OXFORD UNIVERSITY PRESS | Journal of Public Health

http://mc.manuscriptcentral.com/jph

Getting shops to voluntarily stop selling cheap, strong beers and ciders: a time-series analysis evaluating impacts on alcohol availability and purchasing

Journal:	*Journal of Public Health*
Manuscript ID	JPH-17-0237.R2
Manuscript Type:	Original Article
Date Submitted by the Author:	n/a
Complete List of Authors:	Pliakas, Triantafyllos; London School of Hygiene and Tropical Medicine, Health Services Research and Policy Lock, Karen; London School of Hygiene and Tropical Medicine, National Institute for Health Research School for Public Health Research Jones, Amanda; Directorate of Public Health and Protection, Suffolk County Council Aalders, Simon; Directorate of Public Health and Protection, Suffolk County Council Egan, Matt; London School of Hygiene and Tropical Medicine, National Institute for Health Research School for Public Health Research
Keywords:	Public health, Alcohol, Alcohol consumption

Title: Getting shops to voluntarily stop selling cheap, strong beers and ciders: a time-series analysis evaluating impacts on alcohol availability and purchasing.

Authors: Pliakas T, Lock K, Jones A, Aalders S, Egan M

Affiliations:

Triantafyllos Pliakas (corresponding author)

Research Fellow

National Institute for Health Research School for Public Health Research, London School of Hygiene & Tropical Medicine, 15-17 Tavistock Place, London, WC1H 9SH, UK

Email: triantafyllos.pliakas@lshtm.ac.uk

Karen Lock

Professor of Public Health

National Institute for Health Research School for Public Health Research, London School of Hygiene & Tropical Medicine, 15-17 Tavistock Place, London, WC1H 9SH, UK

Amanda Jones

Directorate of Public Health and Protection, Suffolk County Council, Ipswich, UK

Simon Aalders

Directorate of Public Health and Protection, Suffolk County Council, Ipswich, UK

Matt Egan

Associate Professor

National Institute for Health Research School for Public Health Research, London School of Hygiene & Tropical Medicine, 15-17 Tavistock Place, London, WC1H 9SH, UK

Declaration of interest: This study was funded by the National Institute for Health Research School for Public Health Research (NIHR SPHR). Two co-authors (AJ and SA) contributed as part of their normal salaried work for Suffolk County Council. The East of England Co-operative Society supplied the retail sales data but played no role in the funding of the study. The East of England Co-operative Society, the NHS, the NIHR SPHR and the Department of Health played no role in the design of the study, the interpretation of the findings, the writing of the paper or the decision to submit.

Abstract

Background

'*Reducing the Strength*' (RtS) is a public health initiative encouraging retailers to voluntarily stop selling cheap, strong beers/ciders (≥6·5% alcohol by volume). This study evaluates the impact of RtS initiatives on alcohol availability and purchasing in three English counties with a combined population of 3,62 million people.

Methods

We used a multiple baseline time-series design to examine retail data over 29 months from a supermarket chain that experienced a two-wave, area-based role out of RtS: initially 54 stores (W1), then another 77 stores (W2). We measured impacts on units of alcohol sold (primary outcome: beers/ciders; secondary outcome: all alcoholic products), economic impacts on alcohol sales and substitution effects.

Results

We observed a non-significant W1 increase (+3.7%, 95% CI = -11.2, 21.0) and W2 decrease (-6.8%, 95% CI = -20.5, 9.4) in the primary outcome. We observed a significant W2 decrease in units sold across all alcohol products (-10.5%, 95% CI =-19.2, -0.9). The direction of effect between waves was inconsistent for all outcomes, including alcohol sales, with no evidence of substitution effects.

Conclusions

In the UK, voluntary RtS initiatives appear to have little or no impact on reducing alcohol availability and purchase from the broader population of supermarket customers.

Introduction

Modifying the availability of commercial products (e.g. alcohol, food) is a widely advocated public health strategy.[1, 2] The World Health Organization has proposed a number of interventions and policies to reduce availability including interventions reducing the alcoholic strength of products.[3] Research from North America, Australia and Europe has examined ways in which modifying local food availability impacts on health outcomes,[4-7] but there are relatively fewer evaluations of local alcohol availability interventions.[1, 6, 8-14]

Alcohol is a causal factor in more than 200 disease and injury conditions accounting for 5.9% of deaths worldwide.[2] Social costs attributable to alcohol, including crime and disorder, representing 1.3% to 3.3% of gross domestic product globally.[2] Interventions modifying alcohol availability have been seen to reduce both alcohol consumption and alcohol related harm.[2, 15-19] In many countries, including the United Kingdom (UK), attempts to modify availability through national government regulation, such as minimum unit pricing, have been met with political and legal barriers. Regulating the sale and consumption of alcohol products often takes place at sub-national levels.[6, 8, 20] Local government initiatives to reduce alcohol availability have been implemented, involving both statutory and voluntary approaches, the latter often targeting specific population groups.[15, 21-24]

Evaluative research of natural policy experiments is important because innovative practices can diffuse to new settings, including across national boundaries, sometimes before they have been robustly evaluated.[25, 26] Reducing the strength of alcoholic products or modifying high strength product availability have been proposed as 'best practices' to regulate physical availability.[3, 27] This, however, stems from an interpretation of availability theory rather than a synthesis of empirical evidence assessing impacts of reducing availability of high strength beers and ciders (so-called 'superstrength' products) and the evidence base around this is

under-developed. Superstrength products and their marketing have been said to encourage alcohol misuse and harmful behaviours among vulnerable populations.[28] In the UK, the term 'Reducing the Strength' (RtS) is now widely used to refer to area-based public health initiatives that involve removing low price, superstrength alcoholic products from sale in stores through voluntary agreements with local retailers and off-licenses. RtS has been originally designed to tackle problems associated with alcohol social harms, often focused on street drinking.[22] Suffolk was the first UK area to adopt the initiative in 2012 as part of a multi-intervention approach to tackling street drinking. Since then at least 30 schemes have been implemented in the UK.[29] The approach varies, but most RtS initiatives tend to target alcohol products above 6.5% alcohol by volume (ABV), although some have focused on a slightly lower ABV or lower cost products.[22] In this RtS, the products targeted were lower cost products above 7.5% ABV. Superstrength products vary by price, brand and strength. The least expensive products (e.g. 'white ciders') are amongst the lowest cost per unit alcohol products in UK stores, purchased for as little as 11.1 pence per unit.[30, 31] UK local and regional governments have complained to the alcohol industry that specific superstrength products sold in 500ml cans encourage rapid consumption of high quantities of alcohol causing population harms; although this is refuted by the industry.[32]

It has been argued that targeted interventions, such as RtS, offer local and regional government authorities a potential means of tackling publicly visible social and health problems associated with alcohol consumption.[21, 22, 29] Retailers and the alcohol industry have raised concerns about RtS that have included questioning its evidence base, legal status (in terms of competition law) and its potential financial impact.[22, 33-35] On the other hand, some retailers arguably demonstrate a degree of support for RtS by voluntarily participating in initiatives, although their reasons for doing so may vary. For example, some retailers saw street drinking as a problem in their area and hoped that participation would reduce anti-

social behaviour within their own shops while others saw this as an opportunity to co-operate with the licensing authorities.[35] An intervention that is designed to deter anti-social customers could potentially improve shops' image with the wider customer base in addition to licensing authorities and other stakeholders.[22, 33, 36, 37]

From a public health perspective, it remains unclear to what extent local-level voluntary interventions, such as RtS, can play an effective role in reducing alcohol consumption at the population level.[12] Retail sales data routinely collected by shops provides one means of measuring the impact of alcohol interventions. Such data can provide an objective and accurate estimate of alcohol purchase and proxy consumption, particularly in the case of larger supermarket and shop chains that have invested heavily in data collection.[38] However, shop-level data are hard to obtain due to commercial sensitivity.[39] There are few published evaluations of alcohol interventions in the UK using retail data to assess changes in physical and economic availability of specific alcohol products for health improvement.[18, 40]

The RtS studied here was originally launched as a joint initiative between Suffolk Police, Ipswich Borough Council, Suffolk County Council and the National Health Service (Suffolk) in September 2012.[41] Following interviews with local practitioners and policymakers who designed and implemented the RtS in Suffolk, we hypothesised several possible mechanisms for RtS impacts on alcohol availability and sales. These include a potential 'nudge' effect where the impact of reducing physical availability of alcohol products by removing super-strength products helped discourage and denormalise the practice of purchasing cheap products. The RtS was also theorised as an economic availability intervention: customers with finite resources wishing to purchase low cost per unit super-strength products may, on finding those products removed, substitute for products with lower alcohol content or for different alcohol products.[29, 35] This study aims to evaluate the impact of the introduction of a

RtS initiative on alcohol availability in the form of overall availability of alcohol units and purchasing in one national retail chain across three English counties using time-series analyses of retail sales data.

