independent reviewers (TM, KA) searched PubMed via MEDLINE, Embase, Scopus, APA Psycinfo, CINAHL Plus and Cochrane Reviews for titles and abstracts containing the keywords or thesaurus terms "Minimum Unit Pric*", "Minimum Pric*", "Alcohol floor pric*", "Alcohol policy", "Hospitalisation [MeSH]" (which expands to emergency department and inpatient), "Emergency service, Hospital [MeSH]", "Critical care [MeSH]", "Hospital Mortality" and "Liver Disease" from 01 January 2011 to 11 November 2022. This time frame allowed sufficient modelling studies and natural experiment studies on minimum alcohol pricing. Additional articles were found by manual searching the grey literature. The methods were registered a priori on PROSPERO (CRD42021274023) and the full search strategy can be found in the online supplemental section 1. TM and KA independently screened articles via full-text review, or limited to abstract or title review if the articles clearly did not meet criteria for inclusion.

Patient and public involvement

Patients and the public were not involved in production of this research.

Data analysis

Independent reviewers (TM, KA) used a purposively designed template to extract study data on authors, year of publication, country, aims of study and results (absolute or relative reductions, or odds ratios). There was no blinding to the authors, institutions or publication sources of the articles. The risk of bias of the studies was independently assessed using the Effective Public Health Practice Project (EPHPP) tool as recommended by the Cochrane Handbook for assessing quantitative studies in public health.[14 15] Due to the marked heterogeneity of study methodologies and outcome measures, it was not possible to conduct a meta-analysis of the empirical studies in this review. The use of the Bradford Hill Criteria in a narrative systematic review has been applied where traditional statistical techniques such as meta-analyses are not practical or possible.[16] These criteria were applied to all studies independently (TM, KA) to draw an inference of causality. Our interpretation of the Bradford Hill Criteria for this review can be found in the online supplemental section 2. Any discrepancies between TM and KA were resolved by a consensus for all independent reviewer assessments, or by a third independent reviewer (JR). Where studies differentiated findings by sex or gender, we presented our reporting in accordance with the Sex and Gender Equity in Research guidelines.[17]

RESULTS

The search identified 591 articles: 233 articles from PubMed, 134 articles from Embase, 91 articles from Scopus, 131 articles from APA Psycinfo and CINAHL Plus, and 2 articles from Cochrane reviews. An additional 20 studies were retrieved from the grey literature and manual searches. A total of 120 articles underwent detailed full-text review, 98 articles were excluded after

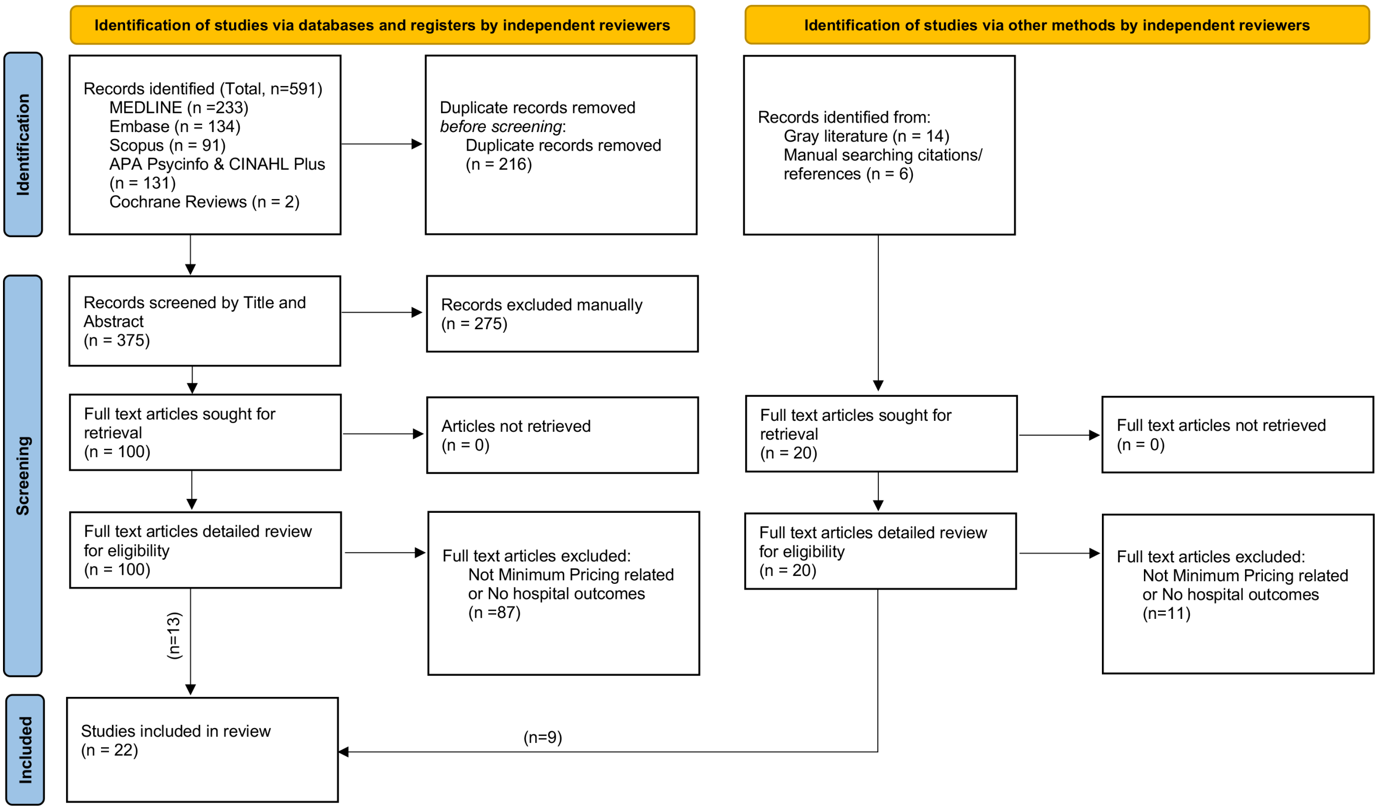

Figure 1 Preferred Reporting Items for Systematic Reviews and Meta-Analyses 2020 flow diagram of study selection in this systematic review.

full-text review (online supplemental section 3) and a total of 22 studies met inclusion criteria (see figure 1).

