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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

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ABSTRACT

Background: The introduction of lower strength alcohol products results in less absolute alcohol purchased. This paper estimates the potential impact of price in shifting British household purchases from higher to lower strength beers and ciders.

Methods: Descriptive statistics and controlled interrupted time series analyses using Kantar Worldpanel's British household purchase data from 70,303 households during 2015–2018 and the first half of 2020.

Findings: No and low-alcohol products were less likely to be on price promotion than higher strength products. No and low-alcohol beers were cheaper per volume than higher strength beers; the reverse was the case for ciders. With the exception of low strength ciders (which had very few purchases) a higher volume was purchased when the product was on price promotion than when not. Again, with the exception of low strength ciders, the cheaper the cost, the greater the volume of purchase, more so when the product was on price promotion. The introduction of minimum unit price in Scotland (when controlling for changes in Northern England) and in Wales (when controlling for changes in Western England) shifted purchases from higher to lower strength products, more so for ciders than beers. In relative terms, the alcohol by volume of beer dropped by 2% and of cider by 7%. Changes did not differ by household income or the age of the main shopper.

Interpretation: There are opportunities for governments and alcohol producers and retailers to facilitate shifts of purchases from higher to lower alcohol strength products. Alcohol producers and retailers can ensure that the price of lower strength products is competitive vis a vis higher strength products. Governments can introduce minimum unit prices for the sale of alcohol, as has been done in Scotland and Wales.

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1. Background

Alcohol use is a leading risk factor for ill-health and premature death (GBD 2016 Alcohol Collaborators, 2018; Wood et al., 2018). The World Health Organization (WHO) has set a global target to reduce the harmful use of alcohol by 10% between 2010 and 2025 (World Health Organization, 2013). The WHO SAFER (World Health Organization, 2020) initiative calls on governments at all levels to: (1) Strengthen restrictions on alcohol availability; (2) Advance and enforce drink driving counter measures; (3) Facilitate access to screening, brief interventions and treatment; (4) Enforce bans or comprehensive restrictions on alcohol advertising, sponsorship, and promotion; and (5) Raise prices on alcohol through excise taxes and pricing policies. WHO's global alcohol strategy called on the alcohol industry to contribute to reducing the harmful use of alcohol by addressing its products (World Health Organization, 2010) by, for example, reducing the amount of alcohol they contain (Rehm et al., 2016).

Previously, we have shown that the introduction of new lower

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strength beers, and the reformulation of beer products to contain less alcohol in them result in British households purchasing less alcohol (Anderson et al., 2020a, 2020b). During 2015 to 2018, the introduction of 46 new lower strength beers and the reformulation of 33 beer products to contain less alcohol, were associated with relative reductions in purchases of grams of alcohol across all beer products of between 7.1% and 10.2%, and purchases of grams of alcohol within all alcohol products of between 2.6% and 3.9% (Anderson et al., 2020a). The data demonstrated that a little over a half of the changes were due to two beer products, indicating the public health potential of switching from higher to lower strength beer products, were their availability more widespread.

There is a wealth of evidence that demonstrates, common to many beverage and food products (Watt et al., 2020), that increasing the price of alcohol (Burton et al., 2017), including setting a minimum unit price (MUP) (O'Donnell et al., 2019), and restricting price promotions and discounts (Robinson et al., 2014) results in less purchase and consumption of alcohol. Minimum unit price (MUP) is a pricing policy that sets a strength-based threshold price for alcohol products, below which they cannot be legally sold. Previously, we have shown that the introduction of MUP in Scotland on May 1, 2018, with a minimum of 50 British pence per 8 g of alcohol (one British alcohol unit), was associated with a 7.9% increase in the price per gram of alcohol and a 7.6% decrease in the number of all grams of alcohol purchased, including price increases for and reductions in purchases of beers and ciders. The converse of pricing policy is that it could purposely be used to promote a switching of purchase and consumption from higher to lower strength beer and cider products, thus leading to overall reductions in purchased grams of alcohol.

In this paper, we use household purchase data from Great Britain (GB, England, Scotland and Wales) to consider the extent to which price could be purposefully used to promote the switching from purchases of higher to alcohol-free and lower strength beers and ciders. We focus on beers due to the growth in no- and low-alcohol beer products (Anderson et al., 2020a). We include ciders on the basis of previous evidence showing that heavy drinkers at most risk of harm, such as those living in deprivation, are more likely to choose cheap, high-strength white ciders on the basis of easy access and relative affordability (McGill et al., 2016; Gill et al., 2015). Finally, the introduction of a minimum unit price in Scotland and in Wales (on March 2, 2020, also at 50 GB pence per 8 g of alcohol), allows us to compare the impact of differential pricing mechanisms on consumer purchases of beers and ciders with neighbouring regions of England, where MUP has not been introduced.

We investigate whether or not there are differences between three distinct groups (alcohol-free, lower strength, and higher strength) of both beer and cider products in: (i) the proportion of products on price promotion, and the price paid in GB pounds per litre purchased; (ii) the relationship between price paid, price promotion and volume purchased; and, (iii) the impact of the introduction of MUP in Scotland on May 1, 2018 and in Wales on March 2, 2020. We also examine whether and how the findings differ by household income and age of main household shopper.

2. Methods

We use descriptive statistics, general linear models and controlled interrupted time series analyses with ARIMA (Autoregressive Integrated Moving Average) models.

2.1. Data source

Our data source is Kantar Worldpanel's (KWP) household shopping panel. KWP is a quota sample, comprising 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 social class groupings, AB, C1, C2, D, and E, based on the National Readership Survey classification (National Readership Survey, 2019). Households record daily all purchases brought back into the home using barcode scanners. We obtained raw KWP data of all take-home purchases of all alcohol products, including no- and low-alcohol products, for the four years, 2015–2018 (Anderson et al., 2020a, 2020b; O'Donnell et al., 2019) and for the first half of 2020 (until 12th July) (Anderson et al., 2020c). KWP data classifies all brands into drink categories, including beers and ciders. Barcodes report the brand, the alcohol by volume (ABV), including alcohol-free beers and ciders, the volume of the purchase, and the price paid. For beer and cider products, we calculated the price paid (in British pounds) per litre purchased. We combined volume purchased with ABV to calculate grams of alcohol purchased.