Methods

Setting and intervention

A major supermarket chain (East of England Co-operative Society, known commonly as 'Co-op') voluntarily joined RtS in Suffolk and consequently ensured that its stores in that county cleared their stock of all their low-priced brands of high-strength beers/lagers and ciders in the month leading up to September 2012. These consisted of four superstrength products (7.5% to 9.0% ABV) but did not include any more expensive 'craft' or 'premium' high-strength products as the implementers did not associate such products with street drinking (Table 1). The same chain required stores in Essex and Norfolk to begin a similar process of withdrawing those products from sale by September 2013. Every shop from the chain participated in the intervention although a minority of stores, 6% from wave 1 and 36% from wave 2, took longer than one month to stop selling superstrength products (Appendix S1).

[Table 1 here]

Data

Monthly retail sales data were provided for the period January 2012 to May 2014 obtained for 131 stores in one retail chain in the three English counties. We used the full range of data that East of England Co-operative Society provided us with for this analysis: the researchers did not have direct access to the company's internal data systems but rather were sent data pertaining only to the intervention period and localities so that the researchers could analyse them independently. Shop-level characteristics and sales data were available including prices,

quantities, product brands, alcohol content, and sales for the following drink categories: beer/ lager and cider, wines, affordable sparkling and low alcohol wines, and spirits. Our primary outcome was units of alcohol sold for beer/lager and cider. Secondary outcomes included units of alcohol sold for two high strength premium products (ABV over 7.5%) not removed as part of the RtS (Table 1), the remaining drink categories and for all products in order to examine substitution effects and in line with qualitative findings on drinkers' responses to RtS. We looked at sales value to assess the potential economic impact of RtS on stores. Stores in Suffolk (n=54) were regarded as stores participating in wave 1 (W1) of the intervention and stores in Norfolk and Essex (n=77) as stores participating in wave 2 (W2) a year later.

Statistical analysis

We used a quasi-experimental multiple baseline time-series design[42] to study changes in units of alcohol sold and sales value for beer/lager and cider, wines, sparkling and low alcohol wines, spirits and for total alcohol products after the introduction of the RtS initiative. The RtS was introduced in a staggered approach, implemented at two different time points (W1 and W2) across three different geographical areas with a combined population of 3,62 million people.[43] We examined the impact of implementing RtS separately for the two waves in order to identify whether the intervention produced similar effects in the entire population of interest (ie. whether the impact of the intervention was consistent in the two waves).[42, 44] The repeated pattern of a reduction in the measured outcome following the implementation of the intervention in each geographical area (i.e. wave) would suggest that the intervention is having an effect.[42] An appropriate statistical approach to evaluate such impacts is the use of segmented linear regression, which divides a time series into pre- and post-intervention segments,[44] with panel-corrected standard errors.[45, 46] We took autocorrelation into account by means of a common autoregressive first order (AR(1)) model and we included the

calendar month as a term to adjust for seasonality.[44, 47] Details of the assumptions and model specification are available in Appendix S2.

The intervention effect was assumed to occur immediately after implementation, so no transition period was taken into account in the analysis. We log-transformed our dependent variables as these were highly skewed. For ease of interpretation, regression coefficients (β) were converted into per cent change in sales and units of alcohol sold using the formula [exp(β)-1]*100. This approach was used to ensure data confidentiality when using commercially sensitive information, such as sales of specific alcohol products and brands. We therefore examined substitution effects at a product category level and for high-strength premium products that were not removed rather than at the level of specific products or brands. Analysis was carried out in Stata 14.1.

Results

Stores in W1 and W2 were similar in terms of size, area-level deprivation score and urban vs semi-urban location. Stores in W1 were open on average for fewer hours compared to those in W2 (Appendix S3). Mean units of alcohol sold per store per month were lower in W1 compared to W2 stores in all products. Overall, beer/lager and cider accounted for 32.4% of total units of alcohol sold during the study period. Super-strength products removed had previously accounted for 6.5% and 3.6% of total units sold for beer/lager and cider in W1 and W2 stores, respectively (Table 2). In terms of sales, these four products accounted for 2.1% and 1.3% of total revenue for W1 and W2 stores, respectively, before the intervention (data not shown).

[Table 2 here]

Our analysis indicates that the impact of RtS on units of alcohol sold for beer/lager and cider was not significant in the two waves (Fig. 1 and Appendix S4). More specifically, following

RtS implementation, W1 stores experienced a non significant increase (3.7%, 95% Confidence Intervals (CI) = -11.2 – 21.0, P=0.647) whereas W2 stores experienced a non significant decrease (-6.8%, 95% CI =-20.5 – 9.4, P =0.390) (Figure 1). In terms of all alcohol products, the introduction of RtS was associated with a non significant increase in W1 stores (8.0%, 95% CI = -1.3 – 18.3, P =0.094). In contrast, a significant decrease (-10.5%, 95% CI =-19.2 – -0.9, P =0.034) was observed in W2 stores (Fig. 2 and Appendix S4). Similar patterns for beer/cider and lager were observed for sales value (Fig. 2).

[Figure 1 and Figure 2 here]

In order to examine substitution effects we repeated the analysis for high-strength premium products, spirits, affordable sparkling and low alcohol wines and wines. We found that all product categories experienced similar changes in units of alcohol sold and sales value during this time period in W1 and W2 to those observed for beer/lager and cider. None of them were significant except for units of alcohol sold for wines, which appeared to drive the significant decrease observed in units of alcohol sold for all products. We found no evidence of substitution effects for high-strength premium products (Fig. 1 and Appendix S4).

Discussion

Main findings of this study

We used retail sales data to evaluate the introduction of RtS, a public health initiative targeted at supermarkets and off-licenses to remove low cost, super-strength beers and ciders from sale in three English counties. Our results show that this RtS had no significant impact on total units of alcohol sold and sales value for beer/lager and cider. We also found no observable substitution effects of alcohol products attributable to the RtS intervention in the 131 stores.

What is already know on the topic

Only a small number of previous studies have used retail sales data in quasi-experimental designs to evaluate alcohol interventions. Evaluation of the Scottish Alcohol Act 2010 showed that banning alcohol multi-buy promotions did not reduce alcohol purchasing at the household level,[18] and the introduction of the Alcohol Act was not associated with any changes in off-trade beer sales.[40] In our study, the majority of results were non significant. The small significant decrease in units and value of alcohol sales of all products in W2 stores appears to be driven by declining wine (rather than beer/cider) sales.[48] Furthermore, the changes observed in the two waves were not consistent and so the overall findings showed no intervention attributable impact.[42]

An Australian evaluation of local alcohol availability restrictions (cask wines and products over 2.7% ABV) found that some participants travelled further to access non-participating shops.[13, 14] In our study we theorise that overall alcohol purchases could be influenced by whether or not customers changed where they purchased alcohol (i.e. shops not participating in RtS), or if they substituted products within participating stores.[14] Our study focused on one retail chain which maintained compliance with RtS[22] and we found no substitution effects between categories of alcohol products within study stores attributable to the intervention. Customers in the study areas had the ability to access other local stores that did not participate in the RtS but we did not detect any sudden or sustained loss of income in participating stores that might be expected if substantial numbers of customers had started shopping elsewhere for alcohol. The availability of alternative stores not participating may vary within and between the three counties studied.

