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Impact of minimum unit pricing on shifting purchases from higher to lower strength beers in Scotland: Controlled interrupted time series analyses, 2015–2020

PETER ANDERSON[1,2], DAŠA KOKOLE[2] & EVA JANÉ LLOPIS[2,3,4]

[1]*Population Health Sciences Institute, Newcastle University, Newcastle upon Tyne, UK,* [2]*Department of Health Promotion, CAPHRI Care and Public Health Research Institute, Maastricht University, Maastricht, The Netherlands,* [3]*Institute for Mental Health Policy Research, Centre for Addiction and Mental Health, Toronto, Canada, and* [4]*ESADE Business School, Ramon Llull University, Barcelona, Spain*

Abstract

Introduction. *On 1 May 2018 Scotland introduced a minimum unit price (MUP) of GB50 pence per unit of alcohol (8 g) sold. We analysed household purchase data to assess the impact of MUP in shifting purchases from higher to lower strength beers.* ***Methods.*** *Data from Kantar Worldpanel's household shopping panel, with 75 376 households and 4.76 million alcohol purchases, 2015–2020. We undertook interrupted time series analyses of the impact of introducing MUP in Scotland on changes in the proportion of the volume of purchased beer with an alcohol by volume (ABV) ≤3.5% using purchases in England as control. We analysed the moderating impact of the volume of purchased beer with an ABV ≤3.5% on the size of the associated impact of MUP in reducing purchases of grams of alcohol within beer.* ***Results.*** *MUP was associated with a relative increase in the proportion of the volume of beer purchased with an ABV ≤3.5%, Scotland minus England, of 10.9% (95% CI 10.6–11.1), following a 43.6% (95% CI 40.1–47.1) increase in the volume of beer purchased with an ABV ≤3.5%, and a 9.6% (95% CI 9.4–9.8) decrease in the volume of beer purchased with an ABV >3.5%. MUP was associated with reduced purchases of grams of alcohol within beer by 8% (95% CI 7.8–8.3), increasing to 9.6% (95% CI 9.3–9.9), when accounting for the moderating impact of shifts to lower strength beer.* ***Discussion and Conclusions.*** *MUP seems an effective policy to reduce off-trade purchases of alcohol and encourage shifts to lower strength beers.* [Anderson P, Kokole D, Jané Llopis E. Impact of minimum unit pricing on shifting purchases from higher to lower strength beers in Scotland: Controlled interrupted time series analyses, 2015–2020. *Drug Alcohol Rev* 2021]

Key words: minimum unit price, lower strength beer, Scotland.

Introduction

Alcohol is a risk factor for early death. Forty-year-olds who drink more than 350 g of alcohol a week (about five drinks a day) lose 4–5 years of life, compared with those who drink 100 g of alcohol or less a week (about one and a half drinks a day) [1]. Reducing alcohol consumption reduces the chance of dying prematurely and reduces the likelihood of a wide range of conditions, including cancers, raised blood pressure, strokes, liver disease, mental ill-health and accidents and injuries [2].

There is much that can be done to enable people to drink less alcohol [3]. For example, reducing the affordability of alcohol [4] results in less alcohol bought and drunk. As an additional strategy, there is a growing discourse around the potential public health impact of lower strength alcohol products, including no/low alcohol beers [5,6]. In its consultation document, 'Advancing our health: prevention in the 2020s', the UK Government made a commitment to work with the drinks industry to 'deliver a significant increase in the availability of alcohol-free and low-alcohol products by 2025' [7].

The increased availability of no/low alcohol beers could only advance health if the purchase and consumption of no/low alcohol beers were to replace, and not add to higher strength beers [8]. Using the same data set as the present study, evidence from British household purchase data suggests that no/low alcohol beers act as replacements of, rather than additions to higher strength beers [9]. Based on the same data set,

Peter Anderson MD, Professor, Daša Kokole MSc, PhD Student, Eva Jané Llopis PhD, Associate Professor. Correspondence to: Dr Peter Anderson, Population Health Sciences Institute, Newcastle University, Baddiley-Clark Building, Newcastle upon Tyne NE2 4AX, UK. Tel: +44 191 208 5696; E-mail: peteranderson.mail@gmail.com

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there is also suggestive evidence that price differentials may favour purchase and consumption of lower strength as opposed to higher strength beers [10].

A minimum unit price (MUP) for the sale of alcohol is a policy that has been shown to be associated with reductions in alcohol consumption, and with declines in alcohol-attributable health burden in provinces of Canada [11–14], in Scotland [15–17], Wales [17] and in the Northern Territory of Australia [18].

Scotland introduced an MUP of 50 GB pence per unit (8 g) of alcohol sold (6·25 pence per gram) on 1 May 2018. Previously, we have shown that the introduction of MUP was associated with a 7.6% reduction in purchased grams of alcohol, proportionally greater for beer (15.4%) than for wines (4%) and spirits (6%) [15,17]. In this paper, we focus on beer, which is a target product of MUP in Scotland, and the product that had the largest proportional reduction in purchases associated with MUP. For beer, what we do not know is if the changes are due to just buying less beer overall, to shifts in purchases from higher to lower strength beers or, further, to shifts in purchases from wines and spirits to lower strength beers.

In this paper, using household purchase data for the years 2015–2020 from Scotland, with England as a location control, we investigate two questions: (i) to what extent is the introduction of MUP in Scotland associated with purchase shifts from higher to lower strength beers (by measuring the proportion of the volume of all purchased beer that has an alcohol by volume (ABV) of 3.5% or less, 3.5% being the definition used by the European Commission for a low alcohol product [19]); and (ii) if such shifts exist, to what extent do they, as well as changes in purchases of wines and spirits, moderate the impact of MUP in reducing overall purchases of grams of alcohol within beer.

We hypothesised that MUP would lead to a shift in purchases from higher strength beer (ABV greater than 3.5%) to lower strength beer (ABV of 3.5% or less); and that the reduction of grams of alcohol purchased associated with MUP [15,17] would be moderated by such a shift.

