




BMJ Open Impact of low and no alcohol beers on purchases of alcohol: interrupted time series analysis of British household shopping data, 2015–2018

Peter Anderson ^{1,2}, Eva Jané Llopis,³ Amy O'Donnell ², Jakob Manthey ⁴, Jürgen Rehm⁵

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¹CAPHRI Care and Public Health Research Institute, Maastricht University, Maastricht, The Netherlands

²Population Health Sciences Institute, Newcastle University, Newcastle upon Tyne, UK

³ESADE Business School, Ramon Llull University, Barcelona, Spain

⁴Technische Universität Dresden, Dresden, Germany

⁵Campbell Family Mental Health Research Institute, Centre for Addiction and Mental Health, Toronto, Ontario, Canada

Correspondence to

Dr Jakob Manthey;
jakob.manthey@tu-dresden.de

ABSTRACT

Objective To assess the impact of new low and no alcohol beers and reformulated beers in Great Britain on household purchases of grams of alcohol.

Design Interrupted time series analysis.

Setting Purchase data from Kantar Worldpanel's household shopping panel for 2015–2018.

Participants 64 286 British households.

Interventions Introduction of new no and low alcohol beers during 2017–2018 and reformulation of existing beers to contain less alcohol during 2018.

Main outcome measures Average alcoholic strength of beer and number of grams of alcohol purchased by households.

Results As assessed by British household purchase data, 46 new low and no alcohol beer products were introduced during 2015–2018, with a step-jump in volume purchased occurring at the beginning of March 2017 (event 1). During 2015–2018, 33 beer products were reformulated to contain less alcohol, with a step-jump in volume purchased occurring during mid-March 2018 (event 2). Interrupted time series analyses found a combined associated impact of both events with relative reductions of alcohol by volume of beer between 1.2% and 2.3%; purchases of grams of alcohol within beer between 7.1% and 10.2%; and purchases of grams of alcohol as a whole between 2.6% and 3.9%. The reductions were greater for reformulation than for the introduction of new low and no alcohol products. Reductions were independently higher for younger age groups of shoppers and for households that bought the most alcohol.

Conclusions Even though the events were associated with significant beneficial changes, the volume of purchases of new low and no alcohol beer products (2.6% of the volume of all beers purchased during 2018) and of new reformulated beer products (6.9% of the volume of all beers purchased during 2018) was very small. This indicates that there are future opportunities to increase the volume of such products so as to reduce the harm done by alcohol.

INTRODUCTION

Alcohol use is a leading risk factor for ill health and premature death.^{1–3} There is a global target to reduce the harmful use of

Strengths and limitations of this study

- The study uses a large commercial data set of more than 3.3 million separate alcohol purchases from more than 64 000 British households.
- The study uses objective purchase data obtained from scanned product barcodes.
- The study uses aggregated weekly data over 208 weeks.
- The study only captures off-trade purchases of alcohol and not on-trade purchases.
- The study analyses purchase data rather than consumption data.

alcohol by 10% between 2010 and 2025, with a main indicator of adult alcohol per-capita consumption.⁴ Recent analyses, however, indicate that, overall, the target will not be achieved.⁵

Thus, there is a need to step up action by core stakeholders, including governments and the private sector. For the private sector, the alcohol industry has a responsibility to reduce the harm done by its products. One way that this can be achieved is through actions to reduce the amount of alcohol its products contain.^{6 7}

There are two main mechanisms through which reductions in the amount of alcohol in any product could reduce the harm done by alcohol. First is by current drinkers replacing standard alcoholic beverages with similar beverages of lower alcoholic strength, for example, consuming beer with 4% alcohol content instead of beer with 5% alcohol content, without increasing the volume of alcoholic beverages consumed. In this mechanism, drinkers, while not diminishing the experience of consuming alcohol, end up drinking less grams of ethanol, reducing their risks of the short-term and long-term harm done by alcohol. Second is by current

drinkers switching to low and no alcohol alternatives for part of the time, thereby reducing the average amount of ethanol consumed.⁸ From a public health point of view, it is important that the reduction of alcohol concentration of alcoholic products is evaluated to demonstrate whether or not drinkers consume less grams of alcohol and thus incur less harm.

The model of changing the alcohol concentration of alcoholic products is similar to the model of salt reduction initiatives in which three approaches are identified⁹: introduction of new products with less salt; product reformulation of existing products to contain less salt; and switching from one product with higher salt concentration to another product with lower salt concentration. British household purchase data indicate that almost all salt reductions have been achieved through product reformulation, rather than the introduction of new products with less salt.¹⁰

In this paper, we report on natural experiments in which we analyse British household panel shopping data for the years 2015–2018, covering 30 000 households at any one time. We focus on new low and no alcohol beer products and on reformulation of existing beer products to contain less alcohol in them. Following Rehm *et al.*⁸ we ask two main questions within the British alcohol market:

- To what extent have there been purchases of new low and no alcohol beer products and reformulation of existing products to contain less alcohol, and have the

purchases of such products differed by the sociodemographic characteristics of the households?

- To what extent have the purchases of new low and no alcohol beer products and reformulation of existing products to contain less alcohol been associated with changes in the purchases of grams of alcohol, and do such changes differ by the sociodemographic characteristics of the households?

METHODS

Study design

Plots of the volume of purchases of new no and low alcohol content beers and purchases of reformulated beers that contain less alcohol by British households in 2015–2018 indicated two large step-jumps: for new no and low alcohol content beers occurring at the beginning of March 2017 (event 1) and for reformulated beers occurring during mid-March 2018 (event 2) (see figure 1). We undertook interrupted time series analyses of the associated impacts of these two events on changes in the alcohol by volume (ABV%) of purchased beer, on changes in grams of alcohol purchased within beer, and on changes in grams of alcohol purchased as a whole. We based our time series analyses^{11 12} on the recommendations of Beard *et al.*¹³ for addiction research. We used Autoregressive Integrated Moving Average (ARIMA) models, which treat dependent and independent variables as time series.

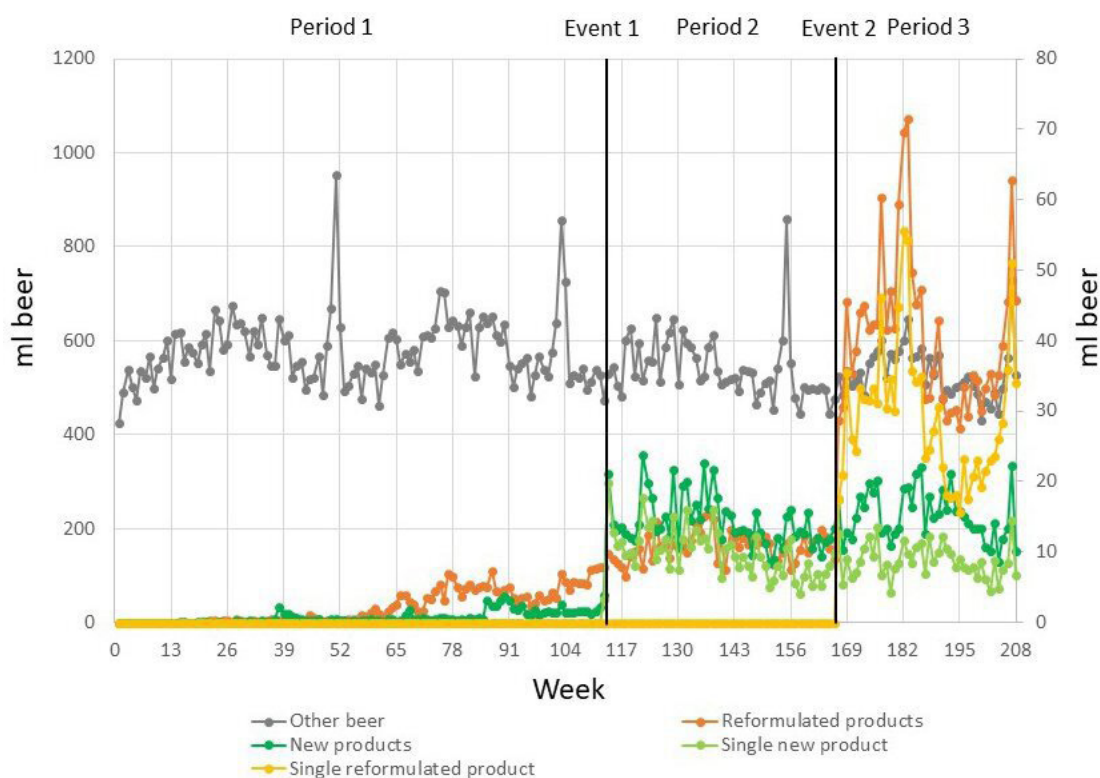


Figure 1 Volume (mL) of beer purchased per adult per household per week across all households from week 1 (first week of 2015) to week 208 (last week of 2018) for new no and low alcohol beer (green, mL right secondary axis; light green, single new product), reformulated beer since time of reformulation (orange, mL right secondary axis; light orange, single reformulated product) and all other beers (grey, left primary axis). Vertical lines, events, dividing periods.

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 the main shopper and occupational group (see O'Donnell et al).¹⁴ Households record all purchases (from all store types) brought back into the home using barcode scanners. To be included in KWP's final data sets, households must meet quality control criteria (meeting thresholds for data recording and purchasing volume/spend (based on household size) every 4 weeks). Panellists also upload digital images of checkout receipts, which KWP uses to verify the accuracy of scanner data.

Households report the age of the main shopper, the number of adults in the household, income, social class and life stage of the household (eg, with young family, retired and so on). Based on UK Office for National Statistics classifications, truncated postcode data were used to group households into one of five areas based on 11 regions: South England (South West, London, South East and Eastern regions), Mid England (West Midlands and East Midlands regions), Wales, North England (North West, North East, and Yorkshire and Humber regions) and Scotland. The distributions of household sociodemographic characteristics were stable across each week for 2015–2018 (data not shown) and thus were not used as covariates in the analyses.

We obtained raw KWP data of all take-home purchases of alcohol products, including no and low alcohol products, for 4 years, 2015–2018. Since only items purchased and taken home are recorded, only off-trade alcohol is included, that is, alcohol bought in supermarkets or other shops for consumption off the premises. Alcohol purchases are recorded daily. A detailed product description identifies the brand, the alcohol by volume (ABV), the volume of the purchase and the price paid. Volume was combined with ABV to calculate grams of alcohol purchased. To compare prices across all categories of products (beers, wines, spirits and so on), we calculated the price paid per gram of alcohol purchased, adjusting all products with an ABV of less than 3.5% to 3.5% to avoid a spurious high price for low alcohol products (see ref 14). For beer products, we calculated the price per millilitre of liquid paid.

From the ABV data, we identified purchases of new no or low beer products and purchases of reformulated existing beer products to a lower alcohol content. A new no or low alcohol beer product was defined as one with an ABV of 3.5% or less that was newly introduced, as evidenced by the purchase data, after week 13 of 2015, and that was still present in 2018. Forty-six products meeting this definition were identified between 2015 and 2018. Millilitres of purchased beer per adult per household per week are plotted in figure 1. Of the 46 products, most had only a small number of purchases, with 41 having less than an average of one purchase a day across all households.