Limitations of this study

The retail data we had available related to one retail supermarket chain and the data available could not be used to consider overall area effects, shop-level or brand/product-level substitution effects, individual or sub-group level purchasing or consumption.[14, 18, 37] Our results cannot be generalized to RtS initiatives that have removed products with >6.5% or lower ABV. We did not have the data to measure long term impacts on purchasing and consumption, although we theorised that RtS should impact on availability as soon as shops stopped selling superstrength products.[13, 14] The confidence intervals for our findings were wide and statistical precision might have been improved with inclusion of a greater number of stores, and/or time points.[44, 46] Stores in W1 and W2 had different rates of compliance, which may compromise internal validity.[42] In addition, RtS is only one intervention targeting alcohol consumption and harms, and we are aware that there are a range of local alcohol policies routinely implemented in local government which we were unable to adjust for. Such unmeasured events may introduce confounding and compromise internal validity.[49] Finally, segmented regression analysis has its own limitations, allowing only linear trends to be examined but changes may follow non-linear patterns.[44]

What this study adds

Our study makes an important contribution to the evidence-base for local voluntary retail alcohol interventions.[18, 40] The use of retail data is novel for evaluating alcohol initiatives and it has been advocated as an important means to monitor alcohol consumption[40, 50] despite the limitations.[38] In this study, we used a retail sales time series panel data set, that contains far more information than single cross-sectional data allowing for an increased precision in estimation.[46] Panel difference-in-differences analysis has been used in a previous study,[18] but we opted to use panel-corrected standard errors within a regression framework, because

ignoring possible correlation of regression disturbances over time and between panels may lead to overly optimistic standard errors and lead to biased statistical inference.[46]

The RtS initiative[21] was originally developed as part of a strategy that also involved alcohol and drug treatment services and street policing to tackle street drinking and anti-social behavior due to excess alcohol consumption, and there is some evidence that this targeted, multi-intervention approach led to reductions in police call outs and other indicators of social problems related to street drinking.[21, 41] This evaluation does not test RtS's impact on wider aims of tackling alcohol social harms including street drinking. The RtS was not originally expected to have impacts on reducing overall population alcohol consumption. Potential secondary effects of RtS on the broader population of alcohol consumers are of interest to the public health community.

Voluntary agreements between governments and the private sector have previously been used to encourage businesses to take actions.[36] However, there is little evidence to suggest such approaches are more (cost-) effective, particularly if they are unaccompanied by monitoring, and appropriate incentives and sanctions.[36] The alcohol industry and retail sector may be more willing to participate in voluntary initiatives targeting selected population groups (i.e. street drinkers) that have minimal impact on their profits. Our analysis suggests that RtS had no impact on revenues. Addressing alcohol related harms and drinking behaviours in 'high-risk' groups is important but our analysis suggests that RtS may not be effective for addressing alcohol harms across the whole population. The evidence base recommends regulatory or statutory enforcement interventions restricting alcohol availability are more effective than local non-regulatory or voluntary approaches targeting specific groups.[12, 51-54]

Conclusion

This evaluation did not specifically test impacts on target groups, such as street drinkers, but examined impacts on all consumers' alcohol purchasing patterns from one retail supermarket chain. Our findings suggest that voluntary RtS initiatives, have little or no impact on reducing alcohol availability and purchase amongst a broader population of customers. The research literature suggests that more effective regulatory public health interventions will be required to achieve substantial population health benefits in reducing alcohol consumption and alcohol-related harms.

Acknowledgements

We would like to acknowledge the invaluable input of and the helpful comments of Professor Mark Petticrew. We would also like to thank Mark Lewenz of East of England Co-operative Society who provided the retail sales data. Antonio Gasparrini provided expert advice on our analysis. The evaluation of the Reducing the Strength initiative is part of the programme of the School for Public Health Research (http://sphr.lshtm.ac.uk/). This is an independent research unit based at the London School of Hygiene and Tropical Medicine, funded by the National Institute for Health Research School for Public Health Research (NIHR SPHR). Sole responsibility for this research lies with the authors and the views expressed are not necessarily those of the NHS, the NIHR SPHR or the Department of Health. The East of England Co-operative Society supplied the retail sales data but played no role in the funding of the study. The East of England Co-operative Society, the NHS, the NIHR and the Department of Health played no role in the design of the study, the interpretation of the findings, the writing of the paper or the decision to submit. The views expressed are those of the author(s) and not necessarily those of the East of England Co-operative Society, NHS, the NIHR or the Department of Health.

References

1. World Health Organization. Global action plan for the prevention and control of noncommunicable diseases 2013−2020. Geneva: WHO, 2013.
2. World Health Organization. Global status report on alcohol and health. Geneva: WHO, 2014.
3. World Health Organization. Global strategy to reduce the harmful use of alcohol. Geneva: WHO, 2010.
4. Morland KB. An evaluation of a neighborhood-level intervention to a local food environment. American journal of preventive medicine 2010; 39:e31-8.
5. Gase LN, McCarthy WJ, Robles B, Kuo T. Student receptivity to new school meal offerings: assessing fruit and vegetable waste among middle school students in the Los Angeles Unified School District. Preventive Medicine 2014; 67 Suppl 1:S28-33.
6. Soler RE, Whitten KL, Ottley PG. Communities putting prevention to work: Local evaluation of community-based strategies designed to make healthy living easier. Preventive Medicine 2014; 67, Supplement 1:S1-S3.
7. Valdivia Espino J, Guerrero N, Rhoads N, Simon N, Escaron A, Meinen A, et al. Community-Based Restaurant Interventions to Promote Healthy Eating: A Systematic Review. Prev Chronic Dis 2015; 12.
8. Nelson TF, Xuan Z, Babor TF, Brewer RD, Chaloupka FJ, Gruenewald PJ, et al. Efficacy and the Strength of Evidence of U.S. Alcohol Control Policies. American journal of preventive medicine 2013; 45:19-28.
9. Rammohan V, Hahn RA, Elder R, Brewer R, Fielding J, Naimi TS, et al. Effects of Dram Shop Liability and Enhanced Overservice Law Enforcement Initiatives on Excessive Alcohol Consumption and Related Harms: Two Community Guide Systematic Reviews. American journal of preventive medicine 2011; 41:334-43.
10. Campbell CA, Hahn RA, Elder R, Brewer R, Chattopadhyay S, Fielding J, et al. The Effectiveness of Limiting Alcohol Outlet Density As a Means of Reducing Excessive Alcohol Consumption and Alcohol-Related Harms. American journal of preventive medicine 2009; 37:556-69.
11. Stockwell T, Zhao J, Giesbrecht N, Macdonald S, Thomas G, Wettlaufer A. The Raising of Minimum Alcohol Prices in Saskatchewan, Canada: Impacts on Consumption and Implications for Public Health. American journal of public health 2012; 102:e103-e10.
12. Martineau F, Tyner E, Lorenc T, Petticrew M, Lock K. Population-level interventions to reduce alcohol-related harm: an overview of systematic reviews. Preventive Medicine 2013; 57:278-96.
13. Kinnane S, Farringdon F, Henderson-Yates L, Parker H. Fitzroy Valley Alcohol Restriction Report: An evaluation of the effects of a restriction on take-away alcohol relating to measurable health and social outcomes, community perceptions and behaviours after a two year period, 2010. Available at: http://www.dao.health.wa.gov.au/DesktopModules/Bring2mind/DMX/Download.aspx?EntryId=680&Command=Core_Download&PortalId=0&TabId=211 (accessed 10 December 2015). Archived at: http://www.webcitation.org/6dhBDi59v on 11 December 2015.
14. National Drug Research Institute. Restrictions on the Sale and Supply of Alcohol: Evidence and Outcomes. Perth: National Drug Research Institute, Curtin University of Technology, 2007. Available at: http://ndri.curtin.edu.au/local/docs/pdf/publications/R207.pdf (accessed 10 December 2015). Archived at: http://www.webcitation.org/6dhAzukmG on 11 December 2015.
15. Maclennan B, Kypri K, Room R, Langley J. Local government alcohol policy development: case studies in three New Zealand communities. Addiction 2013; 108:885-95.