Methods

Study design

We undertook location-controlled, interrupted time series regression analyses of the impact of the introduction of Scottish MUP on Scottish household purchases of alcohol, using purchases made by English households as control. We analysed abrupt level changes in purchases, rather than changes in slopes, in line with the findings of our previous analyses.

Data source

Our data source is Kantar Worldpanel's (KWP) household shopping panel. KWP comprises approximately 30 000 British households at any one time, recruited via stratified sampling, with targets set for region, household size, age of main shopper and occupational group. The same households provide longitudinal data over time. Although there is movement of households, with some households leaving and others joining the panel, in general, the panel remains representative of households in Great Britain as a whole. In the data set we analysed, the average time between the first and last recorded alcohol purchase was just over 19 months per household for the years 2015–2020. Households provide demographic information when joining the panel (age of the main shopper, number of adults in the household, income and occupational group, adjusted to social grade), followed by annual updates. Households record all off-trade purchases from all store types, including Internet shopping, brought back into the home using barcode scanners. To be included in KWP's final datasets, households must meet quality control criteria (meeting thresholds for data recording and purchasing volume or spend [based on household size] every 4 weeks), with some 90–95% of households included.

We obtained raw KWP data on take-home purchasing of alcohol products (including no and low alcohol beers) in Great Britain for the 6 years, 2015–2020. The data included the truncated postcode of each household (up to first four characters, two letters and two numbers). The data we obtained had no missing values, with the exception of household income. Just over one in six households (15.7%) were unwilling to provide household income data, with this proportion roughly constant over the 6 years. We imputed the missing income data using monotonic multiple imputation [20]. Alcohol purchases are recorded daily. For each individual purchase, the data includes the type and volume of the purchase using 19 drink categories, the brand and the ABV. The volume purchased was combined with ABV to calculate grams of alcohol purchased.

We grouped households into: (i) four groups of the age of the main shopper (18–24; 25–44; 45–64; and 65 + years); (ii) four occupation-based social grade groups [AB ('highest'), C1, C2, DE ('lowest')], based on the National Readership Survey [21] (2019); (iii) four similar sized household income groups

(£0–8.75k; >£8.75–15k; >£15–22.5k and >£22.5k per adult per household per year); (iv) four similar sized groups of the number of grams of all alcohol regularly purchased (>0–7; >7–21; >21–70 and >70 g of alcohol purchased per adult per household per week, averaged over the total number of days between first and last recorded day of an alcohol purchase); and (v) five groups of residential deprivation ranging from 1 (most deprived) to 5 (least deprived) based on quintiles of the raw rankings of the multiple indices of residential deprivation aggregated at truncated postcode level separately for each of England [22] and Scotland [23].

We prepared data for each day of the study period (all days from 1 January 2015 to 31 December 2020) for the interrupted time series analyses as follows: first, for any day that a household bought alcohol, we summed: (i) the volume (mL) of all beer purchased; (ii) the volume (mL) of all beer purchased with an ABV of 3.5% or less; (iii) the volume of all wine purchased; (iv) the volume of all spirits purchased; and (v) the amount of alcohol purchased in grams for all beers, with all sums divided by the number of adults in the household; second, for each day, we calculated the means of the volume and grams of purchases across all households; third, for each day, we calculated the proportion (expressed as a percentage) of the volume of all beer purchased that had an ABV of 3.5% or less, hereafter PCLAB; and fourth, the mean ABV of all beer purchased with an ABV greater than 3.5% for each day across all households, using this as a measure of change of purchases of beers with different alcohol strengths above an ABV of 3.5%.

Figure 1, plotting PCLAB, our main dependent variable, by day over the 6 years demonstrates reasonable parallel trends between Scotland and England, confirming the appropriateness of England as a control location (Pearson correlation coefficient, Scotland with England, 0.313, $P < 0.001$). We then generated a new series of dependent variables for each day, representing the differences for each day between Scotland and England. For the analyses, we included one event, the introduction of MUP on 1 May 2018.

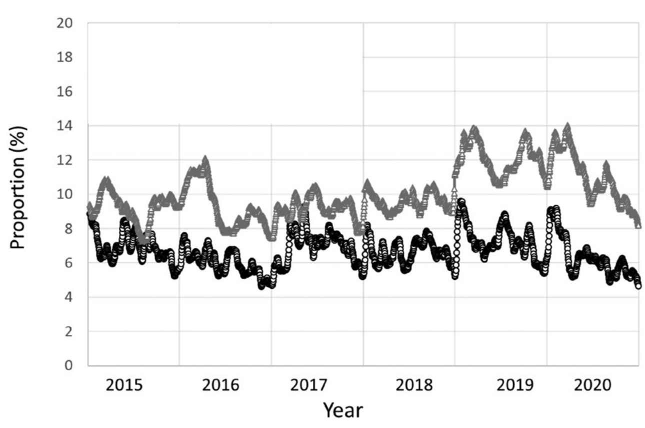

Figure 1. *Proportion of volume of all beer purchased that has an alcohol by volume ≤3.5% for (–○–) England and (–△–) Scotland by year (plots are per day, seasonally adjusted and centred moving averaged over 7 days).*

Statistical analyses

The dependent variables were (Scotland minus England): (i) PCLAB; and (ii) the mean sum of purchases in grams of alcohol within beer per adult per household per day that a household made an alcohol purchase for each day of the study period. For the newly created dependent variables (the difference, Scotland minus England), we examined the distributions visually and with Q-Q plots and found normal distributions (e.g. for PCLAB, the main dependent variable: test for skewness = 0.198; test for kurtosis = −0.424; Kolmogorov–Smirnov test, $P > 0.05$). We used a time series modeller function [24] to estimate best fitting non-seasonal and seasonal auto-regressive integrated moving average models that: (i) specify degrees of differencing and/or a square root or natural log transformation to ensure a stationary series; and (ii) specify autoregressive and moving average orders. For the main dependent variable (PCLAB, differences Scotland minus England), the auto-correlation function and partial auto-correlation function plots of the modelled series demonstrated a stationary series (Augmented Dickey–Fuller test, $P < 0.01$), with no evidence of autocorrelation (Box-Ljung Q statistic, $P > 0.2$), with the following auto-regressive integrated moving average non-seasonal and seasonal model (0,0,0) (1,0,1)7. We repeated the time series modeller function for all dependent variables and for all analyses, confirming in each case a stationary series, with no evidence of autocorrelation. We examined the abrupt level changes due to the event—the introduction of MUP. The event variable was entered as a dummy variable, coded with 0 for each day before the event and with 1 for each day from the event forwards.