Product reformulation was defined as a brand whose ABV dropped by 0.11% or more during 2015–2018, with purchases still present during 2018. The drop of 0.11% was chosen as this represents the accepted margin of error allowed for ABV estimations, based on the mean ABV of purchased beer products in our sample. Millilitres of purchased beer per adult per household per week since reformulation are plotted in figure 1. Given that the change in ABV occurred in an existing product with a natural lag due to shop shelf turnover, the average change in ABV of some reformulated products occurred over several weeks. For the date of the change, we took the week nearest to the midpoint in change of mean ABV. For example, if the change in ABV started in week 160 and finished in week 174, we took week 167 as the date of the change. Of the 33 products, the vast majority had only a small number of purchases, with 24 having less than an average of one purchase a day across all households.

Visual inspection of figure 1 finds three natural periods, with one event (event 1) between periods 1 and 2 and a second event (event 2) between periods 2 and 3. Period 1 has no or very low levels of millilitres of no and low alcohol beer and of reformulated beer. Event 1 is a step-jump in purchases of no and low alcohol beer and a small increase in purchases of reformulated beer. Event 2, between periods 2 and 3, shows no change in purchases of no and low alcohol beer, but a step-jump in purchases of reformulated beer. One new product of ABV of 3.5% was responsible for 64% (95% CI 62 to 67) of all purchased millilitres of new low and no alcohol beers during periods 2 and 3. One product whose ABV was reduced from 4.8% to 4.5% was responsible for 71% (95% CI 69 to 73) of all postreformulation purchased millilitres during period 3. The two step-jumps are the two events used in the interrupted time series analyses, separating period 1 from period 2, and period 2 from period 3.

Figure 1 also illustrates the seasonal and non-seasonal changes in purchases of all other beers (majority of beer purchases, grey line, left primary axis), indicating the need to adjust for these in our time series analyses. There are peaks in purchases at the end of calendar years, associated with Christmas and New Year celebrations. There is also a smaller peak during mid-2018, probably associated with the 2018 football World Cup.

The dependent data were prepared for description and analysis as follows:

- For each of the 208 weeks, we calculated the mean ABV of all purchased beers.
- For each of the 208 weeks, we aggregated daily records of purchases in grams of alcohol in beer, and in all alcohol to weekly records of purchases in grams of alcohol across all households, adjusted for the number of adults in the household.
- We grouped households into the following:
 - Five age groups of the age of the main shopper: 18–34, 35–44, 45–54, 55–64 and 65+ years (which correlated with life stage of the household).

- Five groups based on purchased grams of alcohol per adult per household per week: ≤ 25 , $25-\leq 50$, $50-\leq 100$, $100-\leq 200$, and >200 grams of alcohol.
- Five social class groupings: AB, C1, C2, D and E, a system of demographic classification used in the UK, originally developed by the National Readership Survey to classify readers, with AB including higher and intermediate managerial, administrative or professional workers, C1 supervisory or clerical and junior managerial, administrative or professional workers, C2 skilled manual workers, D semiskilled and unskilled manual workers, and E state pensioners, casual and lowest grade workers, and unemployed with state benefits only.¹⁵
- Five income groups per adult per household per year: £0–7500, >7500–12 500, >12 500–15 500, >17 500–25 000, and >25 000.
- Five areas of Great Britain: South England, Mid England, Wales, North England and Scotland.

Statistical analyses

For each of our three continuous variables over time (mean ABV of beer products; mean grams of purchased alcohol within beer; and mean grams of all purchased alcohol), we seasonally adjusted the series with the Census Method I, ratio-to-moving-average method.^{16 17} For each adjusted variable, we examined the distribution visually and with Q-Q plots and found all variables normally distributed. As recommended by a number of authors,^{13 18} we used a time series modeller function¹⁹ to estimate best fitting ARIMA models that specify degrees of differencing and transformations to ensure a stationary series and that specify autoregressive and moving average orders, thus eliminating the need to identify an appropriate model through trial and error. The model types, summarised in online supplemental table 1, identified no differencing terms, but some non-seasonal and seasonal autoregressive and moving average terms. We examined plots of the residual autocorrelation function summary statistics and residual partial autocorrelation function summary statistics of the modelled continuous variables and found low and non-significant smooth correlations across the range of lags (to lag 24), with no evidence of a non-stationary series and no evidence of autoregression (online supplemental figures 1–3).

In line with other published interrupted time series analyses, we included more than one event²⁰ and slopes^{21 22} in our ARIMA model. Our independent variables were slope 1 before event 1, event 1, slope 2 between events 1 and 2, event 2, and slope 3 after event 2. The two event variables were entered as dummy variables coded with 0 for each week before the event and with 1 for each week from the event forwards. For the three slope changes variables, each week was coded with 0 if it fell outside the respective period and with increasing integers if it fell within the respective period.

We included one covariate, a composite measure of the price paid per quantity of alcohol and the household

income adjusted for each adult in the household. Household income increased over time, and increases in price paid per quantity of alcohol purchased increased during the second 2 years of the study period, surpassing the income increases (online supplemental figure 4). We scaled the price and income variables to a per cent scale, based on the values of each at week 1. The affordability variable for each week was then calculated as (scaled income/scaled price) $\times 100$, where a unit change is a 1% change in affordability. The affordability of both beer and all alcohol decreased during the second 2 years of the study period (online supplemental figure 5).

Thus, the three dependent variables in the ARIMA model were ABV% of beer, grams of alcohol purchased within beer and grams of alcohol purchased as a whole (per adult per household per week). The independent variables were the intercept, the two events, the three slopes before and after the events, and affordability. We report unstandardised coefficients with 95% CIs and probability (p) values.

We conducted a sensitivity analysis to test the assumption of the three distinct periods. Similar to Rehm *et al*,²⁰ we undertook the ARIMA regression models for each dependent variable on two subsets of the time series, namely only periods 1 and 2, and only periods 2 and 3.

A drawback of ARIMA models is their inability to assess moderation effects (eg, by household characteristics). Thus, as recommended by Beard *et al*,¹³ we repeated the ARIMA models for all three periods for each of the five separate groupings of households (by age of the main shopper, amount of alcohol purchased overall, class group, household income and area of Great Britain). Area of Great Britain included Scotland as one of the areas, allowing for us to account for the main policy change that occurred during the time period, the introduction of a minimum unit price in Scotland at week 174, beginning of May 2018.¹⁴ For the ARIMA models, as recommended by Beard *et al*,¹³ we transformed the continuous variables into their z-scores and used the z-scores as the dependent variables, so that the results can be compared between groups in terms of SD, rather than original units. This allows us to compare the relative importance of the regression coefficients, and thus changes, across the characteristics of each of the household groupings and the household groupings themselves. For the five groupings, we report standardised coefficients with 95% CI.

All analyses were performed with SPSS V.25.¹⁹

Patient and public involvement

The research was done without public involvement. The public was not consulted to develop the research questions, nor was it involved in identifying the study design or outcomes. We did not invite the public to participate in the interpretation of results, nor in the writing or editing of this paper. There are no plans to directly involve the public in the dissemination of the research findings.

Table 1 Mean weekly purchases of volume (mL) of new low and no alcohol beer products, reformulated beer products (since time of reformulation), all other beer products, and all beer products (total) for the three periods

Period	Product	Mean mL (95% CI)
1 (weeks 1–112)	New low and no alcohol beers	0.7 (0.6 to 0.9)
	Reformulated beers	2.1 (1.7 to 2.6)
	All other beers	578.1 (565.9 to 592.2)
	All beer products (total)	581.0 (568.7 to 595.4)
2 (weeks 113–166)	New low and no alcohol beers	14.1 (13.1 to 15.2)
	Reformulated beers	10.7 (10.2 to 11.3)
	All other beers	539.9 (522.8 to 558.8)
	All beer products (total)	564.7 (547.0 to 584.0)
3 (weeks 167–208)	New low and no alcohol beers	15.2 (14.3 to 16.3)
	Reformulated beers	40.7 (37.6 to 44.1)
	All other beers	532.0 (516.6 to 549.5)
	All beer products (total)	588.0 (569.3 to 609.9)

RESULTS

Purchases of new low and no alcohol beer products and of reformulated beer products

Table 1 summarises the mean weekly purchases of volume of new low and no alcohol beer products, reformulated beer products, all other beers, and all beer products for the three periods illustrated in figure 1. Purchases of new low and no alcohol beer products were very low during period 1, increased during period 2 and remained stable during period 3. Purchases of reformulated products were very low during period 1, increased during period 2 and increased substantially during period 3. During period 3, new low and no alcohol beer products were 2.6% of the volume of all beer products and reformulated beer products 6.9%.

Online supplemental figure 6 plots the mean ABV (%) for the new and reformulated products over time. The mean ABVs of both categories of products were relatively high to begin with, decreasing over time. In 2018, the mean ABV of new low and no alcohol beer products was 2.08% (95% CI 1.99 to 2.16) and of reformulated beer 4.88% (95% CI 4.83 to 4.93).

Figure 2A–E summarises the mean weekly purchases (per adult per household) of volume of new low and no alcohol beer products and reformulated beer products for the three periods defined in figure 1 by the socio-demographic characteristics of the households. The volume of purchases was considerably greater for both new and reformulated products during periods 2 and 3 the younger the age of the main shopper (figure 2A) and the higher the amount of overall alcohol purchased by

households (expressed as purchased grams of alcohol) (figure 2B). That these are independent effects is indicated by the data in online supplemental table 2. The mean purchase of grams of alcohol per adult per household per week increased progressively from 76.2 g (95% CI 75.7 to 76.7) among the age group of the main household shopper of 18–34 years, to 132.9 g (95% CI 132.4 to 133.4) among those aged 65+ years. Volumes of purchases during periods 2 and 3 were a little higher in class groups D and E than in AB, C1 and C2 (figure 2C). For reformulated products, volume of purchases was a little higher in the higher income households (figure 2D). Volumes of purchases of new no and low alcohol products were higher in North England for periods 2 and 3 (figure 2E).

Impact of new low and no alcohol products on purchases of grams of alcohol

Figure 3 plots the seasonally adjusted dependent variables, with the predicted values derived from the ARIMA models of the impact of the two events, and table 2 displays the coefficients.

Following event 1 (the upward turn in purchased new low and no alcohol beer products), the previous significant upward slopes 1 for each of the three dependent variables plateaued: there was a slight decrease in slope 2 for mean ABV of beer, and there were flat slopes 2 for grams of alcohol purchased within beer and grams of alcohol purchased overall. Following event 2 (the upward turn in purchased reformulated beer), there were significant downward slopes 3 for all three dependent variables. The sizes of the downward slopes were larger for slope 3 (largely reformulated beer products) than for slope 2 (largely new low and no alcohol beers).