16. Ahern J, Margerison-Zilko C, Hubbard A, Galea S. Alcohol outlets and binge drinking in urban neighborhoods: the implications of nonlinearity for intervention and policy. American journal of public health 2013; 103:e81-7.
17. Fone D, Dunstan F, White J, Webster C, Rodgers S, Lee S, et al. Change in alcohol outlet density and alcohol-related harm to population health (CHALICE). BMC Public Health 2012; 12:428.
18. Nakamura R, Suhrcke M, Pechey R, Morciano M, Roland M, Marteau TM. Impact on alcohol purchasing of a ban on multi-buy promotions: a quasi-experimental evaluation comparing Scotland with England and Wales. Addiction 2014; 109:558-67.
19. Purshouse RC, Meier PS, Brennan A, Taylor KB, Rafia R. Estimated effect of alcohol pricing policies on health and health economic outcomes in England: an epidemiological model. Lancet 2010; 375:1355-64.
20. Han D, Gorman DM. Evaluating the Effects of the Introduction of Off-Sale Alcohol Outlets on Violent Crime. Alcohol and Alcoholism (Oxford, Oxfordshire). 2013; 48:370-4.
21. Alcohol Concern. Guide to Alcohol for Councillors. London: 2014. Available at: http://www.alcoholconcern.org.uk/wp-content/uploads/woocommerce_uploads/2014/12/Guide-to-Alcohol-160813-APPROVED.pdf (accessed 10 December 2015). Archived at: http://www.webcitation.org/6dh8ZwRom on 11 December 2015.
22. Local Government Association. Reducing the Strength schemes: Guidance for councils considering setting up a scheme, 2014. Available at: http://www.local.gov.uk/regulatory-services-and-licensing/-/journal_content/56/10180/6793034/ARTICLE (accessed 10 December 2015). Archived at: http://www.webcitation.org/6dh8jYS00 on 11 December 2015.
23. Nicholls J. The Government Alcohol Strategy 2012: Alcohol policy at a turning point? Drugs: Education, Prevention, and Policy 2012; 19:355-9.
24. Hughes K, Bellis MA, Leckenby N, Quigg Z, Hardcastle K, Sharples O, et al. Does legislation to prevent alcohol sales to drunk individuals work? Measuring the propensity for night-time sales to drunks in a UK city. Journal of epidemiology and community health 2014; 68:453-6.
25. McGill E, Egan M, Petticrew M, Mountford L, Milton S, Whitehead M, et al. Trading quality for relevance: non-health decision-makers' use of evidence on the social determinants of health. BMJ open 2015; 5.
26. Dolowitz D, Marsh D. Learning from abroad: The role of policy transfer in contemporary policy□making. Governance 2000; 13:5-23.
27. Alcohol, Public Policy G. Alcohol: No Ordinary Commodity – a summary of the second edition. Addiction 2010; 105:769-79.
28. Goodall T. White Cider and Street Drinkers: Recommendations to Reduce Harm. London: Alcohol Concern UK, 2011. Available at: http://www.thamesreach.org.uk/publications/research-reports/white-cider-and-street-drinkers/ (accessed 25 June 2015). Archived at: http://www.webcitation.org/6ZYIecFEw on 25 June 2015.
29. McGill E, Marks D, Sumpter C, Egan M. Consequences of removing cheap, super-strength beer and cider: a qualitative study of a UK local alcohol availability intervention. BMJ open 2016; 6:e010759.
30. Sweeting H. Alcohol units at pocket money prices [e-letter]. BMJ 2006; 333:825-b.
31. Gornall J. Doctors and the alcohol industry: an unhealthy mix? BMJ 2013; 346:f1889.
32. Portman Group. K Cider, Complaint decision details, 2017. Available at: http://www.portmangroup.org.uk/complaints/complaint-decisions/complaint-decision-

details/2017/01/12/k-cider (accessed 24 January 2017). Archived at: http://www.webcitation.org/6nkoGttF8 on 24 January 2017.
33. Association of Convenience Stores. Reducing the Strength: Retailer Guidance, 2015. Available at: http://www.acs.org.uk/advice/reducing-the-strength/ (accessed 10 December 2015). Archived at: http://www.webcitation.org/6dh7Gcc5S on 11 December 2015.
34. Competition and Markets Authority. High-strength alcohol schemes: competition law advice for retailers, 2015. Available at: https://www.gov.uk/government/publications/high-strength-alcohol-schemes-competition-law-advice-for-retailers (accessed 10 December 2015). Archived at: http://www.webcitation.org/6dh7NK9Rb on 11 December 2015.
35. Sumpter C, McGill E, Dickie E, Champo E, Romeri E, Egan M. Reducing the Strength: a mixed methods evaluation of alcohol retailers' willingness to voluntarily reduce the availability of low cost, high strength beers and ciders in two UK local authorities. BMC Public Health 2016; 16:448.
36. Bryden A, Petticrew M, Mays N, Eastmure E, Knai C. Voluntary agreements between government and business - a scoping review of the literature with specific reference to the Public Health Responsibility Deal. Health policy 2013; 110:186-97.
37. Community Alcohol Partnerships. About Community Alcohol Partnerships, 2015. Available at: http://www.communityalcoholpartnerships.co.uk/ (accessed 10 December 2015). Archived at: http://www.webcitation.org/6dh622qSP on 11 December 2015.
38. Robinson M, Thorpe R, Beeston C, McCartney G. A review of the validity and reliability of alcohol retail sales data for monitoring population levels of alcohol consumption: a Scottish perspective. Alcohol and alcoholism 2013; 48:231-40.
39. Egan M, Pliakas T, Grace D, McGill E, Jones A, Wong J, et al. Use of retail data in the assessment of natural experiments: the case of Reducing the Strength, an intervention to reduce alcohol availability. Lancet 2014; 384:S30.
40. Robinson M, Geue C, Lewsey J, Mackay D, McCartney G, Curnock E, et al. Evaluating the impact of the alcohol act on off-trade alcohol sales: a natural experiment in Scotland. Addiction 2014; 109:2035-43.
41. Suffolk Constabulary. Reducing the Strength Ipswich - One year on, 2012. Available at: http://www.suffolk.police.uk/safetyadvice/personalsafety/alcoholawareness/reducingthestrength/oneyearon.aspx (accessed 10 December 2015). Archived at: http://www.webcitation.org/6dh6n05NZ on 11 December 2015.
42. Hawkins NG, Sanson-Fisher RW, Shakeshaft A, D'Este C, Green LW. The multiple baseline design for evaluating population-based research. American journal of preventive medicine 2007; 33:162-8.
43. Office for National Statistics. Population Estimates for UK, England and Wales, Scotland and Northern Ireland, Mid-2014, 2015. Available at: http://www.ons.gov.uk/ons/publications/re-reference-tables.html?edition=tcm%3A77-368259 (accessed 10 December 2015). Archived at: http://www.webcitation.org/6dh6SoR4s on 11 December 2015.
44. Wagner AK, Soumerai SB, Zhang F, Ross-Degnan D. Segmented regression analysis of interrupted time series studies in medication use research. Journal of clinical pharmacy and therapeutics 2002; 27:299-309.
45. Beck N, Katz JN. What to do (and not to do) with Time-Series Cross-Section Data. The American Political Science Review 1995; 89:634-47.
46. Hoechle D. Robust standard errors for panel regressions with cross-sectional dependence. The Stata Journal 2007; 7:281-312.
47. Linden A. Conducting interrupted time-series analysis for single- and multiple-group comparisons. The Stata Journal 2015; 15:480-500.