The regression equation is:

$$\left(1-\Phi_1 B^7\right) Y_t = \beta_{\text{intercept}} + \left(1-\Theta_1 B^7\right)\alpha_t + \beta_{\text{mup}}\left(1-\Phi_1 B^7\right) X_t,$$

$$\begin{gathered}\text{in words, (seasonal AR(1) term)}\\ \text{(dependent variable at time } t)\\ = \text{Intercept} + \text{(seasonal MA(1) term) (random error)}\\ + \text{(coefficient MUP) (seasonal AR(1) term) (MUP),}\end{gathered}$$

where Y_t is the dependent variable at day t; Φ_1 is seasonal autoregressive operator at lag 1; B^7 is the backshift operator; $\beta_{\text{intercept}}$ is the pre-event intercept, in this case, the average of the differences between Scotland and England in PCLAB for each day across all days prior to the event; Θ is the seasonal moving average operator at lag 1; α_t is the error term; β_{mup} is the impact of MUP, in this case, the change of mean daily PCLAB per household for the time period since MUP took effect versus before MUP; X_t is MUP.

We repeated the models separately for the household groupings of amount of alcohol normally purchased, age, income, social grade and residential deprivation, with the dependent variables converted to percent scales, where 100% is the mean of the dependent variable per day for the average prior to the introduction of MUP, calculated separately for each element of the groups. This allowed us to compare the relative importance of the regression coefficients, and thus changes, across the elements of the household groups.

We investigated the moderating influence of a range of independent variables on MUP's impact in changing purchases of grams of alcohol within beer, the dependent variable. Moderation variables could increase or decrease the influence of MUP's association with changes in purchases of grams of alcohol within beer – in other words, they could change the size of the coefficient. They are examined by adding the moderating variable and the interaction of the moderating variable and MUP as independent variables to the model. We examined four potential moderating variables: (i) PCLAB, our original main dependent variable; (ii) the ABV of beer purchased with an ABV greater than 3.5%, as an operationalisation of the impact of changes in the purchase of beers with an ABV greater than 3.5%; (iii) the volume of wine purchased; and (iv) the volume of spirits purchased. All four potential moderating variables were first mean centred by subtracting the overall mean of the variable across all days, from each daily value.

We analysed two linear regression models separately for each potential moderating variable, the first without the moderating variables, and the second with adding the moderating variable and the interaction term, moderating variable*event, where the event is the introduction of MUP, with the following regression equations:

$$\left(1-\Phi_1B^7\right)Z_t=\beta_{\text{intercept}}+\left(1-\Theta_1B^7\right)\alpha_t+\beta_{\text{mup}}\left(1-\Phi_1B^7\right)X_t$$

$$\left(1-\Phi_1B^7\right)Z_t=\beta_{\text{intercept}}+\left(1-\Theta_1B^7\right)\alpha_t+\beta_{\text{mup}}\left(1-\Phi_1B^7\right)X_t+\beta_p\left(1-\Phi_1B^7\right)P_t+\beta_{p*m}\left(1-\Phi_1B^7\right)P{*}M_t,$$

where for new terms, Z_t is the dependent variable (purchased grams of alcohol within beer, Scotland minus England) at day t; β_p is the impact of the moderating variable; P_t is the moderating variable at day t; β_{p*m} is the impact of the moderating variable*MUP; and, $P{*}M_t$ is the moderating variable*MUP at day t.

For the dependent variable, the level change of purchased grams of alcohol within beer (as % change from baseline of average purchases prior to introduction of MUP) associated with introduction of MUP, we report the coefficients and 95% confidence intervals (CI) and the change in R^2 (and probability value) progressing from the model without each moderating variable to the model with each moderating variable. For each significant moderating variable, we report the coefficient and 95% CI at the values of the moderating variable of −1 standard deviation from the mean, the mean and +1 standard deviation from the mean. For a range of values of PCLAB, the original main dependent variable, we plot the coefficients and 95% CIs.

All analyses were performed with SPSSv26 [25].

Results

Purchase data of 4.76 million separate alcohol purchases were obtained from 68 741 English and 6635 Scottish households. The distributions of households by socio-demographic groups were similar between England and Scotland, Table 1.

Table 2 provides the characteristics, with 95% CIs of the main variables for before and after the introduction of MUP in Scotland, for both England and Scotland. Prior to the introduction of MUP, 9.29% of the volume of all beer purchased in Scotland had an ABV of 3.5% or less (95% CI 8.93–9.63); for the same time period, the proportion in England was 6.58% (95% CI 6.48–6.69), Table 2.

In Scotland, prior to the introduction of MUP, PCLAB was highest for the lowest income households and those households in social grade groups D and E, and tended to be higher amongst the older age groups Figure 2. There was no consistent relation with PCLAB by the amount of grams of alcohol that households regularly purchased, or by deprivation group.

With the introduction of MUP, the interrupted time series analysis found the following associations for changes in the differences, Scotland minus England:

1. The price of beer with an ABV ≤3.5% decreased by 2.73% (95% CI 1.74–3.72);
2. The volume of beer with an ABV ≤3.5% increased by 3.6 mL (95% CI 3.3–3.9), a 43.6% increase (95% CI 42.1–47.1);
3. The price of beer with an ABV >3.5% increased by 8.76% (95% CI 8.68–8.84);

Table 1. *Distribution of households by socio-demographic groups (for definitions, see Methods)*

	England (%)	Scotland (%)
Age group, years		
18–24	1.6	1.3
25–44	40.2	37.3
45–64	40.5	43.8
65+	17.7	17.5
Total	100.0	100.0
Social grade group		
AB	20.9	19.4
C1	39.9	37.7
C2	18.2	17.8
DE	21.0	25.1
Total	100.0	100.0
Income group		
0–8.75k	24.8	25.0
>£8.75–15k	26.8	28.5
>£8.75–15k	23.5	22.0
>£22.5k	24.9	24.6
Total	100.0	100.0
Deprivation group		
1	5.4	5.1
2	25.1	24.7
3	35.4	36.2
4	26.8	26.7
5	7.3	7.3
Total	100.0	100.0

n = 68 741 English households and n = 6635 Scottish households.