The 22 studies in this review were from eight countries including Canada (n=5), England (n=6), Scotland (n=3), Wales (n=2), Northern Ireland (n=1), Ireland (n=1), Australia (n=3) and South Africa (n=1). There was a paucity of research from former Soviet countries on the impacts of minimum pricing and no studies from these countries met inclusion for this review. Most studies (16 of 22) were modelling studies, of which 13 studies used versions of the Sheffield Alcohol Policy Model, 2 studies used versions of the International Model of Alcohol Harms and Policies, and 1 study developed a unique purpose-built epidemiological policy appraisal model. In this review, 21 studies scored low risk of bias and 1 study scored high risk of bias using the EPHPP tool (online supplemental section 4).

The country-specific alcohol measurements referenced in this review include UK alcohol units (8 g of alcohol), South African alcohol units (10 g of alcohol), and standard drinks (10 g of alcohol) in Ireland and Australia. A table of the MUP modelling studies, equivalent MUP conversion rate at the time of this publication and corresponding results at full policy effect are summarised in table 1. Where appropriate, MUP equivalent conversions are also presented within the text.

Few studies were natural experiments originating from Canada (n=2), Scotland (n=1) and Australia (n=3). It should be noted that two large alcohol policy research groups from Canada and the UK conducted 82% (18 of 22) of all the studies included in this review. The detailed data extraction for all studies can be found in table 2.

Modelling studies

Sixteen modelling studies are presented by country in this section. In Canada, Stockwell *et al*[18] proposed that MUPs $C1.50 (£0.52 UK MUP) and $C1.75 (£0.62 UK MUP) could reduce alcohol-related hospital admissions by 8.4% and 16.3% per annum, respectively.[19] In Ontario and British Columbia, Hill-Macmanus *et al*[20] used a $C1.50 MUP per standard drink and estimated 5470 fewer hospital admissions for Ontario (population of 13.43 million in 2012)[21] and 610 fewer admissions in British Columbia (a population of 4.57 million in 2012)[22] annually. Of the total reductions in hospitalisation, harmful drinkers accounted for 79% in Ontario and 58% in British Columbia. They estimated a lag period of 10 years to observe significant impacts for certain chronic conditions.[20] Stockwell *et al*[18] modelled $C1.75 MUP across all Canadian jurisdictions, and estimated that it could reduce alcohol-attributable hospitalisation by more than double (8329 annually) that projected for increases in alcohol taxation alone.[18]

In England, Brennan *et al*[23] estimated the largest reduction in total alcohol-related hospitalisation of 6.2% among the ‘manual or routine’ socioeconomic group (86% share reduction), followed by 1.6% among the ‘intermediate’ group (7% share) and 1.0% among the ‘professional’

Table 1 Table of modelling studies of the impact of MUP on alcohol-related hospitalisation annually

			MUP conversion		Estimated reduction in alcohol-related hospitalisation annually	
Author and year	**Country**	**MUP threshold**	**£/UK unit***	**€/SD†**	**%**	**Cases**
Holmes *et al* (2014)[24]	England	£0.45	—	0.68	3.9	29 900
Brennan *et al* (2014)[23]	England	£0.45	—	0.68	—	23 700
Angus *et al* (2015)[25]	England	£0.50	—	0.86	2.7	22 797
Holmes *et al* (2016)[27]	England	£0.50	—	0.80	—	—
Meier *et al* (2021)[26]	England	£0.50	—	0.73	3.4	22 226
Brennan *et al* (2021)[55]	England	£0.50	—	0.73	5.5	5956
Meng *et al* (2012)[28]	Scotland	£0.40‡	—	0.60	7.8	5100
Angus *et al* (2016)[29]	Scotland	£0.50	—	0.80	6.8	2042
Meng *et al* (2014)[30]	Wales	£0.50	—	0.80	3.8	1422
Angus and Brennan (2018)[31]	Wales	£0.50	—	0.70	3.6	1281
Angus *et al* (2014)[32]	Northern Ireland	£0.50	—	0.80	9.4	2400
Angus *et al* (2014)[33]	Ireland	€1.00	0.67	—	10.0	5900
Hill-Macmanus *et al* (2012)[20]	Canada	$C1.50	0.55	0.85	—	5472 (Ontario) 610 (BC)
Sherk *et al* (2020)[19]	Canada	$C1.50	0.52	0.76	8.4	22 631
Stockwell *et al* (2020)[18]	Canada	$C1.75	0.62	0.82	—	8329
Gibbs *et al* (2021)[34]	South Africa	R10	0.33	0.48	—	—

*Unit=8 g alcohol.
†SD=10 g alcohol.
‡With discount bans.
BC, British Columbia; MUP, minimum unit pricing; SD, standard drink.

group (7% share) with a £0.45 MUP.[24] High-risk drinkers from the lowest socioeconomic group could experience the greatest benefit compared with any other population subgroup.[25] Using sex-disaggregated baseline data of the English drinking population, high-risk female drinkers showed a proportionally higher admission rate than high-risk male drinkers. Meier *et al*[26] tested a £0.50 MUP and estimated a 5.8% reduction in alcohol-related admissions for high-risk male drinkers, but only a 2.7% reduction for high-risk female drinkers annually. It was only when the highest MUP threshold of £0.70 was modelled would high-risk female drinkers demonstrate a substantial reduction in hospitalisation. Still, this effect was limited to women living in the most deprived areas from the lowest socioeconomic group.[26] Alcohol-related cancer hospitalisation could drop by 2.0% (6311 cases) over 20 years with a £0.50 MUP; of which the largest annual reductions were in mouth and throat cancer (0.8%; 1767 cases) followed by oesophageal cancer (0.6%; 2605 cases).[27] Bans on below cost sales (BBCS) were less effective at reducing overall alcohol-related hospitalisation in England when compared with minimum pricing.[23]

In Scotland, alcohol-related hospitalisation could drop by 6.8%–7.8% with a £0.50 MUP at policy maturity (10th year), with the greatest reduction for harmful drinkers (5.5%–7.0%), followed by hazardous drinkers (3.2%–4.6%) and moderate drinkers (1.1%–5.5%).[28 29] When factoring in income, a £0.50 MUP estimated the largest reductions in hospitalisation among moderate drinkers (21.9% reduction in poverty vs a +2.2% increase for those not in poverty), followed by harmful drinkers (12.5% reduction in poverty vs 5.5% not in poverty) and lastly hazardous drinkers (7.9% in poverty vs 3.5% not in poverty). Alcohol taxation underperformed across all income groups in reducing alcohol-related hospitalisation when compared with MUP; and in one scenario, a tax rise of 70% would be needed to target the subgroup ‘harmful drinkers in poverty’ to the same extent as a £0.50 MUP.[29]

In Wales, a £0.50 MUP could reduce alcohol-attributable hospitalisation by 3.6%–3.8% overall, with reductions of 4.6% for ‘100% alcohol-attributable’ conditions, 2.5% for ‘chronic, partially attributable’ conditions and 3.8% for ‘acute (injuries) partially attributable’ conditions. Alcohol-attributable admissions for those in poverty could reduce by 6.6% compared with 3.0% for those not in poverty. Once again, the largest share reduction in total alcohol-attributable admissions was from harmful drinkers from the most deprived socioeconomic quintile.[30 31] Alcohol taxation was less effective overall and would require a rise of 34%–47% to achieve similar effects as a £0.50 MUP.