48. The Drinks Report. UK alcohol market returns to growth, 2015. Available at: http://www.thedrinksreport.com/news/2015/16101-uk-alcohol-market-returns-to-growth.html (accessed 10 December 2015). Archived at: http://www.webcitation.org/6dh702Jz8 on 11 December 2015.
49. Craig P, Cooper C, Gunnell D, Haw S, Lawson K, Macintyre S, et al. Using natural experiments to evaluate population health interventions: new Medical Research Council guidance. Journal of epidemiology and community health 2012; 66:1182-6.
50. Robinson M, Shipton D, Walsh D, Whyte B, McCartney G. Regional alcohol consumption and alcohol-related mortality in Great Britain: novel insights using retail sales data. BMC Public Health 2015; 15:1.
51. de Vocht F, Heron J, Angus C, Brennan A, Mooney J, Lock K, et al. Measurable effects of local alcohol licensing policies on population health in England. Journal of epidemiology and community health 2016; 70:231-7.
52. de Vocht F, Heron J, Campbell R, Egan M, Mooney JD, Angus C, et al. Testing the impact of local alcohol licencing policies on reported crime rates in England. Journal of epidemiology and community health 2017; 71:137-45.
53. Knai C, Petticrew M, Durand MA, Scott C, James L, Mehrotra A, et al. The Public Health Responsibility deal: has a public-private partnership brought about action on alcohol reduction? Addiction 2015; 110:1217-25.
54. de Vocht F, Tilling K, Pliakas T, Angus C, Egan M, Brennan A, et al. The intervention effect of local alcohol licensing policies on hospital admission and crime: a natural experiment using a novel Bayesian synthetic time-series method. Journal of epidemiology and community health 2017.
55. Department of Health. Health risks from alcohol: new guidelines, 2016. Available at: https://www.gov.uk/government/consultations/health-risks-from-alcohol-new-guidelines (accessed 2 August 2017). Archived at: http://www.webcitation.org/6sQ3CIIWX on 2 August 2017.

List of titles for all figures

Figure 1 Percent change in units of alcohol sold after the introduction of the *Reducing the Strength* initiative. Wave 1 stores started implementation by September 2012. Wave 2 stores started implementation by September 2013.

Figure 2 Percent change in sales value after the introduction of the *Reducing the Strength* initiative. Wave 1 stores started implementation by September 2012. Wave 2 stores started implementation by September 2013.

Table 1 List of beer and cider products over 6.5% ABV sold during the 'Reducing the Strength' initiative.

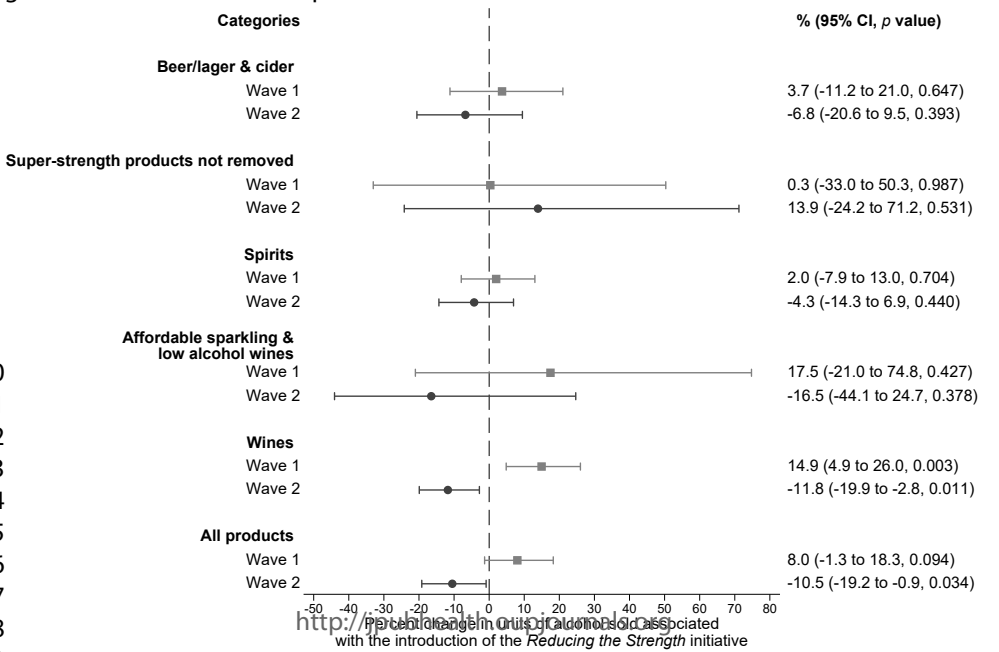
EAN	ABV	Description	Size	Units	Price (£)[a]	Price per unit (£)[a]
5010079105150	7.5	White Star[b]	2Ltr	15.0	2.50 to 5.23	0.17 to 0.35
5010153737048	9.0	Carlsberg special brew[b]	4x440ml	15.8	1.52 to 9.75	0.10 to 0.62
5000128393041	7.5	Co-op superstrength lager [b]	4x440ml	13.2	1.39 to 7.25	0.11 to 0.55
5010017012526	9.0	Tennent's super strong lager [b]	4x440ml	15.8	2.08 to 9.59	0.13 to 0.61
5014201655414	8.2	Special vintage cider [c]	500ml	4.1	1.73 to 2.13	0.42 to 0.52
5012845198120	8.2	Imperial cider [c]	500ml	4.1	2.15 to 2.61	0.52 to 0.64
5016878000207	6.7	Adnams Jack brand innovation	500ml	3.4	1.42 to 2.94	0.42 to 0.88
5012845172809	7.0	Aspall dry Suffolk cider premier cru	500ml	3.5	1.31 to 2.84	0.37 to 0.81
5012845177101	7.0	Aspall premier cru Suffolk cider pack	4x330ml	9.2	1.78 to 6.17	0.19 to 0.67
5012845172830	7.0	Aspall organic Suffolk cider	500ml	3.5	1.15 to 2.79	0.33 to 0.80
8594403110159	7.4	Budweiser Budvar Czech premium lager	330ml	2.4	0.88 to 2.28	0.36 to 0.93
5014201203554	6.5	Westons - Wyld Wood Classic cider	500ml	3.3	1.88 to 2.52	0.58 to 0.78
609722874786	7.0	NSB dry cider	750ml	5.3	1.80 to 3.78	0.34 to 0.72
609722874793	7.0	NSB medium cider	750ml	5.3	1.40 to 3.78	0.27 to 0.72
609722874809	7.0	NSB 7sweet cider	750ml	5.3	0.90 to 3.78	0.17 to 0.72
5020628002809	7.4	Thatchers Katy cider	500ml	3.7	1.78 to 2.51	0.48 to 0.68
5020628006685	7.4	Thatchers vintage cider	500ml	3.4	1.82 to 2.37	0.49 to 0.64
5010327658544	6.6	Innis & Gunn original oak aged beer	330ml	2.2	1.00 to 2.11	0.46 to 0.97
5410228102762	6.6	Leffe blonde	750ml	5.0	2.94 to 4.49	0.59 to 0.91
5410228190424	6.6	Leffe blonde pack	4x330ml	8.7	1.46 to 7.83	0.16 to 0.85
609224793127	7.0	Carter's Essex cider 7%	500ml	3.5	1.25 to 2.49	0.36 to 0.71
5011348010953	7.4	Banks's Barley Gold	4x330ml	9.8	4.42 to 5.70	0.48 to 0.62
5000264004184	7.3	McEwans champion ale	500ml	3.7	2.02 to 2.14	0.55 to 0.58
5010549302348	6.5	Old crafty hen	500ml	3.3	1.93 to 2.40	0.59 to 0.74