4. The volume of beer with an ABV >3.5% decreased by 40.3 mL (95% CI 39.4–41.1 mL), a 9.6% decrease (95% CI 9.4–9.8);
5. PCLAB increased in absolute terms by 1.009% (95% CI 0.983–1.035) and in relative terms by 10.9% (95% CI 10.6–11.1), Figure 3.

After the introduction of MUP, households in the mid-range of the amount of alcohol normally purchased increased their associated PCLAB more than the lowest and highest groups in relative terms, Figure 4. The relative associated increase was very much higher in those aged 65+ years, than in the younger age groups. The relative associated increase in PCLAB was higher in the mid-income and mid-social grade household groups, and in those living in both most and least residential deprived areas. Thus, on the one hand, those households that had the highest values of PCLAB before the introduction of MUP (the poorest households and those in social grade group DE, Figure 1) increased PCLAB associated with MUP the least or not at all; whereas on the other hand, those households with the age of the main shopper 65 years or more that had a relatively high value of PCLAB prior to MUP showed the greatest increase in PCLAB associated with the introduction of MUP.

So far, we have shown that the introduction of MUP was associated with an increase in PCLAB. We

Table 2. *Characteristics (95% confidence intervals) for before and after introduction of Scottish MUP for England and Scotland*

England		Scotland	
Before MUP	After MUP	Before MUP	After MUP
Zero alcohol beer – volume purchased (mL)[a]			
6.17 (5.82–6.53)	11.34 (10.74–11.94)	5.81 (5.45–6.17)	12.89 (12.29–13.48)
Beer with ABV >0 and ≤3.5%—volume purchased (mL)[a]			
23.06 (21.90–24.23)	20.37 (18.92–21.81)	31.85 (30.68–33.02)	32.00 (30.55–33.44)
Beer with ABV >3.5%—volume purchased (mL)[a]			
419.16 (413.80–424.51)	444.69 (438.92–450.47)	383.80 (378.45–389.16)	371.97 (366.19–377.74)
Proportion of volume of all beer purchased with ABV ≤3.5%			
6.58 (6.32–6.85)	6.74 (6.37–7.10)	9.29 (9.02–9.55)	11.06 (10.69–11.42)
Mean ABV of beer of purchased beer with an ABV >3.5%			
4.614 (4.611–4.617)	4.640 (4.637–4.643)	4.630 (4.622–4.638)	4.663 (4.654–4.670)
Price (British pence) per mL of beer with an ABV ≤3.5%			
0.565 (0.558–0.572)	0.686 (0.678–0.695)	0.479 (0.462–0.500)	0.582 (0.565–0.600)
Price (British pence) per mL of beer with an ABV >3.5%			
0.892 (0.888–0.895)	0.926 (0.923–0.930)	0.797 (0.789–0.807)	0.897 (0.887–906)
Volume of wine purchased (mL)[a]			
625.6 (623.3–627.8)	629.2 (626.2–632.3)	678.4 (673.5–683.7)	639.3 (634.3–644.3)
Volume of sprits purchased (mL)[a]			
512.3 (510.3–514.2)	515.8 (513.7–518.0)	523.2 (527.5–535.8)	525.1 (520.6–529.5)
Grams of alcohol purchased within beer[a]			
15.09 (14.90–15.27)	16.05 (15.85–16.25)	13.92 (13.74–14.11)	13.76 (13.55–13.96)

[a]per adult per household per day that a household made an alcohol purchase. ABV, alcohol by volume; MUP, minimum unit price.