In Northern Ireland, a £0.50 MUP could reduce alcohol-related admissions by 9.4% annually (6.7% for acute and 12.2% for chronic alcohol-related conditions). At baseline, high-risk drinkers accounted for the greatest burden of alcohol-related hospitalisation annually, and a £0.50 MUP could reduce admissions in this subgroup by 9.8% (71% share of reduction). At policy maturity, one could expect fewer annual alcohol-related hospitalisation for ALD (−166), alcohol poisoning (−108), cancers (−93), road traffic accidents (−42), intentional self-harm (−33)

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Table 2 Table of all studies included in this review with results, risk of bias assessments and Bradford Hill Criteria fulfilled

Author and year	Country	Study aim(s) relevant to this review	Study design	Sample	Results	Risk of bias	Bradford Hill Criteria
Natural experiments							
Stockwell *et al* (2013)[37]	Canada	10% increase in minimum prices on alcohol-related admissions	Time series analysis	89 areas in BC	10% increase in minimum pricing resulted in an immediate 8.95% reduction in acute alcohol-attributable admissions and 9.22% reduction in chronic alcohol-attributable admissions 2 years later.	Low	SA, EX, CON, SP, TE, BG, PL, CO
Zhao and Stockwell (2017)[38]	Canada	1% increase in minimum prices on alcohol-related admissions by income	Time series analysis	89 areas in BC	For '100% alcohol-related admissions', acute conditions showed an immediate 3.6% reduction in low-income group. Chronic conditions showed 2.2% reduction in low-income group after 2–3 years. Effects were greatest among the lowest-income groups.	Low	SA, EX, CON, SP, TE, BG, PL, CO
Chaudhary *et al* (2020)[40]	Scotland	£0.50 MUP and alcohol-related liver disease (ALD) hospital outcomes	Retrospective before and after study	513 patients with ALD	No change in ALD hospital discharge rate, hospital mortality or liver decompensation. Reduction in presentations of all-cause UGIB, but not for variceal bleeding as aetiology.	High	EX, TE, PL
Secombe *et al* (2020)[41]	Australia	Police Auxiliary Liquor Inspectors and $A1.30 MUP on intensive care unit (ICU) admissions	Before and after study	557 ICU admissions	4.9% absolute risk reduction in ICU admissions for acute alcohol misuse (9.0% pre-MUP vs 4.1% post-MUP; p=0.022). Chronic alcohol misuse was not significant.	Low	SA, EX, CON, TE, PL, CO
Secombe *et al* (2021)[42]	Australia	Police Auxiliary Liquor Inspectors and $A1.30 MUP on critical care admissions	Before and after study	2281 ICU admissions	4.5% (95% CI: 0.8% to 8.2%) absolute risk reduction with introduction of alcohol policies (p=0.01). Acute alcohol misuse 2.3% reduction (95% CI: −0.2% to 4.9%; p=0.06). More marked regional reduction in Central Australia vs the city of Darwin (27.0% vs 16.7%).	Low	SA, EX, CON, TE, PL, CO
Wright *et al* (2021)[43]	Australia	$A1.30 MUP and ICU outcomes in the Northern Territory, Australia	Time series analysis	1323 ICU admissions	ICU admission OR 0.61; p<0.01. 7% reduction for acute alcohol misusers vs 3.7% for chronic alcohol misusers. 234 patient-days saved (p<0.05). No reduction in ICU or hospital mortality (p=0.17).	Low	SA, EX, CON, TE, PL
Modelling studies							
Hill-Macmanus *et al* (2012)[20]	Canada	MUP on health outcomes in Ontario and BC	Modelling study (SAPM)	Ontario and BC	Alcohol-related admissions: −1390 in Ontario and −240 in BC (year 1) and −5470 and −610 (year 10), respectively. Chronic conditions could lag by 10 years. Harmful drinkers accounted for 79% (Ontario) and 58% (BC) of the total reductions seen.	Low	CON, SP, PL, CO
Stockwell *et al* (2020)[18]	Canada	MUP vs alcohol tax on health outcomes in Canada	Modelling study (InterMAHP)	All Canadian jurisdictions	$C1.75 MUP could reduce alcohol-attributable hospitalisation by 8329 annually vs 3453 for inflation-adjusted alcohol excise tax.	Low	CON, SP, BG, PL, CO, AN
Sherk *et al* (2020)[19]	Canada	MUP and alcohol-related hospitalisation by sex-disaggregated data	Modelling study (InterMAHP)	Quebec population	$C1.50 MUP: estimated drop in alcohol-related admissions (males 6.7%; females 14.5%; overall 8.4%). $C1.75 MUP: drop in alcohol-related admissions (males 13.2%; females 27.6%; overall 16.3%)	Low	CON, SP, BG, PL, CO
Holmes *et al* (2014)[24]	England	£0.45 MUP alcohol-related harms by socioeconomic group	Modelling study (SAPM)	English population 10 588	'Routine or manual' group: 6.2% annual reduction in admissions (86% share of the reduction). 'Intermediate' 1.6% reduction (7% share). 'Professional' 1.0% reduction (7% share).	Low	CON, SP, PL, CO
Brennan *et al* (2014)[23]	England	MUP vs BBCS on health outcomes	Modelling study (SAPM)	Adults aged >16	MUP could have a greater reduction on hospitalisation compared with BBCS (23 700 vs 500 per annum) and the effect was most significant in high-risk drinkers.	Low	CON, SP, BG, PL, CO, AN
Angus *et al* (2015)[25]	England	MUP on health harms by drinking level and socioeconomic status	Modelling study (SAPM)	English population	£0.50 MUP: estimated 2.7% (22 797) fewer annual admissions. High-risk drinkers in the lowest socioeconomic group could have largest impact vs other consumption levels or socioeconomic groups.	Low	CON, SP, BG, PL, CO
Holmes *et al* (2016)[27]	England	MUP policies (£0.50–£0.70) impact on alcohol-related cancer hospitalisation	Modelling study (SAPM)	Great Britain national data	£0.50 MUP: 2.7% (385 785) cumulative reduction in acute alcohol admissions and 2.0% (6311) reduction in alcohol-related cancer admissions (20th year). Largest reduction could be in mouth and throat cancer followed by oesophageal cancer.	Low	CON, SP, BG, PL, CO, AN
Brennan *et al* (2021)[55]	England	MUP impact by upper-tier local authorities	Modelling study (SAPM)	English population	£0.50 MUP: NW and NE England could see a greater effect than SE England and London regions.	Low	CON, SP, BG, PL, CO