We grouped households into: (i) five age groups based on the age of the main shopper: 18–34; 35–44; 45–54; 55–64; and 65+ years; and, (ii) five income groups per adult per household per year of: £0-7.5 k, >7.5–12.5 k; >12.5–17.5 k, >17.5 to 25 k, and >25 k. Based on UK Office for National Statistics classifications for truncated postcode data look-ups, we grouped households into Scotland and Northern England (the regions of North West, North East and Yorkshire and the Humber) for analysing the impact of Scottish MUP; and, into Wales and Western England (the regions of North West, West Midlands, and South West) for analysing the impact of Welsh MUP.

Due to licensing restrictions, the Kantar Worldpanel data cannot be shared. Ethical approval was not required as the paper is a statistical analysis of anonymized data purchasable and publicly available from Kantar Worldpanel.

2.2. Measures

The following variables comprised our outcome measures: (i) proportion of all separate beer and cider purchases that were on any form of price promotion; (ii) price paid in GB pounds per litre per individual purchase of beer and cider; (iii) volume of beer and ciders bought per separate purchase; and, (iv), the ABV of purchased beers and ciders. We classified beers and ciders into three distinct groups of products: (a) all products with an ABV = 0.0% (hereafter, alcohol-free); (b) all products with an ABV >0.0% and ≤3.5% (a standard definition of low alcohol beers and ciders, hereafter lower strength); and, (c) all products with an ABV >3.5% (hereafter, higher strength).

We prepared the daily data on volume of alcohol purchases for the controlled interrupted time series analyses by, first, for each household, summing up records of purchases of volume of beers and ciders per purchase day, divided by the number of adults in the household (on any one purchase day, households could buy more than one type of beer or cider product); and, then second, for each day of the analysis during 2015–2018, and the first half of 2020 (until 12th July), we calculated the mean of the sum of the volume of purchases per adult per household per day that a household made a beer or cider purchase across all households (households, on average, made at least one alcohol purchase every 15.5 days, median, 6.9 days).

2.3. Statistical analysis

We plotted changes over the years 2015–2018 and first half of 2020 in the volume of purchased beer and cider for each of the three product groups (alcohol-free, lower strength, and higher strength).

Using a generalized linear model, we estimated means and odds ratios for each of the beer and cider groups for the proportion of purchased products that were on price promotion, and the price paid in GB pounds per litre of product purchased, with time (day of study period) as a covariate. In addition, we ran models for each of the beer and cider groups, with the dependent variable, the volume of the product purchased converted to standardized values, by, as independent variables, whether or not the purchase was on price promotion, the price paid per litre converted to standardized values, the interaction standardized price paid per litre and whether or not the purchase was on price promotion,

and time (day of study period) as covariate. We used standardized variables to account for the large differences in volumes purchased between alcohol-free, lower strength and higher strength products, with the coefficients being unitless, referring to how many standard deviations the volume purchased changes per standard deviation change in price.

2.4. Controlled interrupted time series analysis

We adhered to published guidance for undertaking interrupted time series (Bhaskaran et al., 2013; Beard et al., 2019) and controlled interrupted time series (Bernal et al., 2018) analyses in the health field. Based on our previous methodology (O'Donnell et al., 2019), we generated a new series of dependent variables representing the differences between Scotland and Northern England, and between Wales and Western England. We selected the two control areas due to their geographic proximity and relative cultural similarity to Scotland and Wales, respectively.

Our days of study analysing the impact of MUP in Scotland are the 1461 days of 2015–2018, as we have done previously (O'Donnell et al., 2019), and the 194 days of 2020 (until 12th July). As we did not have data for 2019, we also checked for any differences in the impact of MUP between the time period 2018 (after introduction of MUP on 1st May) and 2020. For Wales, we used the 194 days of 2020, ensuring a more reasonable balance, as recommended (Simonton, 1977), in number of days before and after the introduction of MUP. This means that we have fewer data points for Wales, resulting in more variability in the results.

The dependent variables were (Scotland minus Northern England, and Wales minus Western England) in:

i. The mean of the proportion of purchases per study day on price promotion;
ii. The mean price paid per purchase per study day (GB pounds per litre);
iii. The mean volume of purchases (ml) per adult per household (per day that a household made an alcohol purchase) per day of the study period; and,
iv. The mean alcohol by volume (ABV%) per purchase per study day.

To account for any trend differences over time, the mean age of the main shopper, the proportion of households in occupational class groups C2 to E, and household income were added as covariates to the models. To account for potential substitution effects of purchases (e.g., ciders for beers, and beers for ciders), we re-ran the models for the mean volume of purchases adding the respective purchases of cider for the beer analyses, and beer for the cider analyses as covariates, reporting changes in the size of coefficients due to MUP. To account for possible cross effects between the three groups of products based on strength (alcohol-free, lower strength and higher strength), we re-ran the models, including the proportion on price promotion and the price paid of the other strength products as covariates, reporting changes in the size of the impact due to MUP.

For each dependent variable, we examined the distribution visually and with Q-Q plots and found all variables to be normally distributed. As recommended (Jebb et al., 2015), we used a time series modeler function (IBM Corp. Released, 2019) to estimate best fitting non-seasonal and seasonal ARIMA models that: a) specify degrees of differencing and/or a square root or natural log transformation to ensure a stationary series; and, b) specify autoregressive and moving average orders. This eliminated the need to identify an appropriate ARIMA model through trial and error (Makridakis et al., 1983; McLaughlin, 1984). Examination of plots of the residuals, residual autocorrelations, and residual partial autocorrelations for the modelled series demonstrated stationary series, with no evidence of autocorrelation.