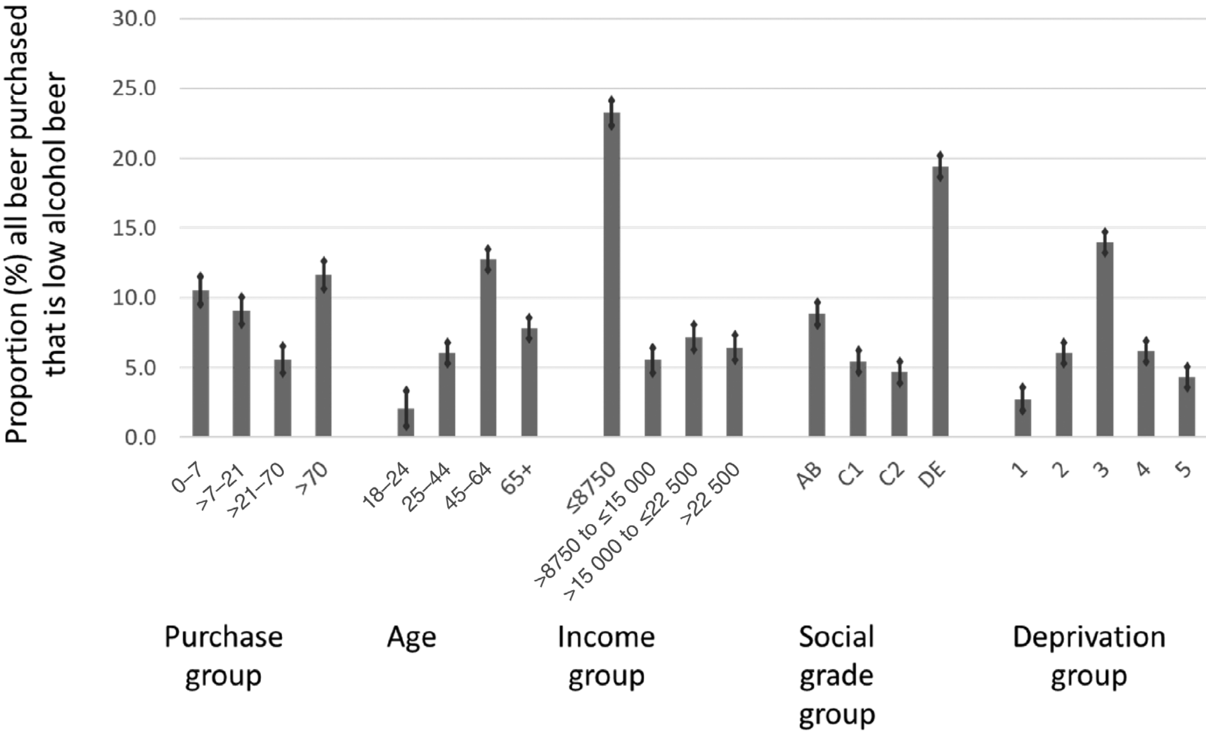

Figure 2. *Proportion of volume of all beer purchased in Scotland that has an alcohol by volume) ≤3.5% prior to introduction of minimum unit price: by purchase group (average amount of alcohol purchased per household per week divided by total time between first and last recorded alcohol purchase), age of main shopper (years), household income (GB£ per adult per household per year), social grade group and deprivation quintile (1 = most deprived; 5 = least deprived). Whiskers: 95% confidence intervals.*

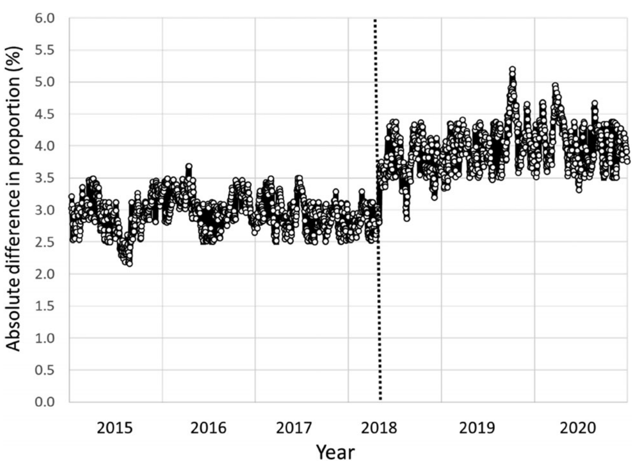

Figure 3. *Differences in household purchases of the proportion of the volume of all beer that has an alcohol by volume of 3.5% or less, absolute difference in proportion (%), Scotland minus England, by year. Vertical black line: introduction of minimum unit price, Scotland (day 1217).*

now address the question as to whether or not this associated change acted as a moderator of the impact of MUP in reducing purchases of grams of alcohol within beer, along with the other three potential moderators we investigated: the ABV of purchased beer with an ABV greater than 3.5%; the volume of wine purchased; and the volume of spirits purchased.

Figure 5 plots for Scotland minus England purchases of grams of alcohol in beer by year, scaled to a percent scale, where 100% is the mean of purchases prior to the introduction of MUP. Interrupted time series analyses indicated that the introduction of MUP was associated with reductions in the purchase of grams of alcohol within beer of 8.01% (95% CI 7.76–8.26).

Table 3 reports the change in R^2 (and P value) going from the model with no moderating variables to the other models with moderating variables, and the coefficients and 95% CIs from the interrupted time series analyses, with level change of purchased grams of alcohol within beer (as % change from baseline of average purchases prior to introduction of MUP) associated with introduction of MUP as the dependent variable. With the addition of moderators:

1. With increasing PCLAB (the proportion of all beer purchased with an ABV ≤3.5%), there was a greater

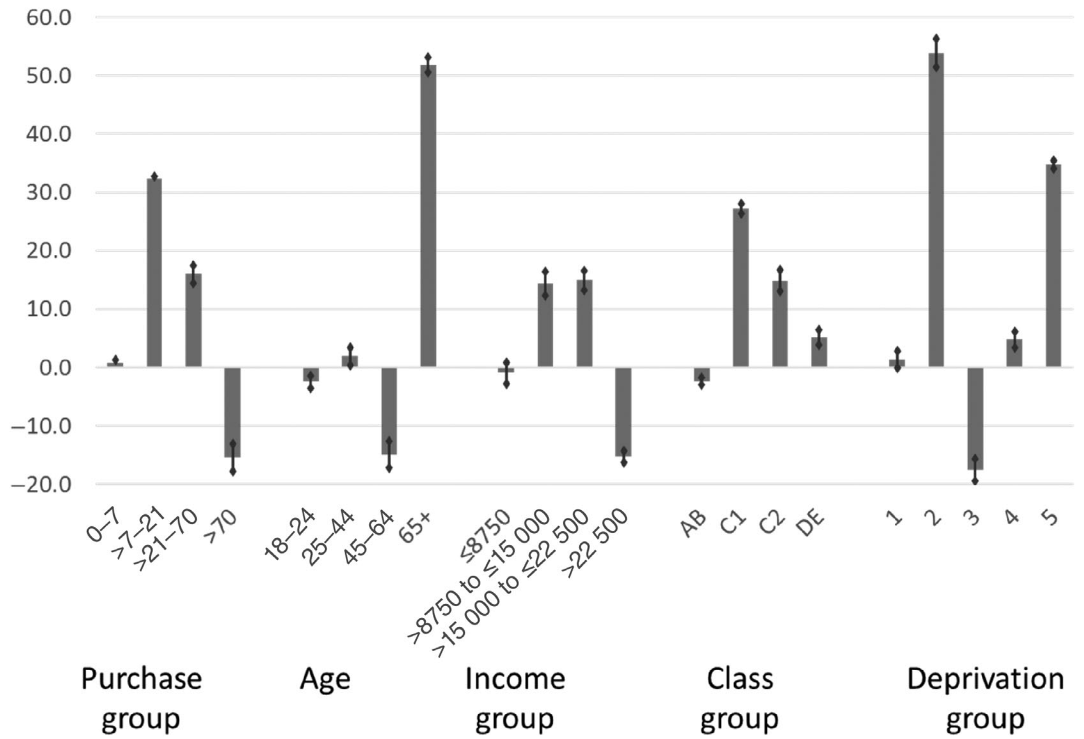

Figure 4. *Proportional changes (%) of PCLAB subsequent to introduction of MUP in Scotland (data, Scotland minus England): by purchase group (average amount of alcohol purchased per household per week divided by total time between first and last recorded alcohol purchase), age of main shopper (years), household income (GB£ per adult per household per year), social grade group and deprivation quintile (1 = most deprived; 5 = least deprived). Whiskers: 95% confidence intervals.*