Continued

Table 2 Continued

Author and year	Country	Study aim(s) relevant to this review	Study design	Sample	Results	Risk of bias	Bradford Hill Criteria
Meier *et al* (2021)[26]	England	MUP on hospitalisation by gender and consumption	Modelling study (SAPM)	Adults aged >18	£0.50 MUP: estimated 4.1% reduction admissions for men (5.8% for high-risk man). 1.6% reduction for women (–2.7% if high-risk woman).	Low	CON, SP, BG, PL, CO
Meng *et al* (2012)[28]	Scotland	MUP (with or without ban on discounts) on health outcomes	Modelling study (SAPM)	Scottish population	£0.50 MUP: estimated 13.3% (8600) reduction in alcohol-related admissions annually. Largest benefit for harmful drinkers (–3600) compared with moderate (–700) and hazardous (–2100).	Low	CON, SP, BG, PL, CO, AN
Angus *et al* (2016)[29]	Scotland	MUP vs alcohol tax on health outcomes by consumption and income	Modelling study (SAPM)	Scottish population	£0.50 MUP: 6.8% reduction in admissions overall (3.0% reduction for acute and 29.8% reduction chronic alcohol admissions). 70% tax rise would be needed to match the benefits of £0.50 MUP on harmful drinkers in poverty.	Low	CON, SP, BG, PL, CO, AN
Meng *et al* (2014)[30]	Wales	MUP and admissions by consumption and income	Modelling study (SAPM)	Welsh population	£0.50 MUP: 3.2% reduction in alcohol-related admissions at 1 year (3.8% at year 20). 0.0% change with BBCS at 1 year (0.1% at year 20).	Low	CON, SP, BG, PL, CO, AN
Angus and Brennan (2018)[31]	Wales	Updated Welsh model: MUP vs alcohol taxation on admissions	Modelling study (SAPM)	Updated Welsh population	£0.50 MUP: estimated 3.6% fewer alcohol-related admissions annually, greatest for harmful drinkers in the most deprived quintile. Alcohol tax would need to rise by 34%–47% to match the benefits of £0.50 MUP.	Low	CON, SP, BG, PL, CO, AN
Angus *et al* (2014)[33]	Northern Ireland	MUP vs price-based promotional bans on health outcomes by consumption and socioeconomic group	Modelling study (SAPM)	Northern Ireland population	£50 MUP: 9.4% reduction in alcohol-related admissions (6.7% for acute and 12.2% for chronic conditions) with greatest impact on high-risk drinkers. 11.6% decrease in ALD admissions annually. MUP was superior to price-based promotional bans at reducing admissions.	Low	CON, SP, BG, PL, CO, AN
Angus *et al* (2014)[33]	Ireland	MUP on health outcomes	Modelling study (SAPM)	Irish population	€1.00 MUP: 10.0% reduction in alcohol-related admissions. 9% immediate reduction (acute conditions) and 11.0% lagged reduction at 10 years (chronic conditions). 17.2% reduction in ALD admissions per year at full policy effect at 20 years.	Low	CON, SP, BG, PL, CO, AN
Gibbs *et al* (2021)[34]	South Africa	MUP on health outcomes	Purpose-built model	South African population	R10 MUP: 62% of HIV cases (266 108) and 50% of liver cirrhosis cases (16 212) could be averted from requiring healthcare resources.	Low	CON, SP, BG, PL, CO

AN, analogy; BBCS, bans on below cost sales; BC, British Columbia; BG, biological gradient; CO, coherence; CON, consistency; EX, experiment; InterMAHP, International Model of Alcohol Harms and Policies; MUP, minimum unit pricing; NE, North East; NW, North West; PL, plausibility; SA, strength of association; SAPM, Sheffield Alcohol Policy Model; SE, South East; SP, specificity; TE, temporality; UGIB, upper gastrointestinal bleed.

and assaults (−27).[32] Bans on price-based promotions had a lesser impact compared with MUP.

In Ireland, a €1.00 MUP could reduce baseline alcohol-related admissions by 10.0%, with price-dependent reductions at higher MUP prices. Acute conditions could see an immediate 9.0% reduction and chronic conditions could see an 11.0% reduction at 10 years. ALD admissions could drop by 17.2% annually at policy maturity, and these effects were greatest with MUP compared with price-based promotional bans, or BBCS in isolation.[33]

In South Africa, Gibbs *et al*[34] noted unique consumption and harm patterns in the drinking population constituting high levels of hazardous episodic drinking, high transmission rates of infectious diseases and high prevalence of intentional harms. A R10 MUP (£0.33 UK MUP) averted approximately 900 332 cases across all health outcomes of HIV, liver cirrhosis, breast cancer, intentional injuries and road injuries over 20 years.[34] It is estimated that 62% of HIV cases[35] and 50% of liver cirrhosis cases[36] would be expected to avail of healthcare resources; hence, one can extrapolate that 266 108 fewer patients with HIV and 16 212 fewer patients with liver cirrhosis could potentially require healthcare resources over 20 years.