We estimated the overall impact of the introduction of new low and no alcohol beer products and reformulation of existing products on changes in the three dependent variables in two ways:

- ▶ Subtracting the predicted values at week 208 from the predicted values at week 112, a lower size estimate.
- ▶ Extrapolating a new predicted value at week 208 by continuing slope 1 through to week 208, and subtracting the original predicted value at week 208 from the extrapolated predictive value at week 208, a higher size estimate.

This resulted in an estimated overall impact of reduction of mean ABV(%) of beer of between 0.052 (lower size estimate) and 0.107 (higher size estimate), a 1.2%–2.3% relative drop; reduction of purchased grams of alcohol within beer (per adult per household per week) of between 1.4 and 2.1 g, a 7.1%–10.2% drop; and reduction of purchased grams of alcohol overall (per adult per household per week) of between 2.8 and 4.2 g, a 2.6%–3.9% drop.

The sensitivity analysis, repeating the ARIMA models for two separate time periods (only periods 1 and 2 and only periods 2 and 3), found similar sizes of coefficients, and strongly confirmed the greater downward slopes during period 3 than during period 2 (table 3).

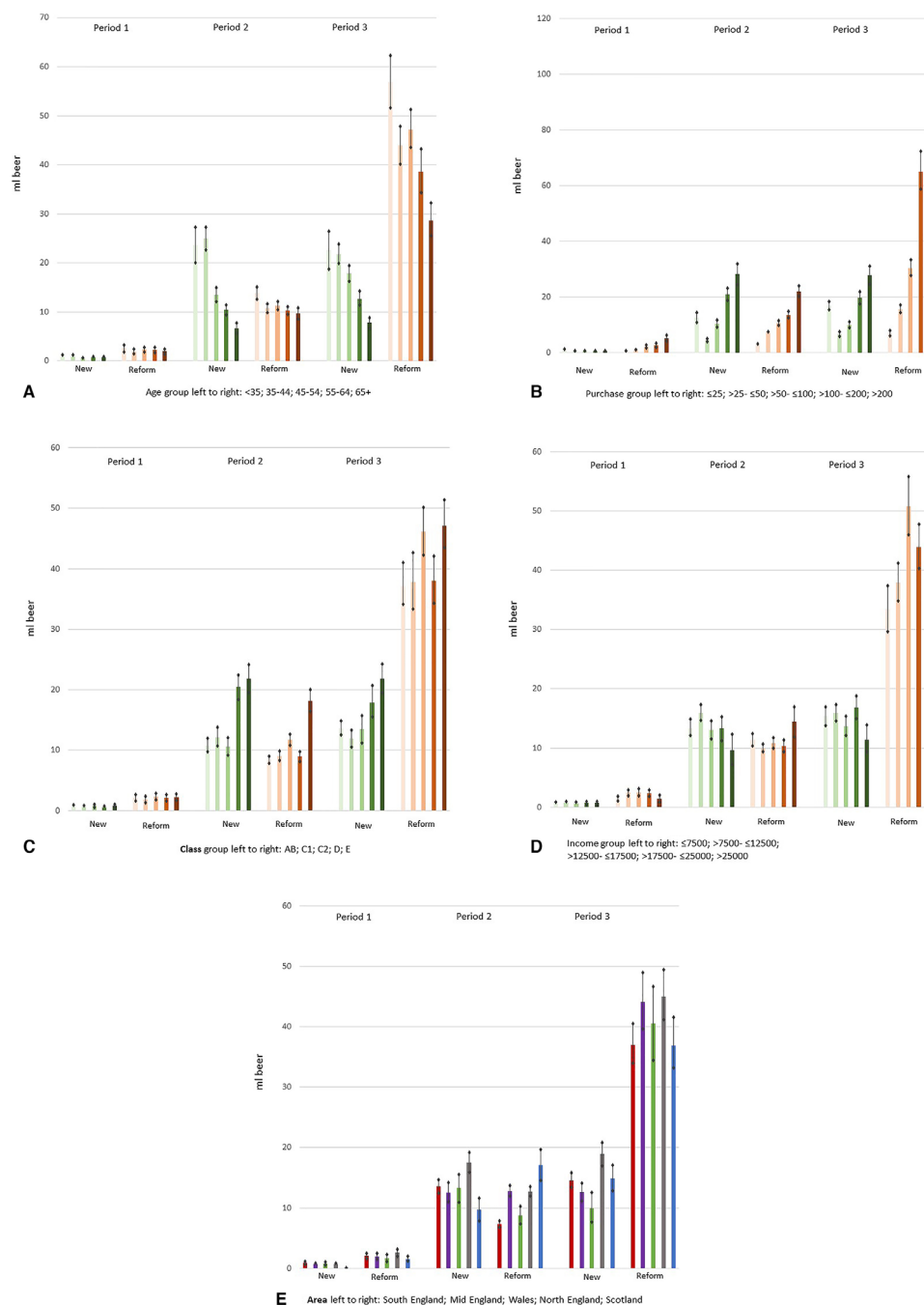


Figure 2 Purchases of new and reformulated beer products (mL of beer) at each of the three periods by sociodemographic characteristics of households: age of the main shopper in years (A); number of grams of alcohol purchased overall per adult per household per week (B); class group (C); household income per adult per year (D); and area of Great Britain (E).

Figure 4A–E plots the fitted values for purchases of grams of alcohol within beer over time from the ARIMA models by household characteristics. The values are standardised coefficients, reporting changes in SD, and thus on a common scale for all outputs, with the coefficients tabulated for all three dependent variables in online supplemental table 3A–E. Drops in purchases of grams of alcohol within beer were greater the younger the age of the main shopper (figure 4A) and were greater the higher the amount of overall alcohol purchased by households (expressed as purchased grams of alcohol

(figure 4B). That these are independent effects is again indicated by the data that the number of grams of alcohol purchased by households increased with increasing age of the main shopper (online supplemental table 2). Drops in purchases of grams of alcohol within beer did not substantially differ by social class groups (figure 4C) and by household income (figure 4D). Drops in purchases of alcohol within beer occurred in all five areas of Great Britain, although were larger in Scotland, a likely reflection of the introduction of minimum unit price during week 174 (figure 4E).

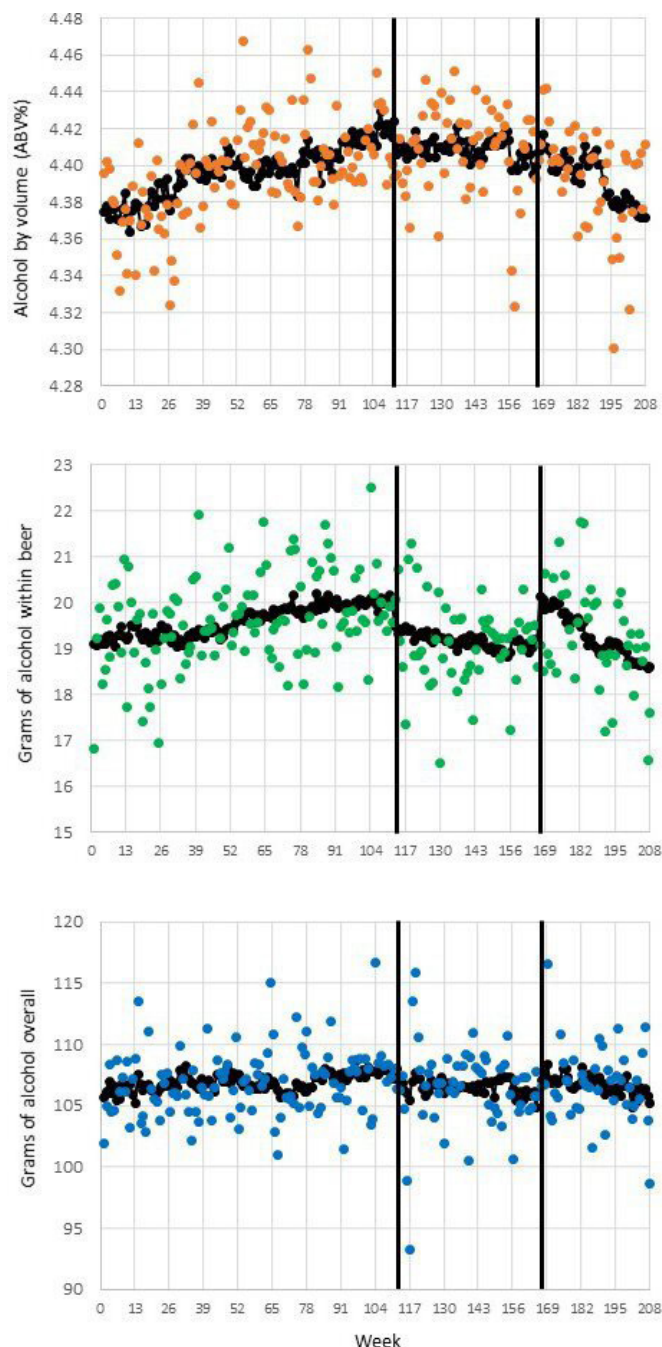


Figure 3 Plots of seasonally adjusted alcohol by volume (%), grams of alcohol purchased within beer and grams of alcohol purchased overall (dots), with predicted values (lines) from the Autoregressive Integrated Moving Average (ARIMA) model. Vertical lines: the two events (jump in purchased new low and no alcohol products, and jump in reformulated products).

For households that were purchasing more than 200 g of alcohol per adult per household per week (the heaviest purchasing group), the estimated overall impact of the two events was reduction of mean ABV(%) of beer of between 0.0018 (lower size estimate) and 0.0.05 (higher size estimate), a 0.4%–1.1% relative drop; reduction of purchased grams of alcohol within beer (per adult per household per week) of between 5.0 and 8.9 g, a

Table 2 Coefficients (95% CI) and p values for slope and level changes of the impact of the two events on ABV of beer and on purchased grams of alcohol within beer and for alcohol as a whole

	ABV (%)		Grams of alcohol within beer		All grams of alcohol	
	Coefficient (95% CI)	P value	Coefficient (95% CI)	P value	Coefficient (95% CI)	P value
Intercept	4.6912 (4.6636 to 4.7188)	0.0000	12.8017 (10.0271 to 15.5764)	0.0000	138.860 (127.840 to 149.881)	0.0000
Slope 1	0.0005 (0.0004 to 0.0005)	0.0000	0.0077 (0.0051 to 0.0103)	0.0000	0.0182 (0.0096 to 0.0268)	0.0000
Level 1	0.0477 (0.0371 to 0.0583)	0.0000	1.1309 (0.0673 to 2.1945)	0.0372	2.1430 (–1.3553 to 5.6412)	0.2299
Slope 2	–0.0001 (–0.0002 to 0.0000)	0.0014	–0.0071 (–0.0145 to 0.0004)	0.0650	–0.0167 (–0.0414 to 0.0080)	0.1852
Level 2	0.1713 (0.1483 to 0.1943)	0.0000	5.6538 (3.3464 to 7.9613)	0.0000	7.7124 (0.1330 to 15.2917)	0.0461
Slope 3	–0.0011 (–0.0012 to –0.0010)	0.0000	–0.0346 (–0.0456 to –0.0237)	0.0000	–0.0547 (–0.0909 to –0.0186)	0.0030
Affordability	–0.0031 (–0.0034 to –0.0029)	0.0000	0.0629 (0.0352 to 0.0906)	0.0000	–0.3316 (–0.4439 to –0.2194)	0.0000

ABV%, alcohol by volume.