We examined abrupt and persistent level changes due to the event, the introduction of MUP in Scotland and Wales, respectively, as such changes were the findings of our previous analyses (O'Donnell et al., 2019). 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 expert modeler identified the ARIMA terms (0,0,0) $(1,0,1)_7$ as the best fitting model for volumes consumed, with the regression model equation:

$$\left(1-\Phi_1 B^7\right)(y_t) = \beta_{intercept} + \left(1-\Theta_1 B^7\right)\alpha_t + \beta_{mup}\left(1-\Phi_1 B^7\right)X_t + \beta_a\left(1 - \Phi_1 B^7\right)A_t + \beta_c\left(1-\Phi_1 B^7\right)C_t + \beta_i\left(1-\Phi_1 B^7\right)I_{t,}$$

that is:

(seasonal AR (1) term) (dependent variable) = Intercept + (seasonal MA(1) term)(random error) + (coefficient MUP)(seasonal AR(1) term) (MUP) + (coefficient age)(seasonal AR(1) term) (age) + (coefficient class)(seasonal AR(1) term)(class) + (coefficient income)(seasonal AR (1) term) (income), where:

- Y_t is the dependent variable at day *t;*
- B^7 is the backshift operator for one seasonal cycle (7 days);
- Φ_1 is the seasonal AR (1) term;
- $\beta_{intercept}$ is the pre-event intercept, in this case, the average of the differences between geographical areas prior to introduction of MUP;
- Θ_1 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 the mean of the dependent variables for the time period since MUP took effect versus before MUP;
- X_t is MUP;
- β_a is the coefficient of age and A_t is age;
- β_c is the coefficient of class and C_t is class; and,
- β_i is the coefficient of income and I_t is income.

For the adjustment of potential substitution effects, we added $\beta_{cider}(1-\Phi_1 B^7)cider_t$ for cider purchases to the model analysing beer, and $\beta_{beer}(1-\Phi_1 B^7)beer_t$ for beer purchases to the model analysing cider. For the assessment of cross-impacts between the different strength products, we added similar components to the equations.

We repeated the ARIMA models for each of the five household age groups and each of the five household income groups. With the obtained coefficients of changes in the mean ABV of beers and ciders, we examined the extent to which there was a relationship between the impact of MUP (coefficient, β_{mup}) and each of the five age groups and five income groups.

All analyses were performed with SPSSv26 (IBM Corp, 2019). (IBM Corp. Released, 2019).

3. Results

Over the four-years, 2015–2018, and the first half of 2020, throughout Great Britain, there were 1,014,122 separate purchases of beer and 384,866 separate purchases of cider spread over 70,303 households. For the full data set for all products, the mean purchases of grams of alcohol was 84.0 g per adult per household (per day of purchase) per study day, of which 18.2% was in the form of beer, 6.8% in the form of cider, 37.3% in the form of wine, 30.8% in the form of spirts, and 6.9% in the form of other products (fortified wines and ready-to-drinks).

Fig. 1 plots for beer and cider, with different scaled vertical axes, purchases in millilitres per adult per household per day for alcohol-free products (ABV = 0.0%), lower strength products (ABV > 0 and ≤ 3.5%), and higher strength products (ABV >3.5%) for all of Great Britain over 2015–2018 and the first half of 2020. Higher strength products showed pronounced seasonal variation with sharp peaks at the end of each year, and broader peaks during the summer months; purchases increased

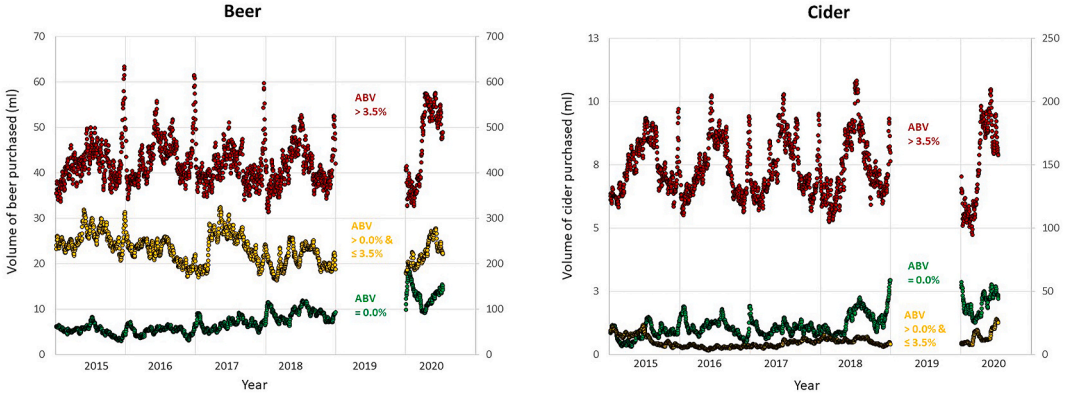

Fig. 1. (Great Britain) Volume (ml) of beer and cider purchased per adult per household (for each day that a household made a purchase of beer or cider respectively) per day by beverage strength. **Left axis**: alcohol-free and lower strength beers and ciders. **Right axis**: higher strength beers and ciders. Data points: daily for 2015–2018 and 2020 until 12th July.

following COVID-19 confinement during the second quarter of 2020, consistent with previous analyses, which also showed a shift from lower strength products to higher strength products (Anderson et al., 2020c). Purchases of alcohol-free products increased over time and purchases of lower strength products showed mixed responses over time. For the full data set, the mean purchased volume of beer, per adult per household (for each day that a household made a purchase of beer or cider respectively) per day, was 264 ml, of which 247 ml was higher strength beer, 13 ml lower strength beer and 4 ml alcohol-free beer. For ciders, of the 86 ml mean purchased, 85 ml was higher strength ciders, 0.3 ml lower strength ciders and 0.7 ml alcohol-free cider.

3.1. Proportion of products on price promotion, and price per millilitre

Table 1 provides data on the proportion of all separate purchases that were on any type of price promotion and the price paid per litre purchased (in British pounds) for the three categories of each of beer and cider products. Alcohol-free and lower strength products were less likely to be on price promotion than higher strength products. The odds ratio for alcohol-free beers being on price promotion compared with higher strength beers was 0.927 (95% CI = 0.920 to 0.933), whilst for lower strength beers, it was 0.851 (95% CI = 0.847 to 0.855). The respective odds ratios for ciders were 0.924 (95% CI = 0.913 to 0.934), and 0.941 (95% CI = 0.926 to 0.957). Although less likely to be on price promotion, the price per litre of alcohol-free and lower strength beers was much less than for higher strength beers; the converse was true for ciders, for which higher strength products were cheaper than alcohol-free and lower strength products.