Natural experiments

Six natural experiments are presented in this section by country. In British Columbia, Stockwell *et al*[37] evaluated a 10% increase in the average minimum price (equivalent to a rise from £0.34 to £0.38 UK MUP) which resulted in an immediate 9.0% reduction (95% CI=2.5% to 15.4%; p<0.001) in acute alcohol-attributable admissions, and a lagged 9.2% reduction (95% CI=1.1% to 17.4%; p<0.05) in chronic alcohol-attributable hospitalisation at 2 years.[37] Zhao and Stockwell[38] later analysed a further 1% increase in average minimum price in British Colombia and demonstrated an immediate 1.6% reduction (95% CI=0.5% to 2.8%; p<0.01) for '100% acute alcohol-related admissions' across all income subgroups. There was a 2.2% reduction (95% CI=0.4% to 4.1%; p<0.05) in '100% chronic alcohol-related admissions' for low-income groups. All chronic alcohol-related admissions showed a lag of 2–3 years, and the greatest overall effects were consistent in the low-income groups.[38]

In Scotland, Ferguson *et al*[39] evaluated a £0.50 MUP and reported a reduction in overall acute upper gastrointestinal bleeding presentations (15.8% vs 7.4%, OR 0.42; p=0.02); however, there was no significant reduction for variceal bleeding when examined by aetiology. They could not conclude a difference in hospital readmission rates with MUP (48.5% vs 54.4%; p>0.05), ALD admission rates (6.2% vs 5.2%; p=0.123) or 90-day hospital mortality (12.4% vs 13.2%; p>0.05). There were no differences in ALD presentations of ascites (45.2% vs 47.8%; p=0.46), hepatic encephalopathy (21.2% vs 24.3%; p=0.38), acute alcoholic hepatitis (18.2% vs 19.3%; p>0.05) or infection (15.4% vs 10.7%; p=0.19).[40]

In the Northern Territory, Australia, a banned-drinker register was introduced in October 2017, the Police Auxiliary Liquor Inspector (PALI) in June 2018, followed by a $A1.30 MUP in October 2018. Secombe *et al*[41] evaluated the impact of the PALI and a $A1.30 MUP (£0.50 UK MUP) on alcohol-related intensive care unit (ICU) admissions.[41] The ICU database allowed acute and chronic alcohol misuse to be flagged. They reported a 4.9% (9.0% vs 4.1%; p=0.02) reduction in acute alcohol misuse ICU admissions without any significant change to chronic misuse ICU admissions within 6 months of the introduction of the policies. Secombe *et al* later extended their sampling period to 1 year post-introduction of the policies, and reported a 4.5% (95% CI: 0.8% to 8.2%; p=0.01) absolute risk reduction in ICU admissions with overall alcohol misuse.[42] Central Australia showed a greater reduction in ICU admission due to alcohol misuse compared with the city of Darwin (27.0% vs 16.7% relative risk reductions, respectively). The reduction in harm from the policies was more pronounced for ICU admissions with acute misuse (adjusted OR 0.45, 95% CI: 0.25 to 0.81; p=0.009) compared with chronic misuse within 1 year of the introduction of the alcohol policies. Wright *et al*[43] also evaluated the policies PALI and a $A1.30 MUP on intensive care outcomes and reported a 7.1% reduction (18.8% vs 11.7%; p<0.01) in alcohol-related ICU admissions with MUP. A greater reduction of 7% (10.6% vs 3.6%, p<0.01) was seen for acute alcohol misusers compared with 3.7% (13.3% vs 9.6%, p=0.03) for chronic alcohol misusers. There was a reduced likelihood of intensive care admission with the introduction of MUP (OR 0.61, 95% CI=0.45 to 0.83; p<0.01). A cumulative of 234 patient-days were saved (p<0.01) due to MUP over the 2-year study period, and there was no statistically significant difference in ICU mortality rate (3.2% vs 4.7%; p=0.17).[43]

Bradford Hill Criteria

The primary outcome of 'alcohol-related hospitalisation' was evaluated across all studies and was therefore suitable for application of the Bradford Hill Criteria. We inferred a 'moderate-to-strong' causal link that MUP could reduce alcohol-related hospital admissions as defined ex ante. All nine Bradford Hill Criteria were met collectively across studies; however, there was heterogeneity in the criteria fulfilment according to study type. Natural experiments fulfilled the criteria 'experiment', 'strength of association' and 'temporality', while modelling studies fulfilled 'specificity', 'biological gradient' and 'analogy' (see table 3).

DISCUSSION

Existing literature

Alcohol is a preventable risk factor of disease burden,[44] meaning that the hospital burden from alcohol-related admissions could in theory be reduced by an aggregate reduction in alcohol consumption in the population. This review found that although different methods were used to study MUP in reducing alcohol-related healthcare burden, the majority of real-world studies showed

Table 3 Bradford Hill Criteria applied to studies

Author and year	Strength of association		EX	CON	SP	TE	BG	PL	CO	AN	Total criteria (%)
Natural experiments											
Stockwell *et al* (2013)[37]	**Hospitalisation** β=−0.895 (95% CI=−1.544 to −0.246; p<0.001) β=−0.922 (95% CI=−1.738 to −0.106; p<0.05)	1	1	1	1	1	1	1	1	0	8 (88.9)
Zhao and Stockwell (2017)[38]	**Hospitalisation** β=−3.90 (95% CI=−6.15 to −1.66; p<0.001) β=−1.97 (95% CI=−3.85 to −0.09; p<0.05)	1	1	1	1	1	1	1	1	0	8 (88.9)
Chaudhary *et al* (2020)[40]	**Hospitalisation** No change; p>0.05	0	1	0	0	1	0	1	0	0	3 (33.3)
Secombe *et al* (2020)[41]	**ICU admission** 54% RR (9.0% vs 4.1%; p=0.022)	1	1	1	0	1	0	1	1	0	6 (66.7)
Secombe *et al* (2021)[42]	**ICU admission** 4.5% (95% CI: 0.8% to 8.2%; p=0.01)	1	1	1	0	1	0	1	1	0	6 (66.7)
Wright *et al* (2021)[43]	**ICU admission** OR 0.61 (95% CI=0.45 to 0.83; p<0.01)	1	1	1	0	1	0	1	1	0	5 (55.6)
Modelling studies											
Hill-Macmanus *et al* (2012)[20]	Modelled figures	0	0	1	1	0	1	1	1	0	5 (55.6)
Stockwell *et al* (2020)[18]	Modelled figures	0	0	1	1	0	1	1	1	1–tax	6 (66.7)
Sherk *et al* (2020)[19]	Modelled figures	0	0	1	1	0	1	1	1	0	5 (55.6)
Holmes *et al* (2014)[24]	Modelled figures	0	0	1	1	0	0	1	1	0	4 (44.4)
Brennan *et al* (2014)[23]	Modelled figures	0	0	1	1	0	1	1	1	1–BBCS	6 (66.7)
Angus *et al* (2015)[25]	Modelled figures	0	0	1	1	0	1	1	1	0	5 (55.5)
Angus *et al* (2016)[27]	Modelled figures	0	0	1	1	0	1	1	1	1–tax	6 (66.7)
Brennan *et al* (2021)[55]	Modelled figures	0	0	1	1	0	1	1	1	0	5 (55.6)
Meier *et al* (2021)[26]	Modelled figures	0	0	1	1	0	1	1	1	0	5 (55.6)
Meng *et al* (2012)[28]	Modelled figures	0	0	1	1	0	1	1	1	1–discount bans	6 (66.7)
Angus *et al* (2016)[29]	Modelled figures	0	0	1	1	0	1	1	1	1–tax	6 (66.7)
Meng *et al* (2014)[30]	Modelled figures	0	0	1	1	0	1	1	1	1–BBCS	6 (66.7)
Angus and Brennan (2018)[31]	Modelled figures	0	0	1	1	0	1	1	1	1–tax	6 (66.7)
Angus *et al* (2014)[33]	Modelled figures	0	0	1	1	0	1	1	1	1–BBCS	6 (66.7)
Angus *et al* (2014)[33]	Modelled figures	0	0	1	1	0	1	1	1	1–BBCS, discount ban	6 (66.7)
Gibbs *et al* (2021)[34]	Modelled figures	0	0	1	1	0	1	1	1	0	5 (55.6)
Total studies per criterion (%)		5 (22.7)	6 (27.3)	21 (95.5)	18 (81.8)	6 (27.3)	17 (77.3)	22(100)	21(95.5)	9 (40.9)	