Table 3 Sensitivity analysis: coefficients and p values for two separate analyses, periods 1 and 2 and periods 2 and 3

	Periods 1 and 2		Periods 2 and 3	
	Coefficient	P value	Coefficient	P value
Alcohol by volume (%) of beer				
Intercept	4.8239 (4.7759 to 4.8718)	0.000	4.6997 (4.6773 to 4.7221)	0.000
First slope	0.0005 (0.0005 to 0.0005)	0.000	−0.0001 (−0.0002 to −0.0001)	0.000
Event	0.0486 (0.0328 to 0.0644)	0.000	0.1702 (0.1583 to 0.1820)	0.000
Second slope	−0.0001 (−0.0003 to 0.0000)	0.014	−0.0011 (−0.0011 to −0.0010)	0.000
Affordability	−0.0045 (−0.0050 to −0.0040)	0.000	−0.0028 (−0.0030 to −0.0026)	0.000
Purchase grams of alcohol within beer				
Intercept	10.5313 (8.3448 to 12.7178)	0.000	14.6872 (12.5802 to 16.7943)	0.000
First slope	0.0076 (0.0058 to 0.0093)	0.000	−0.0056 (−0.0092 to −0.0020)	0.002
Event	0.9975 (0.2772 to 1.7177)	0.007	5.8706 (4.7517 to 6.9894)	0.000
Second slope	−0.0060 (−0.0110 to −0.0009)	0.021	−0.0347 (−0.0400 to −0.0294)	0.000
Affordability	0.0855 (0.0637 to 0.1074)	0.000	0.0531 (0.0327 to 0.0736)	0.000
Purchase grams of alcohol overall				
Intercept	130.839 (119.141 to 142.537)	0.000	180.884 (173.432 to 188.336)	0.000
First slope	0.0167 (0.0085 to 0.0250)	0.000	−0.0196 (−0.0302 to −0.0090)	0.000
Event	2.1522 (−1.1968 to 5.5011)	0.208	8.8731 (5.6206 to 12.1256)	0.000
Second slope	−0.0155 (−0.0392 to 0.0082)	0.199	−0.0661 (−0.0817 to −0.0505)	0.000
Affordability	−0.2503 (−0.3695 to −0.1312)	0.000	−0.7393 (−0.8126 to −0.6660)	0.000

For periods 1 and 2: first slope=slope 1; event=level 1; second slope=slope 2. For periods 2 and 3: first slope=slope 2; event=level 2; second slope=slope 3.

9.5%–15.1% drop; and reduction of purchased grams of alcohol overall (per adult per household per week) of between 3.0 and 9.8 g, a 0.9%–2.8% drop.

DISCUSSION

We report natural experiments from Great Britain in which new low and no alcohol beer products were introduced and in which existing beer products were reformulated to contain less alcohol. We analysed British household panel shopping data for the years 2015–2018, covering 30 000 households at any one time, with 3332140 separate alcohol purchases and 876484 separate beer purchases.¹⁴

We found evidence for purchases of new low and no alcohol beers and for purchases of reformulated existing beers to contain less alcohol in them between 2015 and 2018. For new low and no alcohol beer products, this was only present to a marked degree during 2017 and 2018, with no substantial increase in purchases in 2018 compared with 2017. For reformulated products, the change was only present to a marked degree during 2018. During 2018, new low and no alcohol beer products were responsible for only 2.6% of the purchased volume of all beer products, and reformulated beer products only 6.9% of the purchased volume of all beer products since the time of reformulation. For both cases, one product was responsible in each category for around two-thirds of all volumes of purchases. Trends in the ABV of the new and reformulated products indicate that new products

were low rather than no alcohol products, and that reformulation occurred more in higher strength than in lower strength products (see online supplemental figure 6). The increase in purchases of both low and no alcohol products and of reformulated products was driven to a large extent independently by younger shoppers and by households that bought the most alcohol (expressed as grams). There was no evidence of systematic variation by indices of inequality, class group, household income or area of Great Britain (figure 2).

Despite the small changes in purchases, we found significant associations between both step-jump events, the introduction of new low and no alcohol products and the reformulation of existing products to contain less alcohol, and reductions in the mean ABV of beer and reductions in purchases of both grams of alcohol within beer and grams of alcohol as a whole. Both events led to an overall reduction in the ABV of beer of between 1.2% and 2.3%; a reduction in the purchases of grams of alcohol within beer of between 7.1% and 10.2%; and a reduction in the purchases of grams of alcohol as a whole of between 2.6% and 3.9%. Associated reductions over time were greater for reformulation than for the introduction of new low and no alcohol products. Reductions in purchases of grams of alcohol within beer due to the events matched the distribution of purchases across the three periods by sociodemographic characteristics



Figure 4 Plots of fitted values from Autoregressive Integrated Moving Average (ARIMA) models reporting standardised coefficients that are SDs, resulting in coefficients that are relative and all on the same scale by sociodemographic characteristics of households: age of main shopper in years (A); number of grams of alcohol purchased overall per adult per household per week (B); class group (C); household income per adult per year (D); and area of Great Britain (E) (see online supplemental table 1 for coefficients). Black vertical lines: timing of events.

summarised in figure 2. The reductions, summarised in figure 4, were greater the younger the age of the shopper and greater in the households that purchased the higher number of grams of alcohol, both independent effects. That relative reductions are greater among higher purchasing households is of public health importance given that the same reduction in alcohol consumption among heavier drinkers brings greater health gain than among lighter drinkers.²³ There was no evidence in terms of inequality in reductions, which did not differ substantially by class group, household income group or area of Great Britain other than Scotland. That reductions occurred across all five areas of Great Britain demonstrates that the associated reductions were independent of the introduction of minimum unit price in Scotland. Reductions, though,

were greater in Scotland during period 3, coinciding with the introduction of minimum unit price.¹⁴

Given the potential impacts of reformulated beer products on reducing purchases of grams of alcohol, it is disappointing to note the low overall volumes of such purchased products, with 71% of postreformulation volume of purchases contributed by just one product alone. This indicates that there are large missed opportunities for beer producers as a whole to take responsibility for their products and to contribute to a reduction in the harmful use of alcohol. Our data suggest that, at least in the British market, this is likely best achieved through reformulation of existing regular strength beer products with high-volume-sales beer to contain less alcohol.

Our study has several strengths. First, it uses a large commercial data set with more than 3.33 million separate alcohol purchases and 876 000 separate beer purchases from more than 64 000 British households, with objective purchase data obtained from scanned product barcodes.¹⁴ 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 new no and low alcohol beer products on public health relevant outcomes.¹⁴ Third, there was internal consistency in that the greatest impacts occurred among lower age shoppers and in households that purchased the greatest amount of alcohol, the two groups that had the higher purchases of new and reformulated products. Fourth, our analysis by area of Great Britain allowed us to account for the main alcohol policy change that occurred during the time frame, the introduction of minimum unit price in Scotland, May 2018,¹⁴ where we found an impact of the two events in areas of Great Britain other than Scotland.

Our study, though, has three main weaknesses. First, panel data may not capture all beer purchases. While most primary shopping is done by women, secondary top-up shopping, which is more likely done by men, may be less well recorded.²⁴ Second, panel data may exclude certain segments of the population that are more likely to be heavy drinkers, such as homeless people, and may have lower representation of single adult households.¹⁴ Third, panel data only capture off-trade purchases, and not on-trade purchases,²⁰ with panel data being purchase and not actual consumption data. Over the 4-year period, 2015–2018 for Great Britain, off-trade purchases accounted for 69.4% of all alcohol purchases in 2015, increasing to 71.5% in 2018; for beer, the equivalent proportions were 50.1%–52.9%.²⁵ Ideally, we would want similar analyses for all alcohol purchases, both off and on trade. Fourth, although we had a relatively large number of observations before and after the events, as indicated by the requirements of Beard *et al*,¹³ our overall time frame does not necessarily allow for analyses of durability and sustainability of the findings. Periods 2 and 3 following event 1 amounted to nearly two complete annual seasons of alcohol purchases, whereas period 3 following event 2 amounted to less than full one season. Ideally, changes should be studied over a longer time period, matching, for example, studies of salt reformulation that have examined changes in Britain over a 6-year period.¹⁰ Despite these shortcomings, the findings, though, are consistent with the mechanisms that we previously identified.⁸

We are not aware of any similar large-scale natural experiments that have evaluated the impact of the introduction of new no and low alcohol products and of product reformulation on purchases of grams of

alcohol.⁸ Although a Department of Health's interim evaluation of the UK alcohol industry's 'billion units pledge' suggested that the initiative had been a success,²⁶ the methods have been strongly criticised,²⁷ and there has been no further independent evaluation.

Outside of alcohol, there are parallel examples with salt reduction initiatives.⁹ For example, an analysis of salt reduction initiatives in the British market, using KWP data, found that the salt concentration (similar to ABV) was 0.370 g per 100 g of food purchases in 2005, reducing to 0.351 g per 100 g in 2011, a 5.1% reduction over the 6-year period.¹⁰ Our analysis found a 1.2%–2.3% reduction in the mean ABV of beer over a shorter 2-year period. For salt reduction initiatives, salt reduction was almost exclusively due to product reformulation of existing products, rather than the introduction of new products with less salt in them (Trieu *et al*).⁹ Our analyses found that whereas period 2 (largely the introduction of new products with less alcohol in them) led to a plateauing of the previous increases during period 1, period 3 (largely the reformulation of existing products to contain less alcohol in them) had significant downward slopes, suggesting that reformulation was having greater associated impacts in reducing the purchases of grams of alcohol than the introduction of new low and no alcohol beer products.

CONCLUSION

While the purchase data find the introduction of new low and no alcohol beers and reformulation of existing beer products to contain less alcohol in Great Britain during 2015–2018, the volume of changes has been small and dominated by just two products. Nevertheless, small though they are, these changes are associated with reductions in the mean ABV of beer and reductions in household purchases of grams of alcohol within beer and in purchases of grams of alcohol as a whole, with reductions greater in higher alcohol-purchasing households than in lower alcohol-purchasing households. Despite these changes, the data on small volumes of new and reformulated products indicate that the beer industry as a whole has, at least by the end of 2018, yet to live up to its responsibilities to address its products in such ways so as to reduce the harm done by alcohol.

Twitter Jakob Manthey @MantheyJakob

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Contributors PA and AO'D obtained the data and managed the data set. PA, EJJ, AO'D, JM and JR collectively conceptualised the paper. PA did the first draft of the original paper. PA undertook the analyses, with input and advice from JM and JR. PA, EJJ, AO'D, JM and JR refined the various versions of the paper and approved the final manuscript. JM, as the corresponding author, attests that all listed authors meet the authorship criteria and that no others meeting the criteria have been omitted. PA and AO'D are the guarantors.