Table 1
Proportion of all separate purchases that were on price promotion and the mean price (in British pounds) paid per litre purchased for beers and ciders by ABV group.

	Alcohol-free products (ABV = 0.0%)	Lower strength products (ABV >0% and ≤3.5%)	Higher strength Products (ABV > 3.5%)
Proportion on price promotion (95% confidence interval)			
Beer	0.296 (0.289–0.3030)	0.211 (0.206–0.215)	0.372 (0.371–0.373)
Cider	0.274 (0.263–0.286)	0.293 (0.277–0.310)	0.354 (0.352–0.355)
Mean price paid in Great Britain pounds per litre per purchase (95% confidence interval)			
Beer	2.82 (2.77–2.87)	2.60 (2.57–2.63)	4.04 (4.03–4.05)
Cider	4.41 (4.32–4.49)	4.58 (4.46–4.70)	4.00 (3.99–4.01)

3.2. Volume purchased by price promotion and price

Table 2 provides the standardized coefficients of average volume purchased of all separate purchases by: when on price promotion compared to when not on promotion; for every less purchase price of one GB pound per litre; and, interaction of every less purchase price of one GB pound per litre with when on price promotion compared to when not on promotion.

With the exception of low alcohol ciders (which had very few purchases), the volume purchased was greater when the product was on price promotion than when not; however, the increase in volume purchased was much greater for the higher strength products than for the alcohol-free products. The volume purchased was higher the lower the price per litre for all products, was similar for all categories of beer products, but the increase in purchase was much lower for alcohol-free and low alcohol cider products, as opposed to higher strength cider products. The interaction terms indicated that, for alcohol-free beers, lower prices were related to very similar purchase volumes, whether or not the product was on price promotion; whereas, for higher strength beer and ciders, lower prices were associated with greater volume purchases when the product was on price promotion than when not.

3.3. Impact of minimum unit price in Scotland and Wales

Table 3 (Scotland) and Table 4 (Wales) list the unstandardized coefficients (i.e., absolute changes) for the intercepts and level changes for the proportion of purchases on price promotion, the mean price per litre purchased (GB pounds) and the volume purchases of beer and cider for the three categories of products, alcohol-free products, lower strength products and higher strength products. With the introduction of minimum unit price, there were the following associations (for Scotland minus Northern England, and for Wales, minus Western England):

Proportion of purchases on price promotion: In Scotland, Table 3, a drop in the proportion of purchases of higher strength beers that were on price promotion, with a small drop for lower strength beers, and a small increase for alcohol-free beers; for ciders, there was a drop in both higher strength ciders and alcohol-free ciders, and no change in lower strength ciders. In Wales, Table 4, there were drops for all three groups of beers, larger for higher strength beers than for alcohol-free beers; for ciders, there was a drop for higher strength ciders, but no change for lower strength and alcohol-free ciders.

Price paid per purchase: In Scotland, Table 3, there was an increase in price for all categories of products, except for alcohol-free ciders, for which there was a drop. For alcohol-free beers, the increase in price closed the pre-MUP gap between Scotland and Northern England, with the price still less (GB pounds 3.15/litre, 95% CI = 2.99 to 3.31) than for higher strength beers (GB pounds 4.26/litre, 95%CI = 4.20 to 4.32). In

Table 2
Standardized coefficients (95% confidence intervals) of average volume purchased of all separate purchases by: whether or not on price promotion; every decrease in price of 1 GB pound per litre; and, interaction of every decrease in price of 1 GB pound per litre by whether or not on price promotion. All independent variables included in same model (separately for beer and cider), with time (study day) included as covariate.

	Alcohol-free products (ABV = 0.0%)	Lower strength products (ABV >0% and ≤3.5%)	Higher strength Products (ABV > 3.5%)
Beer			
Coefficient of volume purchased for when on promotion compared to when not on promotion	0.043 (0.011–0.074)	0.335 (0.315–0.356)	0.317 (0.313–0.321)
Coefficient of increase in volume purchased for every decrease in price of 1 GB pound per litre	0.301 (0.285–0.316)	0.223 (0.213–0.232)	0.300 (0.297–0.302)
Coefficient of increase in volume purchased for every decrease in price of 1 GB pound per litre volume by interaction with when on promotion compared to when not on promotion	0.061 (0.027–0.096)	0.149 (0.127–0.172)	0.135 (0.132–0.139)
Cider			
Coefficient of volume purchased for when on promotion compared to when not on promotion	0.087 (0.075–0.100)	−0.095 (−0.114 to −0.075)	0.250 (0.243–0.256)
Coefficient of increase in volume purchased for every decrease in price of 1 GB pound per litre	0.050 (0.044–0.057)	0.056 (0.046–0.066)	0.263 (0.259–0.267)
Coefficient of increase in volume purchased for every decrease in price of 1 GB pound per litre volume by interaction with when on promotion compared to when not on promotion	0.046 (0.059–0.032)	−0.023 (−0.042 to −0.004)	0.169 (0.163–0.175)

Wales, Table 4, there was no change in the price of all products, except for higher strength ciders, for which there was an increase.