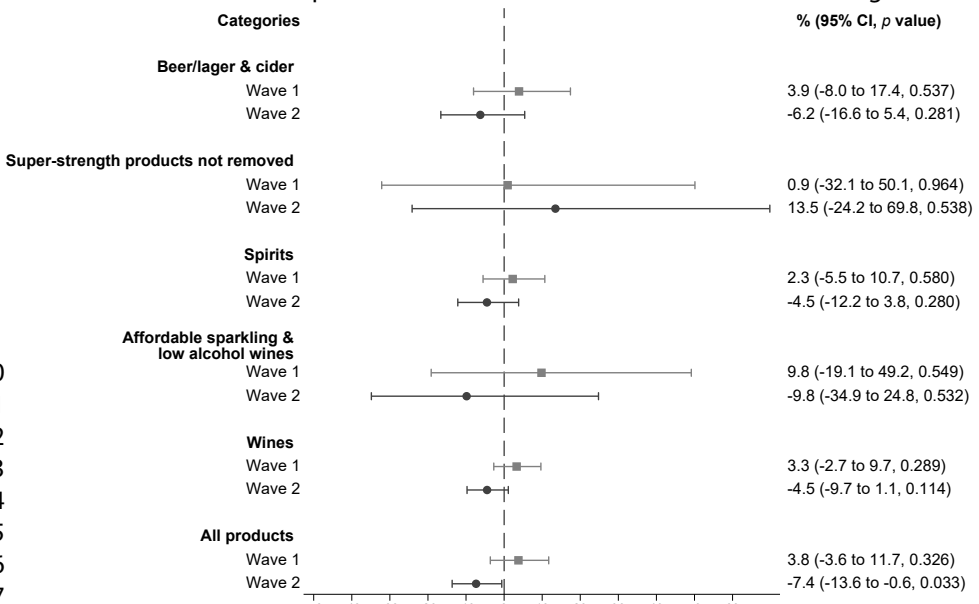
[a]: Range of values during the period of study.
[b]: Superstrength products (over 7.5% ABV) removed as part of the Reducing the Strength initiative.
[c]: High strength premium products (over 7.5% ABV) not removed as part of the Reducing the Strength initiative.
[d]: High strength premium products (over 6.5% but below 7.5% ABV) still available during the study period.
EAN: European Article Number (also called International Article Number)
ABV: Alcohol by volume (ABV) (%)
Recommended weekly limit of 14 units of alcohol for men and women[55]

Table 2 Summary statistics for units of alcohol sold per store per month.

	Stores in wave 1 (n=54)			Stores in wave 2 (n=77)			All stores (n=131)		
Product categories	**Mean (SD)**	**Median**	**Min - Max**	**Mean (SD)**	**Median**	**Min - Max**	**Mean (SD)**	**Median**	**Min - Max**
Beer/lager & cider	11,641 (8,364)	9,189	2,566 – 61,692	14,159 (9,330)	11,646	884 – 71,467	13,120 (9,029)	10,489	884 – 71,467
Of which super-strength products removed [a]	761 (680)	547	13 - 4782	512 (614)	305	13 - 5165			
Of which super-strength products not removed	334 (273)	246	4 – 1,816	388 (344)	279	4 – 2,325	365 (317)	258	4 – 2,325
Spirits	9,002 (8,261)	6,602	1,984 – 62,816	9,903 (8,279)	7,280	334 – 72,664	9,531 (8,282)	6,967	334 – 72,664
Affordable sparkling and low alcohol wines	951 (1,047)	643	66 – 13,151	1,080 (1,089)	711	35 – 9,819	1,026 (1,074)	680	35 – 13,151
Wines	16,280 (16,722)	11,334	2,485 – 133,557	17,147 (15,134)	12,786	668 – 102,783	16,790 (15,812)	12,087	668 –133,557
All products	37,873 (33,311)	28,273	10,314 – 262,238	42,277 (32,390)	33,023	1,920 –221,608	40,462 (32,840)	30,944	1,920 –262,238

[a]: Only for the period up until September 2012 for wave 1 and September 2013 for wave 2.





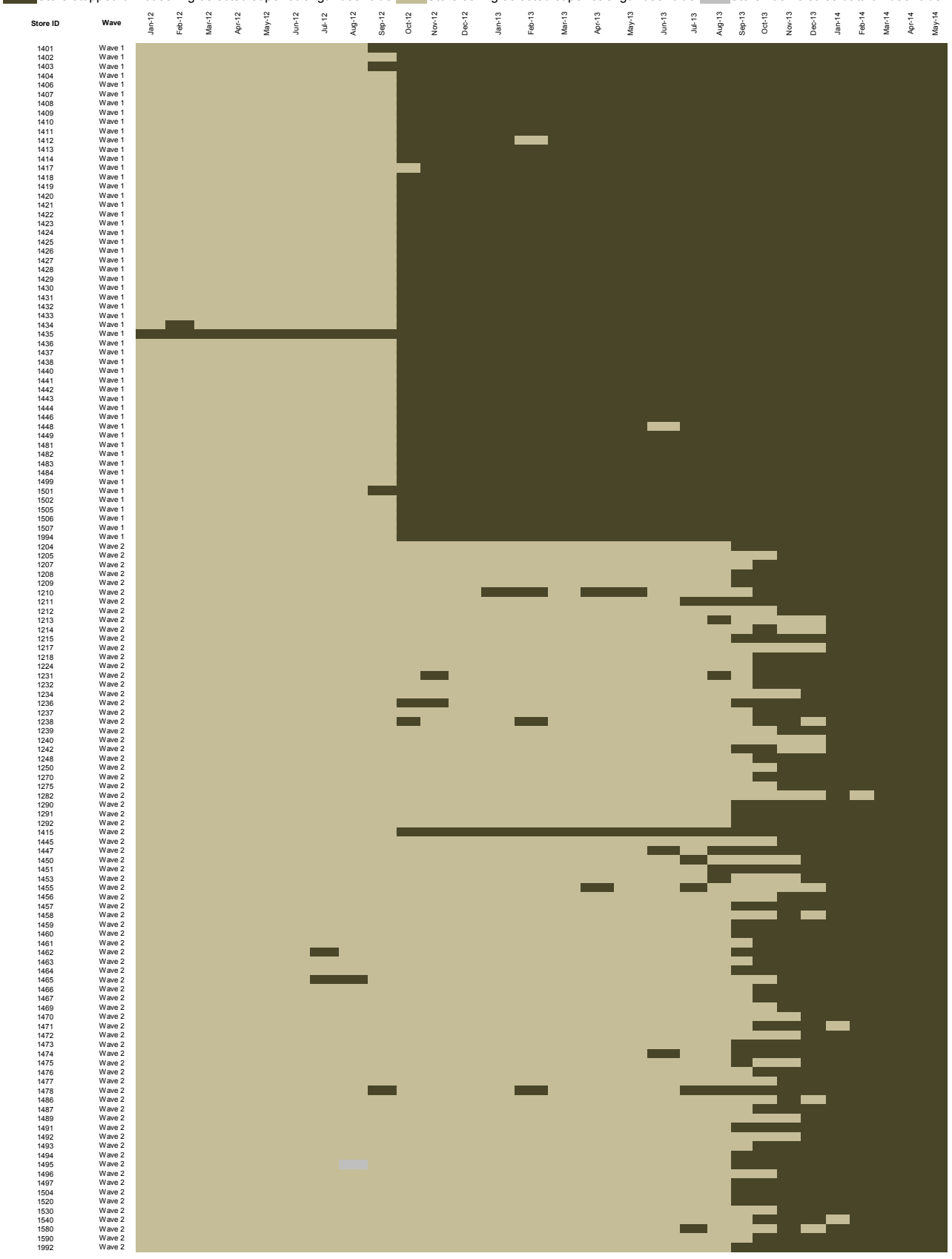
Appendix S1 Voluntary compliance in stores participating in the Reducing the Strength initiative.

Table S1 below illustrates the voluntary compliance of stores that took part in the *Reducing the Strength* initiative.

In wave 1 (Suffolk) all but three stores (94.4%) were compliant in removing the four superstrength products. However, it should be noted that only one item of a withdrawn product was sold in those three stores. In October 2012, in store ID 417, one item of 7.5% White Star (EAN 5010079105150) was sold. In February 2013, in store ID 412, one item of 7.5% CP S/Strength lager (EAN 5000128393041) was sold. In June 2013, in store ID 448, one item of 7.5% White Star (EAN 5010079105150) was sold.

In wave 2 (Essex and Norfolk), a more mixed picture of compliance was observed. The chain required stores to withdraw the *RtS* products from sale by September 2013. In October 2013, 49 of 77 stores (63.6%) had withdrawn these products. A total of 66 out of 77 (85.7%) stores had withdrawn the *RtS* products within three months. Full voluntary compliance in wave 2 stores was achieved six months (February 2014) after the initiation of the *RtS* in those areas (September 2013).