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ORCID iDs

Peter Anderson <http://orcid.org/0000-0003-4605-9828>

Amy O'Donnell <http://orcid.org/0000-0003-4071-9434>

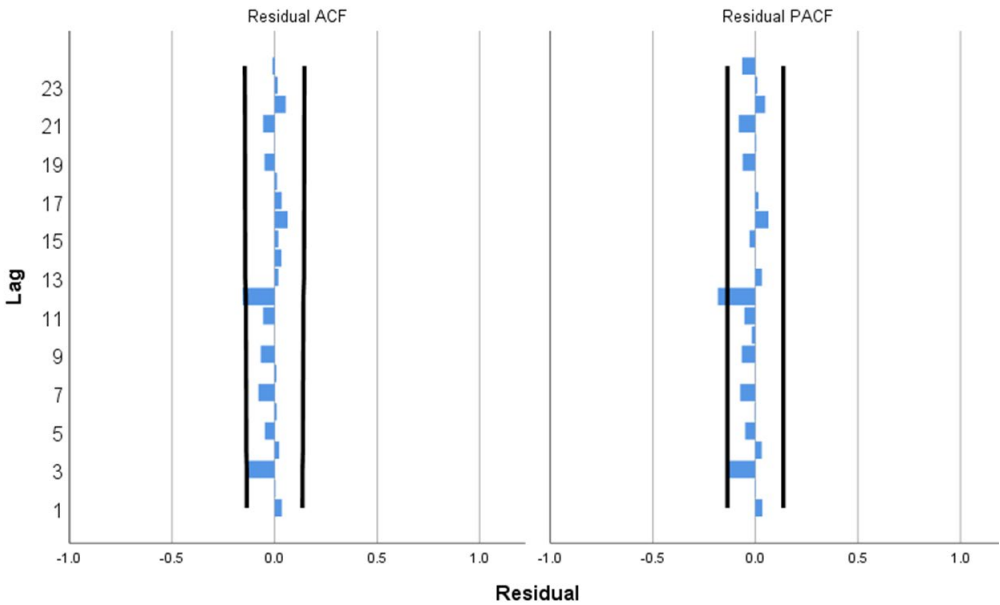
Jakob Manthey <http://orcid.org/0000-0003-1231-3760>

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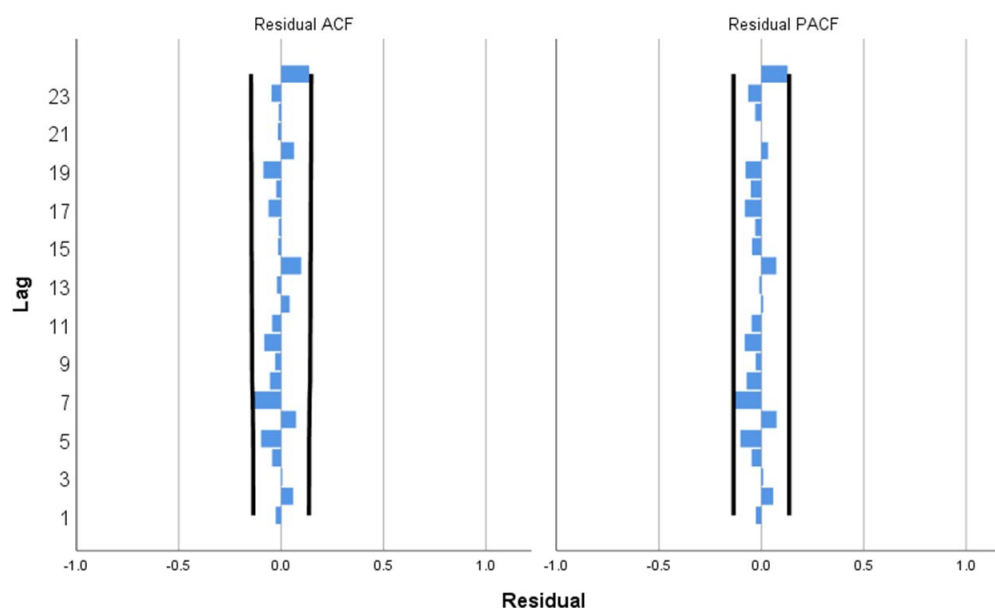
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Supplement Table 1 ARIMA model types for the three dependent variables

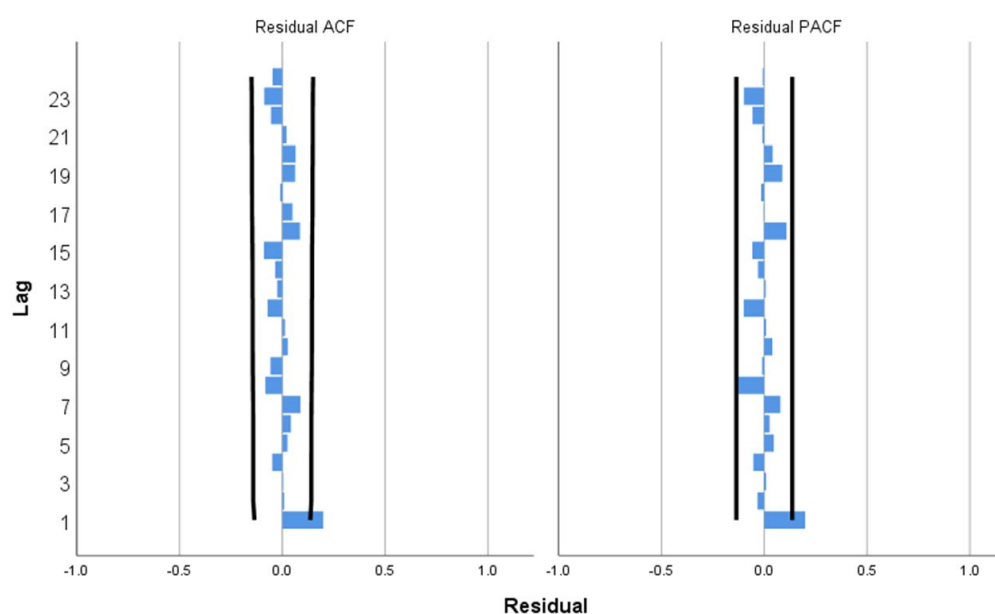
Variable	Model type
Purchased grams of alcohol as a whole	ARIMA(2,0,0)(0,0,1)
Purchased grams of alcohol within beer	ARIMA(1,0,0)(0,0,1)
Alcohol by volume of beer (ABV)	ARIMA(2,0,0)(0,0,0)



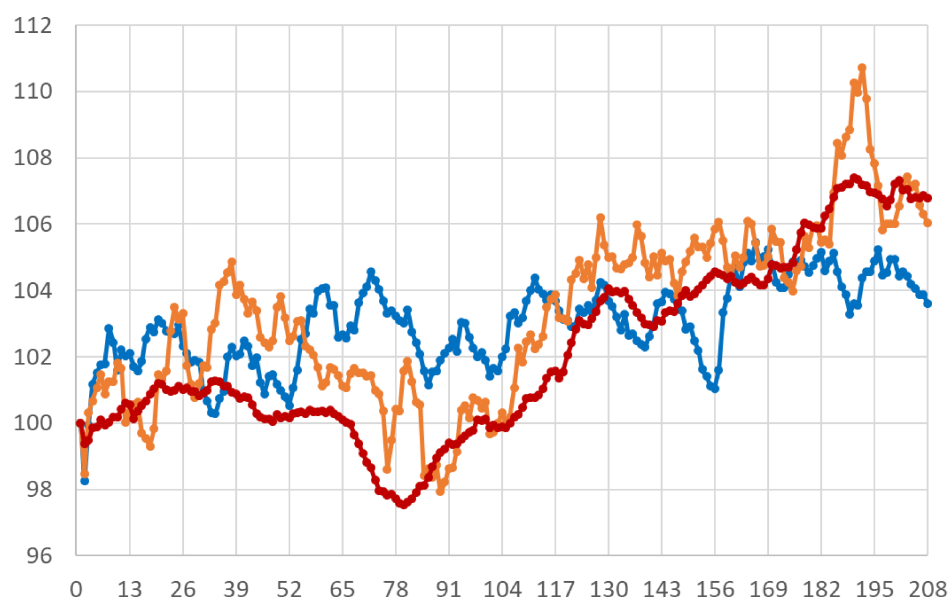
Supplement Figure 1 Residual autocorrelation function (ACF) summary statistics and residual partial autocorrelation function (PACF) summary statistics of modelled mean grams of purchased alcohol.



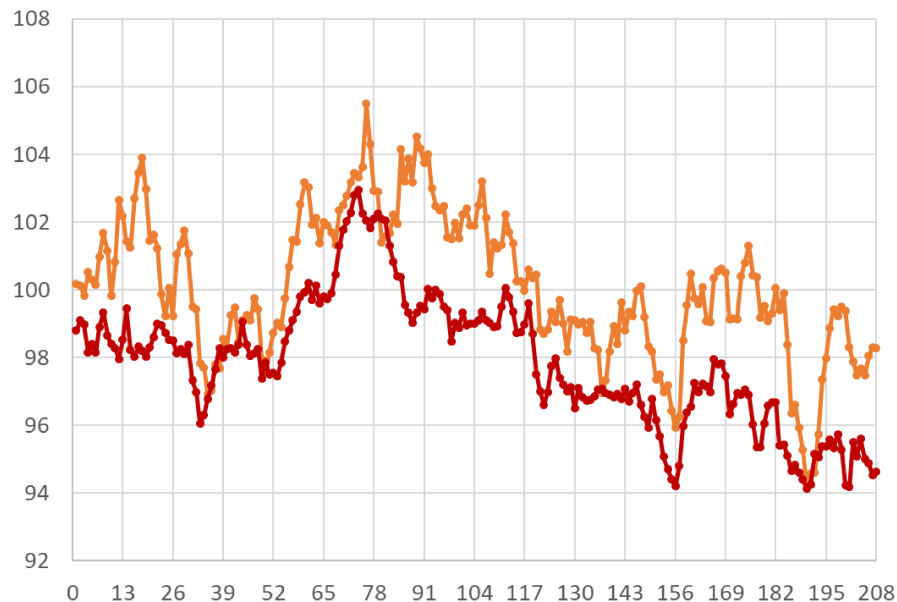
Supplement Figure 2 Residual autocorrelation function (ACF) summary statistics and residual partial autocorrelation function (PACF) summary statistics of modelled mean grams of purchased alcohol within beer.



Supplement Figure 3 Residual autocorrelation function (ACF) summary statistics and residual partial autocorrelation function (PACF) summary statistics of modelled mean Alcohol by Volume (ABV) of beer.



Supplement Figure 4 Exponential smoothed plots of mean price of beer (orange line), mean price of all alcohol (red line), and household income (adjusted for number of adults in the household) across all households from week 1 (first week of 2015) to week 208 (last week of 2018). Variables were scaled to a percent scale, based on the values of each at week 1.