AN, analogy; BBCS, ban on below cost sales; BG, biological gradient; CO, coherence; CON, consistency; EX, experiment; ICU, intensive care unit; PL, plausibility; RR, relative risk; SP, specificity; TE, temporality.

consistencies with modelling studies. These consistencies spanned the projected direction of outcomes and effect sizes, price-dependent responses, and expected temporal responses from acute and chronic alcohol-attributable conditions. For example, in Canada, reductions in acute alcohol-attributable admissions were observed with each incremental increase in existing minimum pricing (9.0% reduction from a 10% increase in minimum price,[37] followed by another 1.6% reduction from a further 1.0% increase in minimum price).[38] They also demonstrated that acute alcohol-attributable conditions would respond immediately after price change, and chronic conditions would lag by 2–3 years. Additionally, Australian natural studies focusing on the impact of MUP on critical care admissions demonstrated reductions up to 7%. These are in keeping with modelling studies which estimated annual reductions in alcohol-related admissions at policy maturity ranging from 2.7% to 10.0%, that health benefits could increase as prices are increased, and acute alcohol-attributable conditions could respond first.

Such immediate temporal responses from acute alcohol-related conditions have also been reported in the Northern Territory, Australia in previous alcohol taxation studies.[45] These findings make sense as one would expect acute alcohol-related admissions to include road traffic accidents, violent or accidental injuries, or acute alcohol poisonings which could respond immediately to a reduction in aggregate alcohol consumption. Conversely, chronic alcohol-related conditions such as liver cirrhosis or cancers usually take some time to develop and for complications to arise. Modelling studies suggest that benefits for chronic alcohol-related conditions are expected at policy maturity (10–20 years), whereas natural studies have demonstrated benefits as early as 2–3 years after policy change.[37 38]

The study by Chaudhary *et al*[40] was inconsistent with studies in this review and did not demonstrate any change in hospital discharges, hospital mortality or hepatic decompensation among patients with ALD. This study scored a high risk of bias as they limited their study population to the gastroenterology/liver wards of their hospital which introduced selection bias as it is possible that eligible patients could have been admitted to other wards in the hospital. Furthermore, by restricting their timelines to the fourth quarters of each year, they effectively reduced their sample sizes and potential power to detect a true change.

MUP and ALD

Modelling studies would suggest that ALD admissions could drop by 6.3% in Wales[30] or 17.2% in Ireland[33] at MUP policy maturity, and the natural study by Chaudhary *et al* did not demonstrate any effect on ALD admissions 1 year after MUP implementation.[40] Although modelling studies reported lagged effects for ALD admissions up to 10 years, Kerr *et al*[46] and Skog[47] demonstrated reductions in ALD cirrhosis mortality within the first year following a change in consumption. This was also demonstrated with the sharp fall in ALD cirrhosis mortality with alcohol rationing measures in Paris during World War II.[48] This would appear counterintuitive as ALD cirrhosis and mortality are usually the result of years of alcohol misuse, and one would have expected distant impacts rather than immediate impacts.[46 47] The notion of 'critical thresholds' by Norström[48 49] and Skog[50] attempted to explain this paradox, and it postulated that at any given time, there would be a cohort of patients with advanced liver cirrhosis in whom a reduction in alcohol consumption could avoid associated harms including hospitalisation, hepatic decompensation or mortality. It is within this cohort that immediate health benefits could be observed with aggregate changes in alcohol consumption. It may be that the natural study by Chaudhary *et al* did not detect these benefits for patients with ALD due to the limitations of the study, and larger prospective studies are awaited to determine the impact and time lag effect of MUP policies on patients with ALD in hospital.

MUP and health inequalities

The heaviest alcohol consumers and those from the lowest socioeconomic group had the greatest level of alcohol harms at baseline. Minimum pricing appeared to be more effective at reducing alcohol-related hospitalisation in these target groups compared with general alcohol taxation, bans on BBCS and restrictions on price promotions.[23 28 30 32] By one estimate, for the highest-risk group 'harmful drinkers in poverty', alcohol taxation would need to increase by 70% to achieve similar reductions in alcohol-related hospitalisation as with a £0.50 MUP.[29] With increases in alcohol taxation, consumers can maintain the same level of alcohol consumption by 'substituting down' to cheaper and lower-quality alcohol.[51] Furthermore, this behavioural response would likely occur among consumers from low-income groups who would seek cheaper products thus exacerbating the already existing health inequalities. This is less likely with minimum pricing as cheaper alternatives are no longer legally available. This targeted potential of MUP on the highest-risk alcohol consumers could be explained by the purchasing patterns of low-income drinkers who purchase greater quantities of cheap alcohol at below proposed MUP thresholds and therefore face a greater increase in price with minimum pricing. This, coupled with their tendency to consume beverages with the highest price elasticities (eg, cider), means that they are expected to show greater behavioural responses to minimum pricing compared with higher-income drinkers who may purchase alcoholic beverages with lower price elasticities (eg, wine).[24 25 29–31 38]