Volume purchased: Figs. 2 and 3 plot the purchases of beers and ciders respectively for Scotland (Scotland minus Northern England) and Wales (Wales minus Western England) before and after the introduction of minimum unit price, with the coefficients presented in Tables 3 and 4. Converting the changes associated with MUP into percentage changes from pre-MUP levels, for beers, in Scotland, there was an 11.9% relative drop in the volume of purchased higher strength beers (95% CI = 11.0 to 12.8), a relative 4% drop in the volume of purchased lower strength beers (95% CI = 1.7 to 6.2), and a relative 54.7% increase in the volume of purchased alcohol-free beers (95% CI = 52.8 to 56.8). Changes in all three categories of beers were larger in 2020 than in 2018 post MUP. In Wales, there was no change in higher strength and lower strength beers, but a relative 80.0% increase in the volume of purchased alcohol-free beers (95% CI = 62.4 to 97.7). For ciders, in Scotland, the equivalent changes were a 35.3% drop in higher strength ciders (95% CI = 34.1 to 36.5), a 24% increase in lower strength ciders (95% CI = 17.5 to 31.0, from a very low level of 0.2 ml) and a 43.0% increase in alcohol-free ciders (95% CI = 38.5 to 47.7). In 2020, the decrease in higher strength ciders was less than in 2018 post MUP. in Wales, there was a 37.6% drop in purchases of higher strength ciders (95% CI = 35.3 to 40.0), no change in lower strength ciders, and an 111.0% increase in purchases of alcohol-free ciders (95% CI = 103.0 to 119.0). Adjusting for cross-purchasing (ciders for beers, and beers for ciders) led to no significant changes in the size of the coefficients.

Table 3
Unstandardized coefficients (B) (95% CI) for level changes before and after introduction of minimum unit price in Scotland (dependent variables, Scotland minus Northern England). Intercept: the pre-event intercept, in this case, the average of the differences between geographical areas prior to introduction of MUP; Level change: the impact of MUP, in this case, the change of the mean of the dependent variables for the time period since MUP took effect versus before MUP.

		Alcohol-free products (ABV = 0.0%)	Lower strength products (ABV >0% and ≤3.5%)	Higher strength Products (ABV > 3.5%)
Beer				
Proportion on promotion	Intercept	−0.029 (−0.033 to −0.024)	−0.075 (−0.076 to −0.073)	−0.057 (−0.059 to −0.055)
	Level change	0.030 (0.024–0.036)	−0.065 (−0.068 to −0.063)	−0.114 (−0.117 to −0.111)
Price (pounds per litre)	Intercept	−0.857 (−0.894 to −0.820)	−0.168 (−0.203 to −0.134)	0.008 (−0.003 to 0.019)
	Level change	0.814 (0.761–0.867)	0.112 (0.062–0.161)	0.336 (0.320–0.352)
Purchases (ml)	Intercept	0.558 (0.477–0.639)	4.482 (3.975–4.988)	−92.236 (−94.662 to −89.811)
	Level change	3.187 (3.071–3.302)	−1.268 (−1.988 to −0.548)	−45.511 (−48.963 to −42.059)
Purchases (ml), adjusted for cider purchases	Intercept	0.553 (0.467–0.639)	4.764 (4.040–5.488)	−96.167 (−99.404 to −92.930)
	Level change	3.177 (3.050–3.304)	−1.335 (−2.065 to −0.605)	−54.523 (−60.530 to −48.516)
Difference in purchases following MUP, 2020 compared with 2018 post-MUP		0.630 (0.442–0.818)	1.374 (0.191–2.557)	−6.037 (−11.716 to −0.359)
Cider				
Proportion on promotion	Intercept	−0.065 (−0.072 to −0.057)	−0.002 (−0.013 to 0.009)	−0.077 (−0.079 to −0.075)
	Level change	−0.043 (−0.054 to −0.032)	−0.006 (−0.022 to 0.010)	−0.033 (−0.036 to −0.030)
Price (pounds per litre)	Intercept	1.934 (1.870–1.998)	0.149 (0.145–0.153)	0.229 (0.212–0.245)
	Level change	−1.493 (−1.584 to −1.402)	0.248 (0.242–0.254)	0.863 (0.839–0.886)
Purchases (ml)	Intercept	0.277 (0.238–0.316)	−0.202 (−0.211 to −0.192)	−18.742 (−19.765 to −17.718)
	Level change	0.512 (0.458–0.567)	0.048 (0.035–0.062)	−42.923 (−44.380 to −41.467)
Purchases (ml), adjusted for beer purchases	Intercept	0.274 (0.234–0.315)	−0.203 (−0.214 to −0.193)	−22.168 (−24.299 to −20.037)
	Level change	0.500 (0.408–0.591)	0.048 (0.035–0.062)	−44.614 (−46.334 to −42.894)
Difference in purchases following MUP, 2020 compared with 2018 post-MUP		−0.114 (−0.204 to −0.024)	0.062 (0.040–0.084)	10.251 (7.905–12.597)

Table 4
Unstandardized coefficients (B) (95% CI) for level changes before and after introduction of minimum unit price in Wales (dependent variables, Wales minus Western England). Intercept: the pre-event intercept, in this case, the average of the differences between geographical areas prior to introduction of MUP; Level change: the impact of MUP, in this case, the change of the mean of the dependent variables for the time period since MUP took effect versus before MUP.

		Alcohol-free products (ABV = 0.0%)	Lower strength products (ABV >0% and ≤3.5%)	Higher strength Products (ABV > 3.5%)
Beer				
Proportion on promotion	Intercept	−0.045 (−0.052 to −0.039)	0.008 (−0.015 to 0.030)	0.035 (0.035–0.035)
	Level change	−0.027 (−0.034 to −0.020)	−0.208 (−0.232 to −0.183)	−0.143 (−0.143 to −0.143)
Price (pounds per litre)	Intercept	−0.930 (−10.019 to −0.840)	−0.351 (−0.378 to −0.324)	0.284 (0.284–0.284)
	Level change	0.008 (−0.082 to 0.098)	−0.023 (−0.053 to 0.007)	0.000 (0.000–0.000)
Purchases (ml)	Intercept	−6.843 (−8.324 to −5.363)	2.417 (−1.991 to 6.826)	−30.643 (−30.643 to −30.643)
	Level change	7.237 (5.644–8.830)	3.845 (−.764 to 8.454)	0.000 (0.000–0.000)
Purchases (ml), adjusted for cider purchases	Intercept	−8.446 (−12.549 to −4.343)	2.999 (−1.633 to 7.632)	−30.643 (−30.643 to −30.643)
	Level change	8.522 (5.066–11.978)	3.794 (−0.808 to 8.397)	0.000 (0.000 –0.000)
Cider				
Proportion on promotion	Intercept	0.140 (0.066–0.214)	−0.069 (−0.100 to −0.038)	0.000 (0.000–0.000)
	Level change	−0.024 (−0.101 to 0.052)	0.000 (0.000-0.000)	−0.094 (−0.094 to −0.094)
Price (pounds per litre)	Intercept	0.362 (−0.035 to 0.759)	0.383 (0.221–0.544)	−0.014 (−0.070 to 0.042)
	Level change	−0.138 (−0.533 to 0.258)	0.000 (0.000-0.000)	0.880 (0.819–0.941)
Purchases (ml)	Intercept	−0.932 (−0.982 to −0.882)	0.450 (0.216–0.684)	50.358 (46.839–53.877)
	Level change	0.747 (0.693–0.801)	0.022 (−0.224 to 0.267)	−60.629 (−64.413 to −56.845)
Purchases (ml), adjusted for beer purchases	Intercept	−0.952 (−10.013 to −0.891)	0.533 (0.301–0.766)	50.358 (46.839–53.877)
	Level change	0.767 (0.701–0.832)	−0.034 (−0.278 to 0.210)	−60.629 (−64.413 to −56.845)