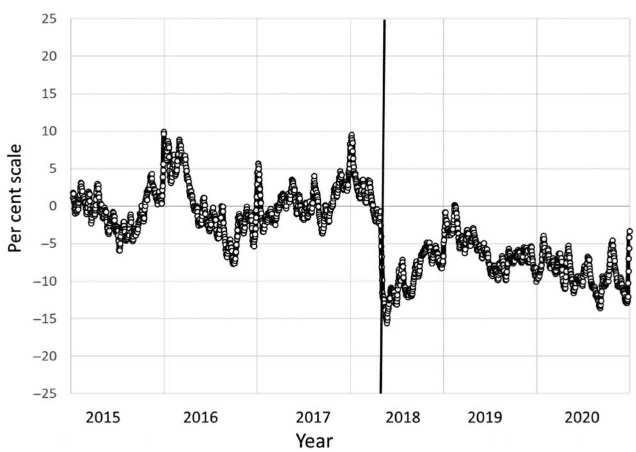

Figure 5. *Purchases of grams of alcohol in beer for Scotland minus England by year, scaled to a percent scale. Vertical black line: introduction of minimum unit price in Scotland.*

reduction in purchased grams of alcohol in beer associated with MUP.

2. With decreasing ABV of beer with an ABV >3.5% (as a measure of buying less higher strength beers above an ABV of 3.5%), there was no moderating impact.
3. With decreasing purchases of wine, there was a smaller reduction in purchased grams of alcohol in beer associated with MUP, this reduction being less small, the greater the reduction in purchased volume of wine.
4. With decreasing purchases of spirits, there was a smaller reduction in purchased grams of alcohol in beer associated with MUP, this reduction being smaller, the greater the reduction in purchased volume of spirits.

Thus, of the four moderator variables tested, the only variable that increased the reduction of grams of alcohol purchased within beer was the proportion of all beer purchased with an ABV ≤3.5% (PCLAB), with the increase larger the greater the value of PCLAB, Figure 6. At the mean value of PCLAB (3.42%), the associated reduction in grams of alcohol purchased within beer was 9.6% (95% CI 9.3–9.9), 1.6% (95% CI 1.0–2.1) greater than the reduction of 8% (95% CI 7.8–8.3) without the moderating impact. In other words, the reduction in grams of alcohol purchased within beer was 20% higher (1.6/8.0) (95% CI 13–

Table 3. *Change in* R^2 *(and* P *value) going from the model with no moderating variables to the other models with moderating variables, and the unstandardised coefficients (95% confidence intervals) from the interrupted time series analyses, with level change of purchased grams of alcohol within beer (as % change from baseline of average purchases prior to introduction of MUP) associated with introduction of MUP as the dependent variable*

		Model 1, with no moderating variables	Model 2, adding PCLAB as moderating variable	Model 3 adding ABV of beers with an ABV >3.5% as moderating variable (*−1, thus ranging from highest to lowest)	Model 4 adding volume of wine purchased as moderating variable (*−1, thus ranging from highest to lowest)	Model 5 adding volume of spirits purchased as moderating variable (*−1, thus ranging from highest to lowest)
Change in R^2 from Model 1 to other models			0.001, $P = 0.0065$	0.0002, $P = 0.2297$	0.0023, $P = 0.0001$	0.0130, $P = 0.0000$
Intercept		0.06 (−0.109 to 0.229)	0.872 (0.690 to 1.054)	−0.047 (−0.214 to 0.121)	−0.170 (−0.378 to 0.036)	−0.979 (−1.162 to −0.795)
Level change of purchased grams of alcohol within beer (as % change from baseline of average purchases prior to introduction of MUP) associated with introduction of MUP	−1 SD of value of moderator		−9.205 (−9.615 to −8.796)	—	−6.462 (−6.915 to −6.010)	−8.041 (−8.479 to −7.603)
	Mean of value of moderator	−8.009 (−8.262 to −7.757)	−9.591 (−9.871 to −9.312)	−7.717 (−7.976 to −7.458)	−7.072 (−7.385 to −6.758)	−6.616 (−6.905 to −6.326)
	+1 SD of value of moderator		−9.975 (−10.352 to −9.598)	—	−7.681 (−8.112 to −7.251)	−5.190 (−5.567 to −4.814)
Moderator			2.689 (2.371 to 3.007)	2.688 (2.059 to 3.316)	−0.115 (−0.175 to −0.054)	−2.452 (−2.687 to −2.216)
Interaction, moderator*level change due to event			−0.637 (−1.095 to −0.178)	0.961 (−0.608 to 2.530)	−0.166 (−0.250 to −0.081)	1.784 (1.424 to 2.144)

ABV, alcohol by volume; MUP, minimum unit price; PCLAB, proportion of all beer purchased with an ABV ≤3.5%.

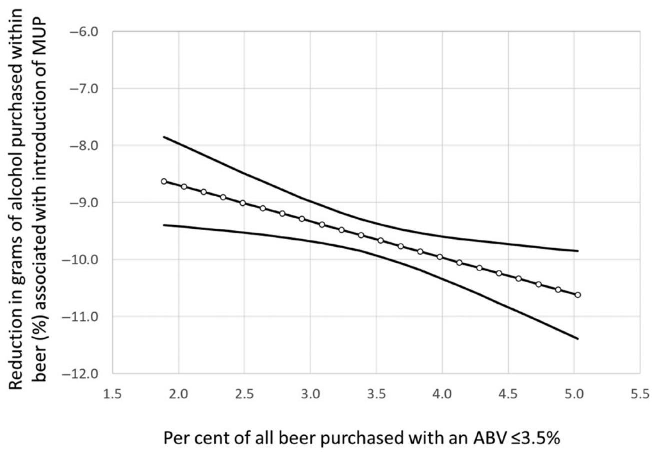

Figure 6. *Percent reduction in grams of alcohol within beer (Scotland minus England) associated with introduction of minimum unit price (MUP), vertical axis, by increasing proportion of all beer purchased with an alcohol by volume (ABV) ≤3.5% (proportion of all beer purchased with an ABV ≤3.5%), horizontal axis. Central line: mean value; higher and lower lines, 95% confidence intervals.*

25) when taking into account the moderating impact of PCLAB.