Table S1 Compliance of stores participating in the Reducing the Strength initiative.



Appendix S2 Assumptions and model specification of segmented linear regression and results before and after taking into account first-order autocorrelation (AR(1)) within panels.

Assumptions

We used segmented linear regression to examine the impact of the introduction of a *RtS* initiative on alcohol availability and purchasing in one retail chain. Segmented linear regression requires a number of assumptions that need to be met, including the typical assumptions of linear ordinary least squares analysis, the presence of seasonal trends, autocorrelation and taking into account the panel structure of the data.[1,2] Details on how these assumptions were addressed are presented below.

Model specification

Our analysis was carried out treating the data as two time series panel datasets for each of the two waves, with the primary outcomes analysed at individual store level. In each series we estimated the change in level (ie. step change) following the *RtS* intervention in wave 1 and 2, using the following regression model[2,3]:

$$Y_t = \beta_0 + \beta_1 T_t + \beta_2 X_t + \beta_3 T_t X_t + \varepsilon_t$$

where Y_t is the outcome variable at time t, T_t is the time (ie. months) since the start of the study and X is a dummy variable representing the intervention (coded as 0 and 1, before and after the intervention, respectively), and $T_t X_t$ is the interaction between time and intervention. The parameter of interest is the β_2 coefficient which represents the step change following the intervention (i.e. the introduction of *RtS*). The β_3 coefficient and the interaction term $T_t X_t$ represents the slope change (i.e. change over time). The error term ε_t at time *t* represents the random variability not explained by the model. It consists of a normally distributed random error and an error term at time *t* that may be correlated to errors at preceding or subsequent time points [3]. For an AR(1) process, the random error term ε_t is specified as follows:

$$\varepsilon_t = \rho \varepsilon_{t-1} + u_t$$

where ρ is the autocorrelation parameter (i.e. the correlation coefficient between adjacent error terms) and the disturbances u_t are independent.[3]

This analysis was separately done for stores in wave 1 and wave 2. The coefficient β_2 in the two series can then be compared to assess the consistency of the effects of the intervention across the entire study sample.[2,4] Our hypothesis was that the introduction of *RtS* would lead to a statistically significant downward change (ie. a negative β_2 coefficient) in sales and units of

alcohol sold for beer/lager and cider and all products and the observed effect would be consistent across both time series. As a result we excluded the β_3 coefficient and the interaction term $T_t X_t$ in our models.

Results before and after taking into account first-order autocorrelation (AR(1)) within panels

Our analysis indicated that the estimate of the autocorrelation parameter were high, and the standard errors were found to be larger than for the model without autocorrelation, which is to be expected if there is autocorrelation (Table S2-1 and Table S2-2).

Table S2-1 Coefficients of segmented linear regression on log transformed total units of beer/lager and cider sold without taking autocorrelation into account

	Estimated RtS effect at wave 1				Estimated RtS effect at wave 2			
Product category and parameter	beta	SE	95% CI	p value	beta	SE	95% CI	p value
Beer/lager and cider (units)								
Pre-intervention slope	0.0017	0.00173	-0.0016 to 0.0051	0.319	0.0051	0.00181	0.0015 to 0.0086	0.005
Intercept/step change	-0.0270	0.03460	-0.0948 to 0.0408	0.435	-0.0590	0.03448	-0.1265 to 0.0085	0.087
High-strength premium products (over 7.5% ABV) not removed as part of RtS (units)								
Pre-intervention slope	0.0062	0.00434	-0.0022 to 0.0147	0.150	0.0135	0.00449	0.0047 to 0.0223	0.003
Intercept/step change	0.2481	0.08701	0.0775 to 0.4186	0.004	-0.1448	0.08602	-0.3134 to 0.0237	0.092
Spirits (units)								
Pre-intervention slope	-0.0046	0.00121	-0.0069 to -0.0022	<0.001	-0.0029	0.00131	-0.0054 to -0.0003	0.027
Intercept/step change	-0.0090	0.02428	-0.0566 to 0.0385	0.710	-0.0248	0.02504	-0.0738 to 0.0243	0.323
Affordable sparkling/low alcohol wines (units)								
Pre-intervention slope	0.0081	0.00471	-0.0011 to 0.0173	0.086	0.0102	0.00468	0.0010 to 0.0193	0.030
Intercept/step change	0.0183	0.09443	-0.1667 to 0.2033	0.846	-0.0928	0.08937	-0.2679 to 0.0823	0.299
Wines (units)								
Pre-intervention slope	0.0054	0.00115	0.0031 to 0.0076	<0.001	0.0169	0.00121	0.0145 to 0.0193	<0.001
Intercept/step change	0.1202	0.02314	0.0748 to 0.1656	<0.001	-0.1327	0.02309	-0.1779 to -0.0874	<0.001
All alcohol products (units)								
Pre-intervention slope	0.0018	0.00105	-0.0002 to 0.0038	0.084	0.0079	0.00119	0.0055 to 0.0101	<0.001
Intercept/step change	0.0345	0.02098	-0.0065 to 0.0756	0.100	-0.0812	0.02265	-0.1256 to -0.0368	<0.001
Beer/lager and cider (value £)								
Pre-intervention slope	0.0005	0.00130	-0.0020 to 0.0030	0.688	-0.0003	0.00127	-0.0027 to 0.0022	0.827
Intercept/step change	-0.0650	0.02616	-0.1163 to -0.0137	0.013	0.0018	0.02415	-0.0455 to 0.0491	0.940
High-strength premium products (over 7.5% ABV) not removed as part of RtS (value £)								
Pre-intervention slope	0.0089	0.00427	0.0005 to 0.0172	0.037	0.0162	0.00446	0.0075 to 0.0250	<0.001
Intercept/step change	0.2501	0.08573	0.0821 to 0.4181	0.004	-0.1518	0.08542	-0.3192 to 0.0156	0.076
Spirits (value £)								
Pre-intervention slope	-0.0033	0.00088	-0.0050 to -0.0015	<0.001	-0.0001	0.00100	-0.0020 to 0.0018	0.933
Intercept/step change	0.0103	0.01775	-0.0244 to 0.0450	0.562	-0.0404	0.01902	-0.0777 to -0.0031	0.033
Affordable sparkling/low alcohol wines (value £)								
Pre-intervention slope	0.0057	0.00308	-0.0003 to 0.0117	0.066	0.0072	0.00343	0.0004 to 0.0139	0.036
Intercept/step change	0.0014	0.06186	-0.1198 to 0.1226	0.982	-0.0509	0.06552	-0.1793 to 0.0775	0.437
Wines (value £)								
Pre-intervention slope	-0.0008	0.00058	-0.0019 to 0.0003	0.150	0.0039	0.00069	0.0025 to 0.0052	<0.001
Intercept/step change	0.0251	0.01165	0.0022 to 0.0479	0.031	-0.0401	0.01314	-0.0658 to -0.0143	0.002

All alcohol products (value £)								
Pre-intervention slope	-0.0008	0.00072	-0.0022 to 0.0005	0.243	0.0017	0.00084	0.0001 to 0.0033	0.040
Intercept/step change	-0.0097	0.01437	-0.0379 to 0.0184	0.498	-0.0279	0.01597	-0.0592 to 0.0033	0.080

CI: Confidence intervals; SE: Standard errors.