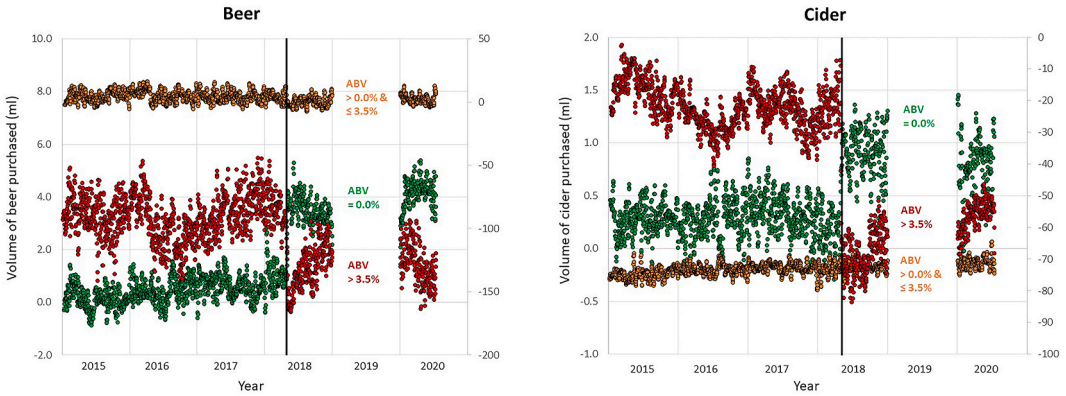

Fig. 2. (Scotland) Mean purchases of beer and cider (Scotland minus Northern England) by beverage strength**. NB, different scaled axes: for beer**: left vertical axis, alcohol-free beers; right vertical axis, lower and higher strength beers. **For cider**: left vertical axis, alcohol-free and lower strength ciders; right vertical axis, higher strength ciders. Vertical black line: introduction of minimum unit price (MUP) in Scotland. Purchases are mean sum of purchases per adult per household (per day that a household made an alcohol purchase) per day of the study period. Data points: daily for 2015–2018 and 2020 until 12th July.

Considering cross-impacts of price promotion and price between product groups and the impact of MUP, we only found cross-impacts of the proportion of higher strength products on the purchases of alcohol-free products, and not vice versa, and no cross-impacts related to lower strength products. The direction of impact is probably largely due to the higher volume of purchased higher strength products. There were no findings of cross-impacts in Wales, likely due to the lower number of data points in Wales, and lack of change in proportion of products on price promotion subsequent to MUP. In Scotland, for every one percent increase in the proportion of higher strength beers on price promotion, the purchase of alcohol-free beer subsequent to MUP dropped by 0.051 ml (9% CI = 0.032 to 0.069), with the adjusted coefficient for the impact of MUP being 2.61 (95% CI = 2.37 to 2.85); for cider, for every one percent increase in the proportion of higher strength ciders on price promotion, the purchase of alcohol-free cider subsequent to MUP dropped by 0.015 ml (9% CI = 0.006 to 0.025), with the adjusted coefficient for the impact of MUP being 0.46 (95% CI = 0.40 to 0.52).

Capturing overall shifts across all beers and ciders, Fig. 4 plots changes in the mean ABV of beers and ciders for Scotland (minus Northern England) and Wales (minus Western England). In both jurisdictions the introduction of MUP was associated with drops in the mean ABV, more so for ciders (in relative terms, for both jurisdictions, a 7% drop) than for beers (in relative terms, for both jurisdictions, a 2% drop), Table 5.

3.4. *Differences by socio-demographic characteristics of the households*

Using the changes of ABV as an overall assessment of shifts to lower

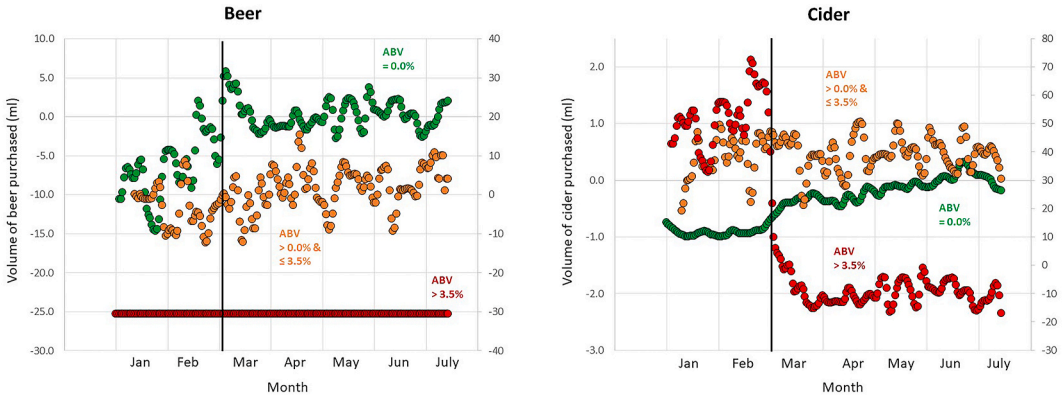

Fig. 3. (Wales) Mean purchases of beer and cider (Wales minus Western England Wales) by beverage strength**. NB, different scaled axes: for beer**: left vertical axis, alcohol-free beers; right vertical axis, lower and higher strength beers. **For cider**: left vertical axis, alcohol-free and lower strength ciders; right vertical axis, higher strength ciders. Vertical black line: introduction of minimum unit price (MUP) in Wales. Purchases are mean sum of purchases per adult per household (per day that a household made an alcohol purchase) per day of the study period. Data points: daily for 2020 until 12th July.