Future direction

Minimum pricing should not be viewed as a panacea to all alcohol-related issues. Instead, further work is needed to determine interactions between MUP in combination with other alcohol policies in the real world to guide effective policymaking. There is lack of awareness of the extent of alcohol-related harms, and this has been identified as a key obstacle in effective alcohol policy implementation.[52] Resolving this will require a paradigm shift in which alcohol misuse is addressed as a serious health concern with intentions to curb any cultural acceptance. Public awareness can be bolstered with the aid of media tools as well as mandated warning labels on alcoholic beverages with key messages regarding the risk of death or cancer. Public engagement and education have been found to increase awareness and support for such policies in the long run.[53] In societies with a high cultural acceptance of alcohol, public outcry to alcohol policies is a real concern; however, survey data from post-MUP Scotland showed that most respondents were in favour of MUP and public attitudes toward MUP became more favourable over time across all subgroups of age, gender and socioeconomic quintiles.[39] Furthermore, the resources saved from reductions in alcohol-related hospitalisation could in theory be reallocated to the development of integrated alcohol service teams or 'Alcohol Care Teams' which have been shown to reduce alcohol-related admissions, readmissions and mortality in the UK.[54]

Similar studies

It should be noted that a systematic review by Boniface *et al*[16] used the Bradford Hill Criteria to evaluate the general effectiveness of MUP at reducing alcohol consumption, morbidity and mortality; however, their review did not seek to quantify the impact of minimum pricing on any specific outcome measures.[16] Our review discussed the outcome direction and effect sizes from minimum pricing on hospital-related outcomes which has not been systematically presented before, and in this regard we believe that our review offers new knowledge.

Strengths and limitations

This review focused on alcohol-related healthcare burden in the context of minimum pricing. We discussed MUP modelling studies alongside MUP empirical studies, as well as included minimum pricing studies not published in the literature. Limitations included the heterogeneity of study methodologies which precluded meta-analyses or subgroup analyses.

CONCLUSION

The majority of empirical studies provided consistent support for modelling studies that minimum pricing strategies could reduce alcohol-related healthcare burden as estimated. Further work is needed to understand the interactions between minimum pricing in combination with existing alcohol policies, which may provide a more holistic approach to alcohol policymaking.

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REFERENCES

1 Griswold MG, Fullman N, Hawley C, *et al*. Alcohol use and burden for 195 countries and territories, 1990–2016: a systematic analysis for the global burden of disease study 2016. *The Lancet* 2018;392:1015–35.
2 O'Dwyer C, Mongan D, Doyle A, *et al*. HRB overview series 11: alcohol consumption, alcohol-related harm and alcohol policy in ireland. *Health Research Board* 2021;
3 Purshouse RC, Meier PS, Brennan A, *et al*. Estimated effect of alcohol pricing policies on health and health economic outcomes in england: an epidemiological model. *Lancet* 2010;375:1355–64.
4 Wilson LB, Pryce R, Angus C, *et al*. The effect of alcohol Tax changes on retail prices: how do on-trade alcohol retailers pass through Tax changes to consumers? *Eur J Health Econ* 2021;22:381–92.
5 Neufeld M, Bobrova A, Davletov K, *et al*. Alcohol control policies in former Soviet Union countries: a narrative review of three decades of policy changes and their apparent effects. *Drug Alcohol Rev* 2021;40:350–67. 10.1111/dar.13204 Available: https://onlinelibrary.wiley.com/toc/14653362/40/3
6 Sassi F, OECD. *Tackling harmful alcohol use*. 12 May 2015.
7 Stockwell T, Thomas G. Is alcohol too cheap in the UK? the case for setting a minimum unit price for alcohol. In: *An institute of Alcohol Studies report. Institute of Alcohol Studies*. 2013.
8 Stockwell T. *Minimum alcohol pricing: canada's accidental public health strategy*. 2014.
9 Lesch M, McCambridge J. Waiting for the wave: political leadership, policy windows, and alcohol policy change in ireland. *Soc Sci Med* 2021;282:114116.