Discussion

The analyses have demonstrated that the introduction of an MUP for alcohol was associated with shifts in household purchases from higher (volume of beer purchases with ABV >3.5% reduced by 9.6%) to lower (volume of beer purchases with ABV ≤3.5% increased by 43.6%) strength beer products, with the associated proportion of the volume of all beer purchases that had an ABV of 3.5% increasing by 11% in Scotland subsequent to the introduction of MUP. The changes were greater in the mid-range of purchasing households (the regular amount of alcohol normally purchased) and in main shoppers who were aged 65 years or older. Changes were greater in mid household income groups and in mid social grade groups, but lower in households situated in the residential mid-deprivation group.

We confirmed our previous findings, based on the same data set, that the introduction of MUP in Scotland is associated with an 8% reduction in purchases of grams of alcohol within beer [15,17]. What we have now demonstrated is that a shift in purchases from higher (ABV greater than 3.5%) to lower (ABV 3.5% or less) strength beer due to MUP moderates the impact of MUP in reducing purchases of grams of alcohol, the more so, the greater the shift. On average, the impact of the moderation was to increase the associated reduction of purchases of beer due to MUP from 8% to 9.6%, a 20% increase. We found no moderating impact of changes in the mean ABV of purchased beer that had an ABV >3.5%, or of changes in the volume of wines and spirits purchased.

Our findings are in line with other evaluations of the introduction of MUP in Scotland. For example, at the retailer level, studies demonstrate a shift in the range of products stocked and sold towards those with a lower ABV [26], although overall, as far as alcohol producers were concerned, changes in products and strategies were limited because Scotland represents a small share of many producer companies' turnover [27].

We are aware of only one other similar study outside of Scotland, that is, of the impact of raising MUPs in Saskatchewan in Canada, which involved setting not only slightly higher rates per litre of beverage, but adjusting these according to five categories of beer strength [28]. These changes led to a 26% shift in sales of beer from higher to lower strength.

Our analyses have several strengths. We obtained data from many households, with a large number of daily data points before and after the events. Further, although relying on compliance at the household level, purchase data based on product bar codes is objective, with attrition rates in recording over time lower, and with more detailed product descriptions and less under reporting than with data from other regular in-person surveys [29]. We undertook controlled interrupted time series analyses, using England as control for Scotland, subtracting the differences between the respective areas for our analyses. The use of location controls helps to control for any confounding events that would affect both locations, such as impacts due to COVID-19 lockdown [30]. Plots of the dependent variables by Scotland and England over time demonstrated reasonably parallel trends prior to the introduction of MUP, demonstrating the validity of England as a control location.

A key limitation of our study is that, except for the purchases during the period of COVID-19 lockdown (between 21 March and 4 July 2020, when on-licensed premises were closed with, in principle, all legal alcohol purchases captured), we only measure off-trade alcohol purchases and not on-trade purchases. By way of example, for Great Britain, on-trade purchases accounted for approximately 28% of all alcohol purchases (expressed in volume of absolute alcohol) and for approximately 48% of all beer purchases over the years 2015–2019 [31]. In addition, for panel shopping data, alcohol purchases have been among the most under-reported categories [32]. This might reflect the method of recording purchases if not all items purchased are taken home and scanned. While most primary shopping is done by women, secondary top-up shopping, which is more likely done by men, may be less well recorded. It may also be the case that such under-recording of alcohol is higher among households purchasing the highest levels of alcohol. Additionally, we are only able to assess changes in off-trade alcohol purchases as opposed to actual levels of alcohol consumption for these time periods. Adults in a household may not have an equal share of the alcohol purchased. Despite these concerns, by conducting a controlled interrupted time series analysis, quality issues are controlled for, and we have no reason to believe that quality issues differed preferentially between Scotland and England over time.

Conclusion

In conclusion, as noted in this paper, the introduction of MUP in Scotland, a government-initiated policy, has been evaluated to a high scientific standard, using quantitative and qualitative data [e.g. 17,26,27]. This is in contrast to alcohol industry-led initiatives, such as the UK alcohol industry's 'billion units pledge', where its implementation and evaluation were not without problems [33]. Our study has demonstrated that the introduction of MUP in Scotland is associated with a shift in purchases from higher to lower strength beers, and that this shift is a moderating factor in increasing MUP's association with reduced purchases of grams of alcohol in beer.

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Conflict of Interest

All three authors have completed the ICMJE uniform disclosure form at www.icmje.org/coi_disclosure.pdf and declare: PA has received funds within the last 5 years from the AB InBev Foundation outside of the submitted work; DK and EJL have no financial relationships with any organisations that might have an interest in the submitted work; PA, DK and EJL have received no support from any organisation for the submitted work; and, PA, DK and EJL have no other relationships or activities that could appear to have influenced the submitted work.

Data Availability Statement

No additional data available. Kantar Worldpanel data cannot be shared due to licensing restrictions.

References

[1] Wood AM, Kaptoge S, Butterworth AS *et al.* Risk thresholds for alcohol consumption: combined analysis of individual-participant data for 599 912 current drinkers in 83 prospective studies. Lancet 2018;391: 1513–23.

[2] World Health Organization. Global Status Report on Alcohol and Health 2018, 2020. Available at: https://apps.who.int/iris/bitstream/handle/10665/274603/9789241565639-eng.pdf?ua=1&ua=1

[3] World Health Organization. SAFER, Alcohol Control Initiative, 2020. Available at: https://www.who.int/substance_abuse/safer/en/

[4] Burton R, Henn C, Lavoie D *et al.* A rapid evidence review of the effectiveness and cost-effectiveness of alcohol control policies: an English perspective. Lancet 2017;389:1558–80.