Supplement Figure 5 Exponential smoothed plots of mean affordability of beer (orange line) and all alcohol (red line) purchased across all households from week 1 (first week of 2015) to week 208 (last week of 2018). Price and income variables were scaled to a percent scale, based on the values of each at week 1. Affordability for each week is calculated as (scaled income/scaled price) *100, where a unit change is a one percent change in affordability, with a higher value being more affordable, and a lower value less affordable.

Supplement Table 2 Mean (95% CI) purchase grams of alcohol per adult per household per week by age group of main household shopper

Age group (years)	Mean (95% CI) purchase grams of alcohol per adult per household per week
18-34	76.2 (75.7 to 76.7)
35-44	89.1 (88.7 to 89.5)
45-54	99.8 (99.4 to 100.2)
55-64	119.8 (119.3 to 120.2)
65+	132.9 (132.4 to 133.4)

Supplement Table 3a Standardized Coefficients (95% confidence intervals) for level and slope changes on three dependent variables by age group of main shopper (summarized in Figure 4a of paper)

Age group	Independent variable	Mean ABV of beer	Grams of alcohol purchased within beer	Grams of alcohol purchased overall
<35	Intercept	15.4236 (15.1010 to 15.7462)	-1.4005 (-3.6065 to 0.8055)	-3.8665 (-7.4743 to -0.2588)
	slope1	0.0192 (0.0186 to 0.0199)	-0.0056 (-0.0103 to -0.0008)	-0.0046 (-0.0102 to 0.0010)
	level1	2.4329 (2.1397 to 2.7261)	0.2992 (-1.7060 to 2.3043)	-0.3697 (-2.7039 to 1.9645)
	slope2	-0.0119 (-0.0139 to -0.0098)	-0.0089 (-0.0230 to 0.0051)	-0.0001 (-0.0166 to 0.0163)
	level2	5.3636 (4.7283 to 5.9988)	4.1698 (-0.1744 to 8.5140)	2.5382 (-2.5235 to 7.5998)
	slope3	-0.0401 (-0.0431 to -0.0371)	-0.0316 (-0.0522 to -0.0111)	-0.0143 (-0.0383 to 0.0096)
	Affordability	-0.1496 (-0.1525 to -0.1467)	0.0194 (-0.0004 to 0.0392)	0.0423 (0.0065 to 0.0781)
35-44	Intercept	18.3217 (17.2729 to 19.3705)	-4.0592 (-6.2888 to -1.8296)	2.2946 (-0.4173 to 5.0065)
	slope1	0.0043 (0.0026 to 0.0059)	0.0024 (-0.0012 to 0.0060)	-0.0074 (-0.0105 to -0.0042)
	level1	3.6833 (2.9673 to 4.3992)	2.7204 (1.1984 to 4.2424)	1.5368 (0.2487 to 2.8248)
	slope2	-0.0310 (-0.0360 to -0.0260)	-0.0272 (-0.0377 to -0.0166)	-0.0250 (-0.0339 to -0.0160)
	level2	8.0023 (6.4782 to 9.5264)	-1.1486 (-4.3887 to 2.0915)	-0.8247 (-3.5893 to 1.9398)
	slope3	-0.0684 (-0.0756 to -0.0612)	-0.0146 (-0.0299 to 0.0008)	-0.0157 (-0.0288 to -0.0026)
	Affordability	-0.2089 (-0.2205 to -0.1973)	0.0520 (0.0274 to 0.0766)	-0.0124 (-0.0411 to 0.0164)
45-54	Intercept	20.7773 (19.9143 to 21.6402)	-14.099 (-16.984 to -11.214)	3.5266 (-0.4825 to 7.5358)
	slope1	0.0221 (0.0208 to 0.0233)	0.0152 (0.0109 to 0.0195)	0.0219 (0.0173 to 0.0265)
	level1	2.6735 (2.1295 to 3.2175)	0.8208 (-0.9980 to 2.6397)	3.6054 (1.7111 to 5.4997)
	slope2	-0.0081 (-0.0119 to -0.0042)	0.0027 (-0.0101 to 0.0155)	-0.0133 (-0.0267 to 0.0000)
	level2	8.5904 (7.4110 to 9.7698)	6.8411 (2.8977 to 10.7844)	6.7025 (2.5902 to 10.8147)
	slope3	-0.0557 (-0.0613 to -0.0501)	-0.0358 (-0.0545 to -0.0171)	-0.0483 (-0.0678 to -0.0288)
	Affordability	-0.2288 (-0.2377 to -0.2198)	0.1365 (0.1066 to 0.1664)	-0.0545 (-0.0991 to -0.0098)
55-64	Intercept	-2.0176 (-2.1404 to -1.8949)	-7.5377 (-10.417 to -4.6583)	4.6614 (1.4496 to 7.8731)
	slope1	0.0374 (0.0372 to 0.0376)	0.0083 (0.0030 to 0.0136)	-0.0070 (-0.0116 to -0.0025)
	level1	2.5477 (2.4666 to 2.6288)	-0.1692 (-2.0726 to 1.7343)	-0.6182 (-2.3123 to 1.0759)
	slope2	0.0035 (0.0030 to 0.0041)	0.0004 (-0.0129 to 0.0137)	-0.0068 (-0.0186 to 0.0050)
	level2	8.4564 (8.2815 to 8.6314)	13.8241 (9.7203 to 17.9279)	-0.8192 (-4.4413 to 2.8030)
	slope3	-0.0441 (-0.0449 to -0.0433)	-0.0687 (-0.0881 to -0.0493)	-0.0027 (-0.0198 to 0.0144)
	Affordability	-0.0045 (-0.0058 to -0.0033)	0.0704 (0.0406 to 0.1002)	-0.0371 (-0.0711 to -0.0032)
65+	Intercept	13.2093 (12.6107 to 13.8080)	-3.4476 (-6.1849 to -0.7103)	11.5511 (7.7406 to 15.3616)
	slope1	0.0325 (0.0313 to 0.0337)	0.0145 (0.0089 to 0.0200)	0.0199 (0.0147 to 0.0250)
	level1	0.8445 (0.4055 to 1.2835)	-0.4548 (-2.4623 to 1.5527)	-0.8691 (-2.7602 to 1.0221)
	slope2	0.0176 (0.0146 to 0.0207)	0.0107 (-0.0033 to 0.0247)	0.0199 (0.0067 to 0.0332)
	level2	12.7443 (11.7935 to 13.6951)	7.8797 (3.5319 to 12.2275)	6.6736 (2.5826 to 10.7645)
	slope3	-0.0622 (-0.0668 to -0.0577)	-0.0307 (-0.0513 to -0.0101)	-0.0192 (-0.0386 to 0.0002)
	Affordability	-0.1528 (-0.1592 to -0.1465)	0.0238 (-0.0052 to 0.0527)	-0.1273 (-0.1659 to -0.0888)

Supplement Table 3b Standardized Coefficients (95% confidence intervals) for level and slope changes on three dependent variables by purchase group (grams of alcohol purchased per adult per household per week) (summarized in Figure 4b of paper)

Purchase group (grams of alcohol)	Independent variable	Mean ABV of beer	Grams of alcohol purchased within beer	Grams of alcohol purchased overall
≤25	Intercept	9.2621 (8.8166 to 9.7076)	-3.6522 (-5.8899 to -1.4144)	-2.7278 (-4.2960 to -1.1595)
	slope1	0.0204 (0.0196 to 0.0212)	0.0019 (-0.0020 to 0.0059)	-0.0023 (-0.0046 to 0.0001)
	level1	7.0436 (6.7113 to 7.3760)	8.3285 (6.6590 to 9.9980)	4.1523 (3.1886 to 5.1161)
	slope2	-0.0451 (-0.0474 to -0.0427)	-0.0655 (-0.0773 to -0.0538)	-0.0361 (-0.0429 to -0.0293)
	level2	2.4924 (1.7724 to 3.2123)	-15.862 (-19.479 to -12.246)	-3.5207 (-5.6085 to -1.4329)
	slope3	-0.0528 (-0.0562 to -0.0494)	0.0366 (0.0195 to 0.0537)	-0.0156 (-0.0255 to -0.0057)
	Affordability	-0.1021 (-0.1067 to -0.0976)	0.0402 (0.0174 to 0.0631)	0.0371 (0.0203 to 0.0540)
25 - ≤50	Intercept	13.8577 (13.3531 to 14.3624)	-5.8244 (-7.6031 to -4.0457)	-2.6547 (-6.7479 to 1.4385)
	slope1	0.0230 (0.0222 to 0.0239)	-0.0022 (-0.0053 to 0.0008)	-0.0092 (-0.0147 to -0.0037)
	level1	-1.3209 (-1.6832 to -0.9586)	0.8969 (-0.3802 to 2.1740)	-2.9220 (-5.2168 to -0.6272)
	slope2	0.0255 (0.0230 to 0.0281)	0.0020 (-0.0070 to 0.0110)	0.0185 (0.0023 to 0.0347)
	level2	-1.7433 (-2.5299 to -0.9566)	0.2421 (-2.5307 to 3.0149)	1.6371 (-3.3075 to 6.5817)
	slope3	0.0267 (0.0230 to 0.0304)	0.0047 (-0.0083 to 0.0178)	0.0023 (-0.0212 to 0.0258)
	Affordability	-0.1682 (-0.1737 to -0.1627)	0.0561 (0.0367 to 0.0754)	0.0307 (-0.0085 to 0.0698)
50 - ≤100	Intercept	14.0977 (13.4898 to 14.7056)	-5.9082 (-8.6250 to -3.1915)	4.2297 (0.8516 to 7.6079)
	slope1	0.0041 (0.0029 to 0.0052)	0.0000 (-0.0050 to 0.0050)	-0.0191 (-0.0235 to -0.0147)
	level1	-2.3690 (-2.8414 to -1.8967)	-0.1398 (-2.2506 to 1.9710)	-6.5799 (-8.4613 to -4.6984)
	slope2	0.0263 (0.0230 to 0.0296)	0.0041 (-0.0108 to 0.0189)	0.0356 (0.0223 to 0.0489)
	level2	16.2869 (15.2612 to 17.3127)	3.5135 (-1.0705 to 8.0974)	11.7529 (7.6903 to 15.8155)
	slope3	-0.0701 (-0.0750 to -0.0653)	-0.0111 (-0.0329 to 0.0107)	-0.0370 (-0.0563 to -0.0176)
	Affordability	-0.1236 (-0.1286 to -0.1185)	0.0465 (0.0240 to 0.0690)	-0.0303 (-0.0653 to 0.0047)
100-≤200	Intercept	12.5773 (12.2365 to 12.9182)	-9.0375 (-11.402 to -6.6731)	12.3549 (8.2640 to 16.4459)
	slope1	0.0290 (0.0284 to 0.0297)	0.0144 (0.0099 to 0.0188)	0.0016 (-0.0032 to 0.0063)
	level1	0.1139 (-0.1480 to 0.3757)	0.8516 (-0.9650 to 2.6682)	2.6165 (0.5934 to 4.6395)
	slope2	0.0152 (0.0133 to 0.0170)	-0.0034 (-0.0162 to 0.0094)	-0.0194 (-0.0336 to -0.0052)
	level2	14.2403 (13.6740 to 14.8067)	4.2137 (0.2849 to 8.1425)	-0.8905 (-5.2969 to 3.5158)
	slope3	-0.0681 (-0.0708 to -0.0655)	-0.0238 (-0.0424 to -0.0052)	-0.0159 (-0.0367 to 0.0049)
	Affordability	-0.1546 (-0.1582 to -0.1509)	0.0902 (0.0646 to 0.1158)	-0.1284 (-0.1716 to -0.0853)
>200	Intercept	5.5016 (5.1643 to 5.8389)	-2.8931 (-5.3083 to -0.4779)	-5.2838 (-8.4358 to -2.1319)
	slope1	0.0254 (0.0247 to 0.0261)	0.0124 (0.0077 to 0.0171)	0.0264 (0.0222 to 0.0306)
	level1	-2.3966 (-2.6743 to -2.1188)	2.0111 (0.0222 to 4.0000)	3.5140 (1.7514 to 5.2765)
	slope2	0.0332 (0.0313 to 0.0352)	-0.0147 (-0.0287 to -0.0008)	-0.0107 (-0.0231 to 0.0017)
	level2	10.7207 (10.1152 to 11.3262)	0.3811 (-3.9546 to 4.7169)	-0.6277 (-4.4811 to 3.2256)
	slope3	-0.0308 (-0.0336 to -0.0279)	-0.0138 (-0.0344 to 0.0067)	-0.0047 (-0.0230 to 0.0136)
	Affordability	-0.0804 (-0.0839 to -0.0768)	0.0280 (0.0025 to 0.0535)	0.0333 (0.0040 to 0.0625)