10 Treno AJ, Marzell M, Gruenewald PJ, *et al*. A review of alcohol and other drug control policy research. *J Stud Alcohol Drugs Suppl* 2014;75 Suppl 17:98–107.
11 Rehm J, Gmel GE Sr, Gmel G, *et al*. The relationship between different dimensions of alcohol use and the burden of disease-an update. *Addiction* 2017;112:968–1001.
12 Stockwell T, Zhao J, Sherk A, *et al*. Underestimation of alcohol consumption in cohort studies and implications for alcohol's contribution to the global burden of disease. *Addiction* 2018;113:2245–9.
13 Moher D, Liberati A, Tetzlaff J, *et al*. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *PLOS Med* 2009;6:e1000097
14 Armstrong R, Waters E, Doyle J, eds. Chapter 21.4: assessment of study quality and risk of bias. In: *Cochrane Handbook*. Available: https://handbook-5-1.cochrane.org/chapter_21/21_4_assessment_of_study_quality_and_risk_of_bias.htm [accessed 8 Sep 2021].
15 Armijo-Olivo S, Stiles CR, Hagen NA, *et al*. Assessment of study quality for systematic reviews: a comparison of the Cochrane collaboration risk of bias tool and the effective public health practice project quality assessment tool: methodological research. *J Eval Clin Pract* 2012;18:12–8.
16 Boniface S, Scannell JW, Marlow S. Evidence for the effectiveness of minimum pricing of alcohol: a systematic review and assessment using the Bradford Hill criteria for causality. *BMJ Open* 2017;7:e013497
17 Heidari S, Babor TF, De Castro P, *et al*. Sex and gender equity in research: rationale for the SAGER guidelines and recommended use. *Res Integr Peer Rev* 2016;1:2
18 Stockwell T, Churchill S, Sherk A, *et al*. How many alcohol-attributable deaths and hospital admissions could be prevented by alternative pricing and taxation policies? modelling impacts on alcohol consumption, revenues and related harms in Canada. *Health Promot Chronic Dis Prev Can* 2020;40:153–64.
19 Sherk A, Stockwell T, April N, *et al*. The potential health impact of an alcohol minimum unit price in Québec: an application of the International model of alcohol harms and policies. *J Stud Alcohol Drugs* 2020;81:631–40.
20 Hill-Macmanus D, Stockwell T, Brennan A. *MODEL-BASED APPRAISAL OF ALCOHOL MINIMUM PRICING IN ONTARIO AND BRITISH COLUMBIA*. University of Sheffield, 2012.
21 Statistics Canada. Table 17-10-0009-01 population estimates, quarterly. n.d. Available: https://www150.statcan.gc.ca/t1/tbl1/en/cv.action?pid=17100009012022
22 Population estimates. Municipal and sub-provincial areas population, 2011 to 2021. n.d. Available: https://www2.gov.bc.ca/gov/content/data/statistics/people-population-community/population/population-estimates2022
23 Brennan A, Meng Y, Holmes J, *et al*. Potential benefits of minimum unit pricing for alcohol versus a ban on below cost selling in England 2014: modelling study. *BMJ* 2014;349:g5452
24 Holmes J, Meng Y, Meier PS, *et al*. Effects of minimum unit pricing for alcohol on different income and socioeconomic groups: a modelling study. *Lancet* 2014;383:1655–64.
25 Angus C, Gillespie D, Ally AK, *et al*. *Modelling the impact of minimum unit price and identification and brief advice policies using the sheffield alcohol policy model version 3*. 2015.
26 Meier PS, Holmes J, Brennan A, *et al*. Alcohol policy and gender: a modelling study estimating gender-specific effects of alcohol pricing policies. *Addiction* 2021;116:2372–84.
27 Holmes J, Pryce R, Meier PAB, *et al*. Alcohol and cancer trends: intervention studies university of sheffield and cancer research UK; 2016.
28 Meng Y, Hill-Macmanus D, Brennan APM. Model-based appraisal of alcohol minimum pricing and off-licensed trade discount bans in scotland using the sheffield alcohol policy model (v 2):- second update based on newly available data. 2012.
29 Angus C, Brennan A, Holmes J, *et al*. *Model-based appraisal of the comparative impact of minimum unit pricing and taxation policies in scotland*. University of Sheffield, 2016.
30 Meng Y, Sadler S, Gell L, *et al*. *Model-based appraisal of minimum unit pricing for alcohol in wales an adaptation of the sheffield alcohol policy model version 3*. University of Sheffield, 2014.
31 Angus CJH, Brennan APM. Model-based appraisal of the comparative impact of minimum unit pricing and taxation policies in wales: final report; 2018.
32 Angus C, Meng Y, Ally AK, *et al*. *Model-based appraisal of minimum unit pricing for alcohol in northern ireland an adaptation of the sheffield alcohol policy model version 3*. University of Sheffield, 2014.
33 Angus C, Brennan A, Meng Y. *Model-based appraisal of minimum unit pricing for alcohol in the republic of ireland*. University of Sheffield, 2014.
34 Gibbs N, Angus C, Dixon S, *et al*. Effects of minimum unit pricing for alcohol in South Africa across different drinker groups and wealth Quintiles: a modelling study. *BMJ Open* 2021;11:e052879
35 UNAIDS. UNAIDS south africa: overview. 2020. Available: https://www.unaids.org/en/regionscountries/countries/southafrica
36 Vento S, Dzudzor B, Cainelli F, *et al*. Liver cirrhosis in sub-saharan africa: neglected, yet important. *Lancet Glob Health* 2018;6:e1060–1.
37 Stockwell T, Zhao J, Martin G, *et al*. Minimum alcohol prices and outlet densities in British Columbia, Canada: estimated impacts on alcohol-attributable hospital admissions. *Am J Public Health* 2013;103:2014–20.
38 Zhao J, Stockwell T. The impacts of minimum alcohol pricing on alcohol attributable morbidity in regions of British Colombia, Canada with low, medium and high mean family income. *Addiction* 2017;112:1942–51.
39 Ferguson K, Beeston C, Giles L. *Public attitudes to minimum unit pricing (MUP) for alcohol in scotland*. Edinburgh: Public Health Scotland, 2020.
40 Chaudhary S, Mackey W, Duncan K, *et al*. Changes in alcohol-related liver disease admissions over the time of minimum unit pricing of alcohol: the GRI q4 study. *Gut* 2020;69
41 Secombe PJ, Bailey MJ, Pilcher D. The impact of an alcohol floor price on critical care admissions in central australia. malden, massachusetts: wiley-blackwell. 2020;385.
42 Secombe P, Campbell L, Brown A, *et al*. Hazardous and harmful alcohol use in the Northern Territory, Australia: the impact of alcohol policy on critical care admissions using an extended sampling period. *Addiction* 2021;116:2653–62.
43 Wright C, McAnulty GR, Secombe PJ. The effect of alcohol policy on intensive care unit admission patterns in central Australia: a before-after cross-sectional study. *Anaesth Intensive Care* 2021;49:35–43.
44 Griswold MG, Fullman N, Hawley C. Alcohol use and burden for 195 countries and territories, 1990-2016: a systematic analysis for the global burden of disease study 2016. *Lancet* 2018;392:1015–35.
45 Chikritzhs T, Stockwell T, Pascal R. The impact of the Northern Territory's living with alcohol program, 1992-2002: revisiting the evaluation. *Addiction* 2005;100:1625–36.
46 Kerr WC, Fillmore KM, Marvy P. Beverage-specific alcohol consumption and cirrhosis mortality in a group of English-speaking beer-drinking countries. *Addiction* 2000;95:339–46.
47 Skog OJ. The risk function for liver cirrhosis from lifetime alcohol consumption. *J Stud Alcohol* 1984;45:199–208.
48 Norström T. The impact of per capita consumption on Swedish cirrhosis mortality. *Br J Addict* 1987;82:67–75.
49 Norström T. The use of aggregate data in alcohol epidemiology. *Br J Addict* 1989;84:969–77.
50 Skog OJ. Liver cirrhosis epidemiology: some methodological problems. *Br J Addict* 1980;75:227–43.
51 Gruenewald PJ, Ponicki WR, Holder HD, *et al*. Alcohol prices, beverage quality, and the demand for alcohol: quality substitutions and price elasticities. *Alcohol Clin Exp Res* 2006;30:96–105.
52 Stockwell T, Giesbrecht N, Vallance K, *et al*. Government options to reduce the impact of alcohol on human health: obstacles to effective policy implementation. *Nutrients* 2021;13:2846
53 Kilian C, Manthey J, Moskalewicz J, *et al*. How attitudes toward alcohol policies differ across european countries: evidence from the standardized european alcohol survey (seas). *Int J Environ Res Public Health* 2019;16:22.
54 Moriarty KJ. Alcohol care teams: where are we now? *Frontline Gastroenterol* 2020;11:293–302.
55 Brennan A, Angus C, Pryce R, *et al*. Potential effects of minimum unit pricing at local authority level on alcohol-attributed harms in North West and North East England: a modelling study. *Public Health Res* 2021;9:1–106.