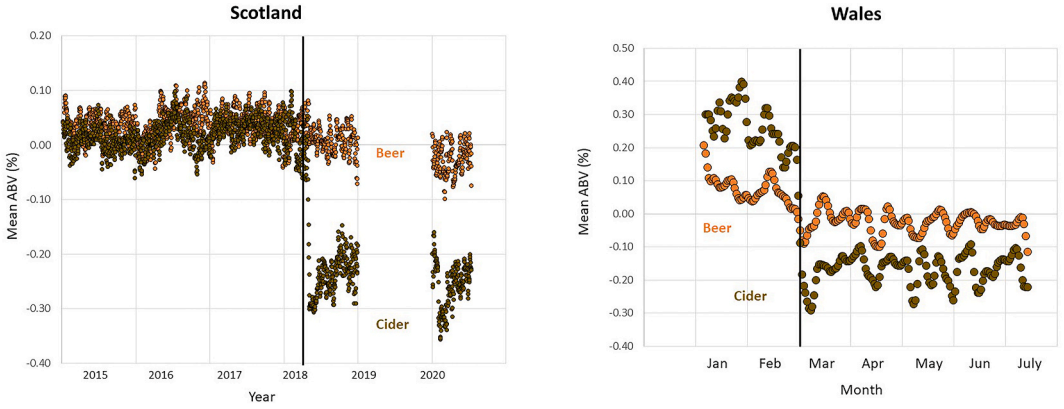

Fig. 4. Mean ABV (%) of purchases of beer and cider (Scotland minus Northern England, and Wales minus Western England). Vertical black line: introduction of minimum unit price (MUP) in Scotland and Wales respectively. Data points: for Scotland, daily for 2015–2018 and 2020 until 12th July; for Wales, daily for 2020 until 12th July.

Table 5
Unstandardized coefficients (B) (95% CI) for level changes for alcohol by volume (ABV%) before and after introduction of minimum unit price in Scotland (minus Northern England) and Wales (minus Western England).

	Beer	Cider
Scotland		
Pre-MUP level	4.396	4.841
Intercept	0.049 (0.047–0.052)	0.012 (0.006–0.018)
Level change	−0.053 (−0.057 to −0.049)	−0.261 (−0.270 to −0.253)
Wales		
Pre-MUP level	4.348	5.238
Intercept	0.061 (0.039–0.082)	0.235 (0.198–0.271)
Level change	−0.095 (−0.118 to −0.072)	−0.418 (−0.457 to −0.379)

strength beers and ciders, there were no associations between the coefficient for the impact of introducing MUP and either household income or age of the main shopper. Moving from lower to higher income groups, there was a non-significant drop in the coefficient of change in ABV due to MUP for beer of −0.018 (95% CI = −0.078 to 0.043) and in ABV for cider of −0.036 (95% CI = −0.245 to 0.173) for each increase in income group. The equivalent changes in coefficients for the impact of introducing MUP for each increase in age group was −0.024 (95% CI = −0.071 to 0.023) for beer and 0.061 (95% CI = −0.100 to 0.223) for cider.

4. Discussion

Using British household purchase data, we set out to consider the potential impact of price, price promotion and pricing policy on purchases of different strength beers and ciders, with the aim of considering if pricing policy could encourage shifts in purchases from higher to lower strength products. We analysed the impact of two new pricing policies, the introduction of minimum unit price in Scotland and Wales, not as an analysis of the overall impact of MUP, as this has been done elsewhere (O'Donnell et al., 2019; Robinson et al., 2020), but rather as a focus on the impact of MUP in shifting purchases from higher to alcohol-free and lower strength beers and ciders.

It is important to note at the outset that purchases of alcohol-free and lower strength beers and ciders represent small proportions of all purchases - 6.4% of all beer volume purchased and 1.2% of all cider volume purchased. Nevertheless, we found differential changes and impacts between the different strength beers and ciders that can give pointers to improved actions and policy options to reduce the harmful use of alcohol.

We found that whilst alcohol-free and lower strength beers and ciders were less likely to be on price promotion than higher strength beers and ciders, alcohol-free and lower strength beers were cheaper per volume than higher strength beers; the converse, though, was true for ciders, for which higher strength products were cheaper than alcohol-free and lower strength products. With the exception of lower strength ciders (which had very few purchases), a greater volume was purchased

when the product was on price promotion than when it was not, more so for higher strength products than for alcohol-free products. Also, the cheaper the product, the greater the volume was purchased, more so for all beers and higher strength ciders. Price impacted similarly on alcohol-free beers whether or not they were on price promotion; whereas price had a greater impact on higher strength products when they were on price promotion than when they were not. The introduction of MUP in both Scotland and Wales was associated with a switching from purchases of higher to lower strength beers and ciders, even accounting for the increase in price for alcohol-free beers that was introduced at the same time as MUP. Controlling for potential switching between beers and ciders did not diminish the size of the findings. The greater the proportion of higher strength products on price promotion, the less the impact of MUP in increasing purchases of alcohol-free beers and ciders. Associations were independent of household income and age of the main shopper.

Our data are consistent with the heath economic literature on fiscal measures to alter purchasing choices, which find impact in reducing unhealthy choices, but less impact in promoting healthier choices (Ludbrook, 2019; Bennett et al., 2020). The impact of price promotions on food stuffs in general indicate that price promotions increase the volume of food and drink purchased during a single shopping trip (Hawkes, 2009), with the impact of price promotions on unhealthy foods and drinks generally being greater than on healthy food and drinks (Watt et al., 2020). The impact of price promotions on healthy items (Hartmann-Boyce et al., 2018; Adam and Jensen, 2016) tend to be more effective when combined with restrictions on promotions of unhealthy food and drinks (Glanz et al., 2012). In our analyses, we found that higher strength (and thus higher risk) products were more likely to be on price promotion than alcohol-free and lower strength (and thus lower risk) products. Further, a greater volume was purchased with a lower price when a higher strength product was on price promotion than when not; this was not the case for alcohol-free products, where lower price was associated with greater volume purchases similarly by whether or not the product was on price promotion.