Supplement Table 3c Standardized Coefficients (95% confidence intervals) for level and slope changes on three dependent variables by class group (summarized in Figure 4c of paper)

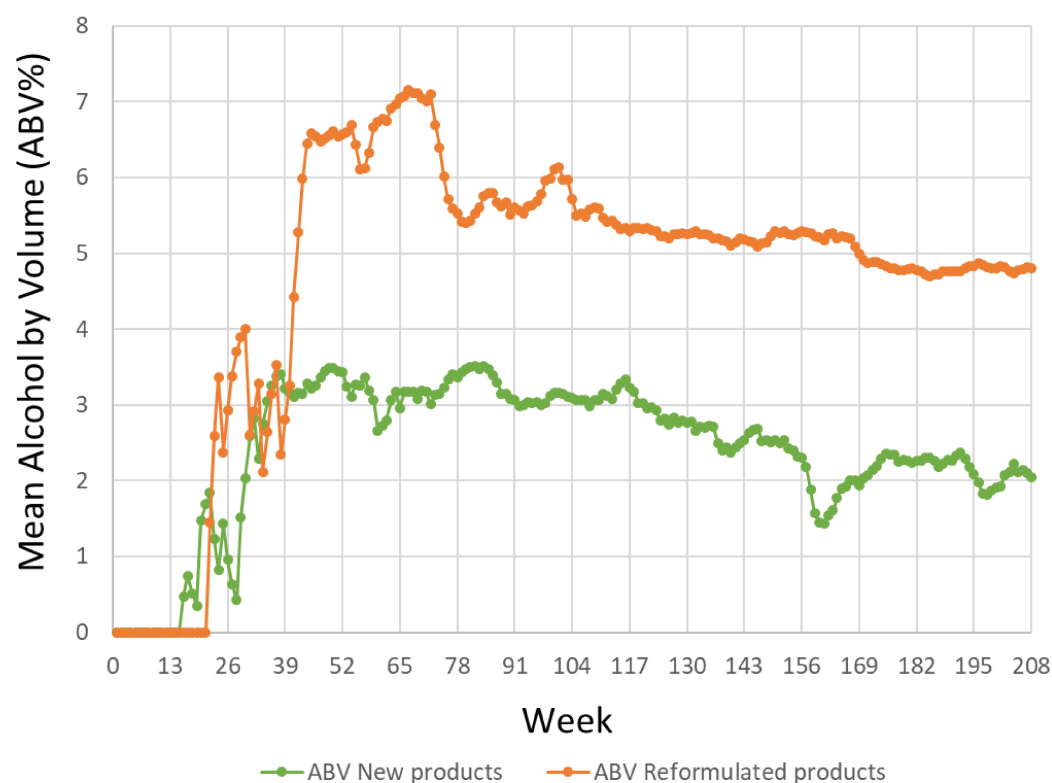
Class group	Independent variable	Mean ABV of beer	Grams of alcohol purchased within beer	Grams of alcohol purchased overall
AB	Intercept	10.3811 (10.1217 to 10.6405)	-7.7018 (-10.694 to -4.7096)	13.2358 (8.7704 to 17.7012)
	slope1	0.0056 (0.0051 to 0.0060)	0.0051 (0.0002 to 0.0101)	-0.0010 (-0.0062 to 0.0041)
	level1	1.0319 (0.8567 to 1.2071)	0.9669 (-1.0541 to 2.9879)	-1.0752 (-3.2549 to 1.1044)
	slope2	-0.0082 (-0.0094 to -0.0070)	-0.0080 (-0.0222 to 0.0063)	0.0027 (-0.0127 to 0.0180)
	level2	9.5631 (9.1821 to 9.9441)	10.1302 (5.7347 to 14.5258)	3.5553 (-1.1735 to 8.2841)
	slope3	-0.0666 (-0.0684 to -0.0648)	-0.0598 (-0.0806 to -0.0391)	-0.0142 (-0.0366 to 0.0082)
	Affordability	-0.0885 (-0.0909 to -0.0862)	0.0664 (0.0398 to 0.0931)	-0.1327 (-0.1783 to -0.0872)
C1	Intercept	18.7251 (18.2803 to 19.1700)	-7.2876 (-10.409 to -4.1657)	11.5097 (5.9802 to 17.0393)
	slope1	0.0305 (0.0299 to 0.0310)	0.0265 (0.0225 to 0.0305)	0.0229 (0.0180 to 0.0278)
	level1	5.8510 (5.6229 to 6.0792)	3.3383 (1.7374 to 4.9392)	2.0898 (0.1470 to 4.0326)
	slope2	-0.0282 (-0.0298 to -0.0265)	-0.0146 (-0.0259 to -0.0033)	-0.0039 (-0.0177 to 0.0098)
	level2	10.6811 (10.1872 to 11.1750)	3.0130 (-0.4525 to 6.4786)	2.5702 (-1.6317 to 6.7720)
	slope3	-0.0828 (-0.0851 to -0.0804)	-0.0267 (-0.0431 to -0.0103)	-0.0181 (-0.0380 to 0.0018)
	Affordability	-0.2080 (-0.2126 to -0.2035)	0.0600 (0.0279 to 0.0921)	-0.1334 (-0.1907 to -0.0760)
C2	Intercept	17.4380 (16.7654 to 18.1105)	-7.1052 (-9.6228 to -4.5875)	0.6762 (-3.1545 to 4.5070)
	slope1	0.0255 (0.0245 to 0.0266)	0.0182 (0.0143 to 0.0221)	0.0059 (0.0014 to 0.0103)
	level1	3.7201 (3.2774 to 4.1629)	0.2289 (-1.4286 to 1.8864)	0.0691 (-1.8158 to 1.9540)
	slope2	-0.0141 (-0.0172 to -0.0110)	0.0084 (-0.0033 to 0.0201)	0.0005 (-0.0128 to 0.0138)
	level2	2.0455 (1.0858 to 3.0051)	18.4034 (14.8108 to 21.9960)	15.5556 (11.4880 to 19.6231)
	slope3	-0.0264 (-0.0309 to -0.0218)	-0.0901 (-0.1071 to -0.0731)	-0.0872 (-0.1064 to -0.0680)
	Affordability	-0.2122 (-0.2197 to -0.2047)	0.0657 (0.0376 to 0.0939)	-0.0075 (-0.0462 to 0.0311)
D	Intercept	6.4778 (6.3203 to 6.6354)	-6.1403 (-8.1824 to -4.0981)	-2.5653 (-6.0471 to 0.9165)
	slope1	0.0214 (0.0211 to 0.0217)	-0.0082 (-0.0118 to -0.0046)	0.0055 (0.0011 to 0.0099)
	level1	-1.6613 (-1.7802 to -1.5424)	-0.2982 (-1.8396 to 1.2432)	2.9013 (1.0339 to 4.7687)
	slope2	0.0235 (0.0227 to 0.0244)	-0.0106 (-0.0213 to 0.0002)	-0.0271 (-0.0402 to -0.0140)
	level2	2.3828 (2.1289 to 2.6367)	3.0638 (-0.2275 to 6.3552)	-7.7948 (-11.827 to -3.7628)
	slope3	0.0108 (0.0096 to 0.0120)	-0.0197 (-0.0353 to -0.0042)	0.0236 (0.0045 to 0.0427)
	Affordability	-0.0877 (-0.0894 to -0.0861)	0.0762 (0.0549 to 0.0974)	0.0302 (-0.0077 to 0.0681)
E	Intercept	4.8166 (3.3762 to 6.2569)	0.6999 (-1.2048 to 2.6046)	1.7636 (-1.1311 to 4.6583)
	slope1	0.0044 (0.0006 to 0.0082)	-0.0112 (-0.0163 to -0.0062)	-0.0002 (-0.0056 to 0.0053)
	level1	-3.2740 (-4.8786 to -1.6693)	0.4102 (-1.7117 to 2.5322)	1.5503 (-0.6544 to 3.7550)
	slope2	0.0308 (0.0195 to 0.0420)	-0.0074 (-0.0222 to 0.0075)	-0.0134 (-0.0290 to 0.0021)
	level2	8.7194 (5.2629 to 12.1760)	5.2901 (0.7191 to 9.8611)	-7.3901 (-12.169 to -2.6110)
	slope3	-0.0288 (-0.0451 to -0.0124)	-0.0384 (-0.0600 to -0.0167)	0.0340 (0.0114 to 0.0566)
	Affordability	-0.0588 (-0.0735 to -0.0442)	0.0012 (-0.0182 to 0.0205)	-0.0210 (-0.0523 to 0.0102)

Supplement Table 3d Standardized Coefficients (95% confidence intervals) for level and slope changes on three dependent variables by income group (annual income per adult per household) (summarized in Figure 4d of paper)