[5] Salanță LC, Coldea TE, Ignat MV *et al.* Non-alcoholic and craft beer production and challenges. Processes 2020;8:1382.

[6] Capitello R, Todirica IC. 2 – Understanding the behavior of beer consumers. In: Capitello R, Maehle N, eds. Case studies in the beer sector. Duxford: Woodhead Publishing, 2021:15–36. https://doi.org/10.1016/B978-0-12-817734-1.00002-1.

[7] UK Government. Advancing our health: prevention in the 2020s – Consultation Document, 2019. Available at: https://www.gov.uk/government/consultations/advancing-our-health-prevention-in-the-2020s/advancing-our-health-prevention-in-the-2020s-consultation-document

[8] Rehm J, Lachenmeier DW, Jané-Llopis E, Imtiaz S, Anderson P. Evidence of reducing ethanol content in beverages to reduce the harmful use of alcohol. Lancet Gastroenterol Hepatol 2016;1:78–83.

[9] Anderson P, Jané Llopis E, O'Donnell A *et al.* Impact of low and no alcohol beers on purchases of alcohol: interrupted time series analysis of British household shopping data, 2015–2018. BMJ Open 2020;10: e036371.

[10] Jané Llopis E, O'Donnell A, Anderson P. Impact of price promotion, price, and minimum unit price on household purchases of low and no alcohol beers and ciders: descriptive analyses and interrupted time series analysis of purchase data from 70, 303 British households, 2015–2018 and first half of 2020. Soc Sci Med 2021;270:113690.

[11] 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.

[12] Stockwell T, Zhao J, Marzell M *et al.* Relationships between minimum alcohol pricing and crime during the partial privatization of a Canadian government alcohol monopoly. J Stud Alcohol Drugs 2015; 76:628–34.

[13] 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.

[14] Sherk A, Stockwell T, Callaghan RC. The effect on emergency department visits of raised alcohol minimum prices in Saskatchewan, Canada. Drug Alcohol Rev 2018;37:S357–65.

[15] O'Donnell A, Anderson P, Jane-Llopis E, Manthey J, Kaner E, Rehm J. Immediate impact of minimum unit pricing on alcohol purchases in Scotland: controlled interrupted time series analysis for 2015-18. BMJ 2019;366:l5274.

[16] Xhurxhi IP. The early impact of Scotland's minimum unit pricing policy on alcohol prices and sales. Health Econ 2020;29:1637–56.

[17] Anderson P, O'Donnell A, Kaner E, Llopis EJ, Manthey J, Rehm J. Impact of minimum unit pricing on alcohol purchases in Scotland and Wales: controlled interrupted time series analyses. Lancet Public Health 2021;6:E557–65.

[18] Taylor N, Miller P, Coomber K *et al*. The impact of a minimum unit price on wholesale alcohol supply trends in the Northern Territory, Australia. Aust N Z Public Health 2021;45:26–33.

[19] European Commission. Service contract for the provision of 2019 – support to Member States in studies and capacity building activities to reduce alcohol related harm. European Commission, Consumers, Health, Agriculture and Food Executive Agency, Ref Ares(2019) 7816625 – 19/12/2019.

[20] Jakobsen JC, Gluud C, Wetterslev J, Winkel P. When and how should multiple imputation be used for handling missing data in randomised clinical trials – a practical guide with flowcharts. BMC Med Res Methodol 2017;17:162.

[21] National Readership Survey. Social Grade London: National Readership Survey, 2019. Available at: http://www.nrs.co.uk/nrs-print/lifestyle-and-classification-data/social-grade/

[22] GOV.UK. National Statistics: English indices of deprivation 2019, 2019. Available at: https://www.gov.uk/government/statistics/english-indices-of-deprivation-2019 (accessed 22 March 2021).

[23] Gov.scot. Scottish Index of Multiple Deprivation (SIMD) 2020 technical notes, 2020. Available at: https://www.gov.scot/publications/simd-2020-technical-notes/ (accessed 21 March 2021).

[24] IBM Corp. IBM_SPSS_Forecasting, 2019. Available at: http://public.dhe.ibm.com/software/analytics/spss/documentation/statistics/26.0/en/client/Manuals/IBM_SPSS_Forecasting.pdf

[25] IBM Corp. IBM SPSS statistics for windows, version 26.0. Armonk, NY: IBM Corp, 2019.

[26] Stead M, Critchlow N, Eadie D, *et al*. Evaluating the impact of alcohol minimum unit pricing in Scotland: observational study of small retailers, 2020. Available at: https://www.stir.ac.uk/media/stirling/services/faculties/sport-and-health-sciences/research/documents/MUP-evaluation-Small-Convenience-Stores-report.pdf

[27] Frontier Economics. Minimum unit alcohol pricing. Evaluating the impacts on the alcoholic drinks industry in Scotland: baseline evidence and initial impacts, 2019. Available at: https://www.frontier-economics.com/media/3481/minimum-unit-alcohol-pricing-2019.pdf

[28] Stockwell T, Zhao J, Giesbrecht N, Macdonald S, Thomas G, Wettlaufer A. The raising of minimum alcohol prices in Saskatchewan, Canada: impacts on consumption and implications for public health. Am J Public Health 2012;2012:e103–10.

[29] Leicester A, Oldfield Z. Using scanner technology to collect expenditure data. Fiscal Stud 2009;30:309–37.

[30] Anderson P, Jané Llopis E, O'Donnell A, Kaner E. Impact of COVID-19 confinement on alcohol purchases in Great Britain: controlled interrupted time-series analysis during the first half of 2020 compared with 2015-2018. Alcohol Alcohol 2021;56:307–16.

[31] Giles L, Richardson E. Monitoring and evaluating Scotland's alcohol strategy: monitoring report 2020. Edinburgh: Public Health Scotland, 2020. Available at: http://www.healthscotland.scot/media/3330/mesas-monitoring-report-2020-english-updated-march-2021.pdf.

[32] Leicester A. How might in-home scanner technology be used in budget surveys? IFS Working Paper W12/01, 2012.

[33] Holmes J, Angus C, Meier PS. UK alcohol industry's 'billion units pledge': interim evaluation flawed. BMJ 2015;350:h1301.