Our results are also consistent with the health economics literature of the impact of alcohol price and alcohol promotion on consumption. For example, modelling studies in England have indicated that price increases, bans on price promotions and implementation of minimum unit prices would all decrease overall consumption, with price changes having greater impact than bans on promotions (Purshouse et al., 2010). The introduction of MUP in Scotland has been associated with overall reductions in purchases (O'Donnell et al., 2019) and sales (Robinson et al., 2020) of alcohol, also for beers and ciders. The present study extends these findings by specifically studying the impact of MUP in promoting shifts form higher to lower strength beers and ciders, including data from the first half of 2020, and examining the impact of the introduction of MUP in Wales at the beginning of March 2020. The introduction of minimum unit price in both Scotland and Wales was associated with switches in purchases from higher to alcohol-free and lower strength products, greater for ciders than for beers. The size of the impact of MUP in promoting purchases of alcohol-free products was diminished the greater the proportion of higher strength products on price promotion.

Our findings are similar to the impact of newly introduced minimum unit prices 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 (Stockwell et al., 2012). These changes led to a 26% shift in sales of beer from higher to lower strength. We are not aware of any other observational studies of the impact of new minimum prices on the sales of different strength beers.

Our study has several strengths. First, it uses a large commercial data set with over one million separate purchases of beer and a little under 400,000 separate purchases of cider from more than 70,000 British households, with objective purchase data obtained from scanned product bar codes. Second, although we are examining associations and cannot be certain of causal effects, the use of interrupted time series analysis represents a strong, appropriate method for the evaluation of natural experiments such as the introduction of MUP in Scotland and Wales, and there were very similar findings in both jurisdictions, noting that we were only able to study an immediate impact of MUP in Wales. Third, with the controlled interrupted time series analyses, by comparing purchase data with that from Northern England (for Scotland) and Western England (for Wales), we were able to control for the impact of any external factors that affected Great Britain as a whole, including, during 2020, impacts due to COVID-19 lockdown (Anderson et al., 2020c). Fourth, since all purchases brought back into the home are scanned, all purchases made across borders (from Scotland to Northern England, and from Wales to Western England) should be included.

Our study, though, has several limitations. First, panel data may not capture all beer and cider purchases. Whilst most primary shopping is done by women, secondary top-up shopping, which is more likely to be done by men, may also be less well recorded (Leicester, 2012). Second, panel data only captures off-trade purchases (from shops, supermarkets and Internet shopping), and not on-trade purchases (from pubs, cafés, restaurants, sports clubs etc.), with panel data being purchase and not actual consumption data, although there is evidence that increased sales of foods and drink due to price promotions follow-through to increased consumption (Watt et al., 2020). Over the four-year period, 2015–2018 for Great Britain, off-trade purchases accounted for 50.1% of all beer purchases, increasing to 52.9% in 2018; similar proportions for cider were 66.2% in 2015 to 66.8% in 2018 (Giles and Robinson, 2019). Ideally, we would want similar analyses for all beer and cider purchases, both off and on trade. Nevertheless, at least during the second quarter of 2020, household purchases of alcohol would have captured almost all purchases of alcohol, since on-license premises were closed due to COVID-19 mitigation measures (Anderson et al., 2020c).

Our results have several policy implications. Price promotions are disproportionally less used for alcohol-free and lower strength products than for higher strength products; yet, for all products, lower prices are associated with greater volume purchases. Alcohol-free and lower strength ciders were disproportionally higher priced than higher strength ciders. In both jurisdictions (Scotland and Wales), the introduction of minimum unit price led to shifts in purchases from higher to lower strength and alcohol-free products, the proportional changes being greater for ciders than for beers. The increases in purchases of alcohol-free products were diminished the greater the proportion of higher strength products on price promotion. Of course, manipulating the price of different strength beers and ciders is only one component of pricing policy and does not replace existing alcohol policy advice: i.e., raise prices on all alcohol products through excise taxes and pricing policies (World Health Organization, 2020).

5. Conclusion

Pricing policies can be used by alcohol producers and retailers and governments to facilitate shifts of purchases from higher to lower alcohol strength products, such shifts having in turn been shown to reduce overall purchases of grams of alcohol (Anderson et al., 2020a). Alcohol producers and retailers can ensure that price promotions and the price per volume of lower strength products are competitive vis a vis higher strength products. Governments should introduce minimum unit prices for the sale of alcohol, as has recently been done in Scotland and Wales, to ensure a regulatory level playing field that promotes shifts to lower strength products and diminishes the relative proportions of higher strength products on price promotion.

Authors' contributions

All authors helped to conceptualise the paper. PA undertook the analyses. All authors refined the various versions of the paper and

approved the final manuscript. The corresponding author attests that all listed authors meet authorship criteria and that no others meeting the criteria have been omitted. EJ-L is the guarantor.

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No funding was received in support of this study. KWP provided the raw data but had no role in the study design, data analysis, data interpretation, or writing of the manuscript.

Conflicts of interest

E.J.L., A.O.'D. declare no competing interests and declare no financial relationships with any organizations that might have an interest in the submitted work in the previous three years. Within the previous three years, P.A. has received financial support from AB InBev Foundation outside the submitted work. All authors have completed the ICMJE uniform disclosure form at www.icmje.org/coi_disclosure.pdf and declare no support from any organization for the submitted work; all authors declare no other relationships or activities that could appear to have influenced the submitted work.

Transparency declaration

EJ-L affirms that this manuscript is an honest, accurate, and transparent account of the study being reported; and, that no important aspects of the study have been omitted.

Data sharing

Kantar Worldpanel data cannot be shared due to licensing restrictions.

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