Income group	Independent variable	Mean ABV of beer	Grams of alcohol purchased within beer	Grams of alcohol purchased overall
£0-7.5k	Intercept	10.7084 (10.5114 to 10.9053)	1.2027 (-2.3718 to 4.7772)	7.1377 (3.0204 to 11.2550)
	slope1	0.0133 (0.0130 to 0.0136)	0.0017 (-0.0038 to 0.0071)	0.0054 (0.0004 to 0.0105)
	level1	3.4587 (3.3335 to 3.5839)	-1.0214 (-3.2940 to 1.2512)	-2.0033 (-4.1770 to 0.1704)
	slope2	-0.0110 (-0.0119 to -0.0101)	0.0037 (-0.0127 to 0.0201)	0.0145 (-0.0017 to 0.0306)
	level2	-4.3528 (-4.6254 to -4.0801)	9.0646 (4.1158 to 14.0134)	6.2994 (1.6569 to 10.9420)
	slope3	0.0006 (-0.0007 to 0.0019)	-0.0461 (-0.0692 to -0.0230)	-0.0236 (-0.0450 to -0.0021)
	Affordability	-0.1380 (-0.1402 to -0.1358)	-0.0121 (-0.0521 to 0.0280)	-0.0897 (-0.1369 to -0.0425)
>7.5-12.5k	Intercept	14.6207 (13.8941 to 15.3473)	-9.4679 (-12.044 to -6.8914)	-3.7412 (-9.3123 to 1.8299)
	slope1	0.0268 (0.0256 to 0.0279)	0.0088 (0.0047 to 0.0129)	0.0162 (0.0108 to 0.0215)
	level1	0.8051 (0.3154 to 1.2948)	2.0152 (0.2787 to 3.7516)	2.8258 (0.6278 to 5.0237)
	slope2	0.0072 (0.0038 to 0.0107)	-0.0173 (-0.0295 to -0.0051)	-0.0119 (-0.0275 to 0.0036)
	level2	15.1413 (14.0793 to 16.2032)	2.8045 (-0.9614 to 6.5704)	0.1073 (-4.6463 to 4.8610)
	slope3	-0.0804 (-0.0854 to -0.0753)	-0.0258 (-0.0436 to -0.0079)	-0.0100 (-0.0328 to 0.0127)
	Affordability	-0.1835 (-0.1917 to -0.1753)	0.1062 (0.0770 to 0.1353)	0.0286 (-0.0291 to 0.0863)
>12.5-15.5k	Intercept	16.2965 (14.3281 to 18.2648)	-10.937 (-14.327 to -7.5466)	6.9795 (1.6331 to 12.3259)
	slope1	0.0195 (0.0169 to 0.0222)	0.0098 (0.0053 to 0.0143)	0.0023 (-0.0026 to 0.0071)
	level1	5.6193 (4.5307 to 6.7080)	0.3358 (-1.5393 to 2.2110)	2.7266 (0.6644 to 4.7888)
	slope2	-0.0325 (-0.0402 to -0.0248)	0.0024 (-0.0109 to 0.0157)	-0.0271 (-0.0418 to -0.0124)
	level2	9.7452 (7.3700 to 12.1205)	14.4585 (10.3674 to 18.5496)	-4.1826 (-8.5973 to 0.2320)
	slope3	-0.0777 (-0.0889 to -0.0665)	-0.0711 (-0.0904 to -0.0518)	0.0011 (-0.0198 to 0.0220)
	Affordability	-0.1845 (-0.2052 to -0.1637)	0.1082 (0.0725 to 0.1440)	-0.0716 (-0.1294 to -0.0138)
>17.5 to 25k	Intercept	8.8221 (8.6147 to 9.0294)	-1.6651 (-3.7553 to 0.4251)	1.8295 (-2.4953 to 6.1544)
	slope1	0.0199 (0.0195 to 0.0203)	0.0145 (0.0107 to 0.0183)	-0.0055 (-0.0107 to -0.0003)
	level1	5.2513 (5.0913 to 5.4113)	4.1802 (2.5674 to 5.7930)	3.5865 (1.3897 to 5.7833)
	slope2	-0.0417 (-0.0428 to -0.0405)	-0.0306 (-0.0420 to -0.0192)	-0.0300 (-0.0455 to -0.0144)
	level2	-6.6277 (-6.9747 to -6.2807)	7.4828 (3.9856 to 10.9800)	-5.7067 (-10.499 to -0.9148)
	slope3	0.0021 (0.0005 to 0.0037)	-0.0632 (-0.0797 to -0.0467)	0.0046 (-0.0179 to 0.0272)
	Affordability	-0.1068 (-0.1092 to -0.1044)	0.0151 (-0.0089 to 0.0391)	-0.0153 (-0.0666 to 0.0361)
>25k	Intercept	13.6878 (13.4368 to 13.9388)	-9.7236 (-12.811 to -6.6364)	-1.1833 (-6.2690 to 3.9025)
	slope1	0.0125 (0.0121 to 0.0129)	0.0143 (0.0095 to 0.0190)	0.0047 (-0.0007 to 0.0101)
	level1	0.5589 (0.3969 to 0.7208)	0.6201 (-1.3722 to 2.6124)	-0.2177 (-2.5269 to 2.0915)
	slope2	-0.0032 (-0.0043 to -0.0020)	0.0015 (-0.0125 to 0.0156)	0.0016 (-0.0146 to 0.0178)
	level2	17.3089 (16.9579 to 17.6600)	4.5841 (0.2655 to 8.9026)	5.0661 (0.0959 to 10.0363)
	slope3	-0.1042 (-0.1058 to -0.1025)	-0.0235 (-0.0440 to -0.0030)	-0.0214 (-0.0450 to 0.0022)
	Affordability	-0.1320 (-0.1343 to -0.1296)	0.0855 (0.0561 to 0.1148)	0.0093 (-0.0446 to 0.0633)

Supplement Table 3e Standardized Coefficients (95% confidence intervals) for level and slope changes on three dependent variables by area of Great Britain (summarized in Figure 4e of paper)

Area	Independent variable	Mean ABV of beer	Grams of alcohol purchased within beer	Grams of alcohol purchased overall
South England	Intercept	15.0851 (14.6594 to 15.5109)	-10.744 (-14.353 to -7.1359)	9.4516 (3.9966 to 14.9067)
	slope1	0.0119 (0.0113 to 0.0125)	0.0123 (0.0073 to 0.0172)	0.0096 (0.0042 to 0.0149)
	level1	4.9291 (4.6984 to 5.1598)	1.6822 (-0.2733 to 3.6377)	3.2200 (1.0032 to 5.4368)
	slope2	-0.0316 (-0.0332 to -0.0300)	-0.0079 (-0.0216 to 0.0058)	-0.0221 (-0.0378 to -0.0065)
	level2	6.4156 (5.9210 to 6.9101)	8.4270 (4.2357 to 12.6184)	-3.2493 (-8.0533 to 1.5547)
	slope3	-0.0684 (-0.0708 to -0.0661)	-0.0488 (-0.0686 to -0.0290)	-0.0020 (-0.0248 to 0.0207)
	Affordability	-0.1487 (-0.1529 to -0.1444)	0.0975 (0.0617 to 0.1334)	-0.0979 (-0.1527 to -0.0431)
Mid England	Intercept	15.1188 (13.9018 to 16.3358)	-6.8273 (-9.9926 to -3.6619)	4.6812 (0.4278 to 8.9346)
	slope1	0.0151 (0.0132 to 0.0169)	0.0075 (0.0026 to 0.0124)	0.0142 (0.0092 to 0.0193)
	level1	2.2080 (1.4099 to 3.0062)	1.6405 (-0.4355 to 3.7164)	1.2195 (-0.8693 to 3.3082)
	slope2	-0.0053 (-0.0109 to 0.0003)	-0.0123 (-0.0269 to 0.0023)	-0.0019 (-0.0167 to 0.0128)
	level2	11.2956 (9.5624 to 13.0289)	6.9552 (2.4471 to 11.4633)	10.5672 (6.0630 to 15.0714)
	slope3	-0.0633 (-0.0715 to -0.0551)	-0.0449 (-0.0662 to -0.0236)	-0.0562 (-0.0776 to -0.0348)
	Affordability	-0.1738 (-0.1867 to -0.1609)	0.0702 (0.0367 to 0.1037)	-0.0542 (-0.0953 to -0.0132)
Wales	Intercept	10.5688 (10.3670 to 10.7707)	-5.6136 (-7.0918 to -4.1355)	1.6984 (0.1397 to 3.2572)
	slope1	-0.0115 (-0.0122 to -0.0109)	-0.0054 (-0.0099 to -0.0009)	-0.0256 (-0.0291 to -0.0221)
	level1	-5.8188 (-6.0780 to -5.5597)	-3.5790 (-5.4769 to -1.6812)	-1.9004 (-3.3707 to -0.4300)
	slope2	0.0360 (0.0342 to 0.0378)	0.0210 (0.0077 to 0.0344)	-0.0030 (-0.0134 to 0.0073)
	level2	12.6154 (12.0532 to 13.1777)	10.8352 (6.7182 to 14.9523)	-1.2597 (-4.4601 to 1.9407)
	slope3	-0.0348 (-0.0375 to -0.0321)	-0.0388 (-0.0583 to -0.0193)	0.0122 (-0.0030 to 0.0274)
	Affordability	-0.1267 (-0.1292 to -0.1242)	0.0749 (0.0566 to 0.0932)	-0.0018 (-0.0216 to 0.0180)
North England	Intercept	5.1873 (3.9921 to 6.3825)	-9.8251 (-12.808 to -6.8425)	6.1450 (1.0442 to 11.2457)
	slope1	0.0330 (0.0313 to 0.0347)	0.0160 (0.0117 to 0.0203)	0.0119 (0.0068 to 0.0169)
	level1	1.2605 (0.5236 to 1.9974)	0.8541 (-0.9849 to 2.6930)	-1.7120 (-3.8138 to 0.3899)
	slope2	0.0089 (0.0037 to 0.0140)	-0.0032 (-0.0161 to 0.0096)	0.0144 (-0.0004 to 0.0291)
	level2	10.0256 (8.4459 to 11.6053)	8.0203 (4.0782 to 11.9624)	3.9712 (-0.5922 to 8.5346)
	slope3	-0.0488 (-0.0562 to -0.0413)	-0.0447 (-0.0634 to -0.0261)	-0.0050 (-0.0267 to 0.0166)
	Affordability	-0.0716 (-0.0831 to -0.0601)	0.0900 (0.0612 to 0.1187)	-0.0707 (-0.1231 to -0.0182)
Scotland	Intercept	1.8890 (1.4742 to 2.3038)	-4.3141 (-6.1605 to -2.4677)	-4.0675 (-6.1548 to -1.9803)
	slope1	0.0363 (0.0353 to 0.0373)	-0.0024 (-0.0067 to 0.0020)	-0.0003 (-0.0034 to 0.0028)
	level1	5.1136 (4.6959 to 5.5313)	1.2579 (-0.6012 to 3.1170)	-0.3175 (-1.6613 to 1.0263)
	slope2	-0.0179 (-0.0209 to -0.0150)	-0.0096 (-0.0227 to 0.0035)	-0.0021 (-0.0116 to 0.0073)
	level2	2.5702 (1.6674 to 3.4731)	2.9179 (-1.1009 to 6.9366)	4.8517 (2.0679 to 7.6355)
	slope3	-0.0336 (-0.0379 to -0.0294)	-0.0285 (-0.0474 to -0.0095)	-0.0336 (-0.0468 to -0.0203)
	Affordability	-0.0366 (-0.0403 to -0.0329)	0.0430 (0.0265 to 0.0596)	0.0471 (0.0258 to 0.0684)



Supplement Figure 6 Mean alcohol by volume (ABV%) of new low and no alcohol products and reformulated products by week.