Table S2-2 Coefficients of segmented linear regression on log transformed total units of beer/lager and cider sold taking into account first-order autocorrelation (AR(1)) within panels

	Estimated RtS effect at wave 1				Estimated RtS effect at wave			
Product category and parameter	beta	SE	95% CI	p value	beta	SE	95% CI	p value
Beer/lager and cider (units)			$\rho = 0.88$				$\rho = 0.84$	
Pre-intervention slope	-0.0011	0.00649	-0.0138 to 0.0117	0.870	0.0057	0.00617	-0.0064 to 0.0178	0.356
Intercept/step change	0.0361	0.07885	-0.1184 to 0.1907	0.647	-0.0700	0.08138	-0.2295 to 0.0895	0.390
High-strength premium (over 7.5% ABV) not removed as part of RtS (units)			$\rho = 0.66$				$\rho = 0.72$	
Pre-intervention slope	0.0159	0.01191	-0.0074 to 0.0393	0.181	0.0012	0.01293	-0.0242 to 0.0265	0.927
Intercept/step change	0.0034	0.20631	-0.4010 to 0.4077	0.987	0.1303	0.20781	-0.2770 to 0.5376	0.531
Spirits (units)			$\rho = 0.81$				$\rho = 0.85$	
Pre-intervention slope	-0.0047	0.00366	-0.0118 to 0.0025	0.202	-0.0009	0.00445	-0.0097 to 0.0078	0.832
Intercept/step change	0.0199	0.05238	-0.0828 to 0.1225	0.704	-0.0436	0.05750	-0.1564 to 0.0691	0.448
Affordable sparkling/low alcohol wines (units)			$\rho = 0.72$				$\rho = 0.76$	
Pre-intervention slope	0.0059	0.01244	-0.0185 to 0.0303	0.634	0.0176	0.01352	-0.0089 to 0.0441	0.193
Intercept/step change	0.1611	0.20263	-0.2360 to 0.5583	0.427	-0.1802	0.20721	-0.5864 to 0.2259	0.384
Wines (units)			$\rho = 0.89$				$\rho = 0.91$	
Pre-intervention slope	0.0050	0.00407	-0.0030 to 0.0130	0.222	0.0170	0.00453	0.0082 to 0.0259	0.000
Intercept/step change	0.1393	0.04688	0.0474 to 0.2312	0.003	-0.1252	0.04945	-0.2221 to -0.0282	0.011
All alcohol products (units)			$\rho = 0.91$				$\rho = 0.89$	
Pre-intervention slope	0.0006	0.00421	-0.0076 to 0.0089	0.885	0.0097	0.00446	0.0010 to 0.0185	0.029
Intercept/step change	0.0774	0.04615	-0.0131 to 0.1679	0.094	-0.1109	0.05218	-0.2132 to -0.0087	0.034
Beer/lager and cider (value £)			$\rho = 0.89$				$\rho = 0.88$	
Pre-intervention slope	-0.0037	0.00536	-0.0142 to 0.0068	0.487	0.0030	0.00496	-0.0067 to 0.0127	0.545
Intercept/step change	0.0385	0.06230	-0.0836 to 0.1606	0.537	-0.0645	0.05971	-0.1815 to 0.0526	0.280
High-strength premium (over 7.5% ABV) not removed as part of RtS (value £)			$\rho = 0.66$				$\rho = 0.72$	
Pre-intervention slope	0.0182	0.01170	-0.0047 to 0.0411	0.120	0.0034	0.01278	-0.0216 to 0.0285	0.787
Intercept/step change	0.0092	0.20257	-0.3878 to 0.4062	0.964	0.1265	0.20558	-0.2765 to 0.5294	0.538
Spirits (value £)			$\rho = 0.82$				$\rho = 0.86$	
Pre-intervention slope	-0.0031	0.00288	-0.0088 to 0.0025	0.276	0.0008	0.00347	-0.0060 to 0.0076	0.808
Intercept/step change	0.0223	0.04043	-0.0569 to 0.1016	0.580	-0.0460	0.04337	-0.1310 to 0.0390	0.288
Affordable sparkling/low alcohol wines (value £)			$\rho = 0.78$				$\rho = 0.78$	
Pre-intervention slope	0.0042	0.01041	-0.0162 to 0.0245	0.690	0.0107	0.01139	-0.0117 to 0.0330	0.349
Intercept/step change	0.0937	0.15624	-0.2126 to 0.3999	0.549	-0.1036	0.16870	-0.4342 to 0.2271	0.539
Wines (value £)			$\rho = 0.93$				$\rho = 0.91$	
Pre-intervention slope	-0.0009	0.00303	-0.0068 to 0.0050	0.763	0.0040	0.00269	-0.0012 to 0.0093	0.133
Intercept/step change	0.0324	0.03053	-0.0274 to 0.0922	0.289	-0.0457	0.02893	-0.1024 to 0.0110	0.114
All alcohol products (value £)			$\rho = 0.92$				$\rho = 0.89$	

Pre-intervention slope	-0.0023	0.00365	-0.0095 to 0.0049	0.527	0.0042	0.00310	-0.0019 to 0.0102	0.179
Intercept/step change	0.0370	0.03767	-0.0368 to 0.1108	0.326	-0.0764	0.03585	-0.1466 to -0.0061	0.033

CI: Confidence intervals; SE: Standard errors.

ρ is the autocorrelation parameter (i.e. the correlation coefficient between adjacent error terms).

References

1. Hoechle D. Robust standard errors for panel regressions with cross-sectional dependence. The Stata Journal 2007;**7**(3):281-312
2. Wagner AK, Soumerai SB, Zhang F, Ross-Degnan D. Segmented regression analysis of interrupted time series studies in medication use research. Journal of clinical pharmacy and therapeutics 2002;**27**(4):299-309
3. Linden A. Conducting interrupted time-series analysis for single- and multiple-group comparisons. The Stata Journal 2015;**15**(2):480-500
4. Hawkins NG, Sanson-Fisher RW, Shakeshaft A, D'Este C, Green LW. The multiple baseline design for evaluating population-based research. American journal of preventive medicine 2007;**33**(2):162-8 doi: 10.1016/j.amepre.2007.03.020[published Online First: Epub Date]|.

Appendix S3 Description of stores.

Table S3 Descriptive statistics of stores.

	Stores in wave 1 (n=54)			Stores in wave 2 (n=77)			All stores (n=131)		
	Mean (SD) or n (%)	**Median**	**Min - Max**	**Mean (SD) or n (%)**	**Median**	**Min - Max**	**Mean (SD) or n (%)**	**Median**	**Min - Max**
Urban	37 (68.5%)			47 (61.0%)			84 (64.1%)		
IMD score	16.6 (10.01)	14.1	3.4 – 43.3	19.3 (11.96)	16.0	4.2 – 51.4	18.2 (11.24)	15.1	3.4 – 51.4
Store size (sq feet)	3908 (3504.3)	2861	1019 - 21205	3974 (3917.8)	2685	1000 - 19709	3947 (3739.1)	2777	1000 - 21205
Opening hours	95 (9.2)*	96	63 – 110.5	99 (7.4)	101	71 - 114	98 (8.4)	97	63 – 110.5

*P<0.05, **P<0.01, ***P<0.001

Appendix S4 Impact of RtS initiative on log transformed sales and units of alcohol sold for different categories of alcohol.

Figure S4-1 Impact of RtS initiative on log transformed units of alcohol sold for beer/lager and cider. Wave 1 stores started implementation by September 2012. Wave 2 stores started implementation by September 2013.

Figure S4-2 Impact of RtS initiative on log transformed units of alcohol sold for high-strength premium products that were not removed as part of the RtS initiative. Wave 1 stores started implementation by September 2012. Wave 2 stores started implementation by September 2013.

Figure S4-3 Impact of RtS initiative on log transformed units of alcohol sold for spirits. Wave 1 stores started implementation by September 2012. Wave 2 stores started implementation by September 2013.

Figure S4-4 Impact of RtS initiative on log transformed units of alcohol sold for affordable sparkling and low alcohol wines. Wave 1 stores started implementation by September 2012. Wave 2 stores started implementation by September 2013.

Figure S4-5 Impact of RtS initiative on log transformed units of alcohol sold for wines. Wave 1 stores started implementation by September 2012. Wave 2 stores started implementation by September 2013.

Figure S4-6 Impact of RtS initiative on log transformed units of alcohol sold for all alcohol products. Wave 1 stores started implementation by September 2012. Wave 2 stores started implementation by September 2013.

Figure S4-7 Impact of RtS initiative on log transformed sales for beer/lager and cider. Wave 1 stores started implementation by September 2012. Wave 2 stores started implementation by September 2013.

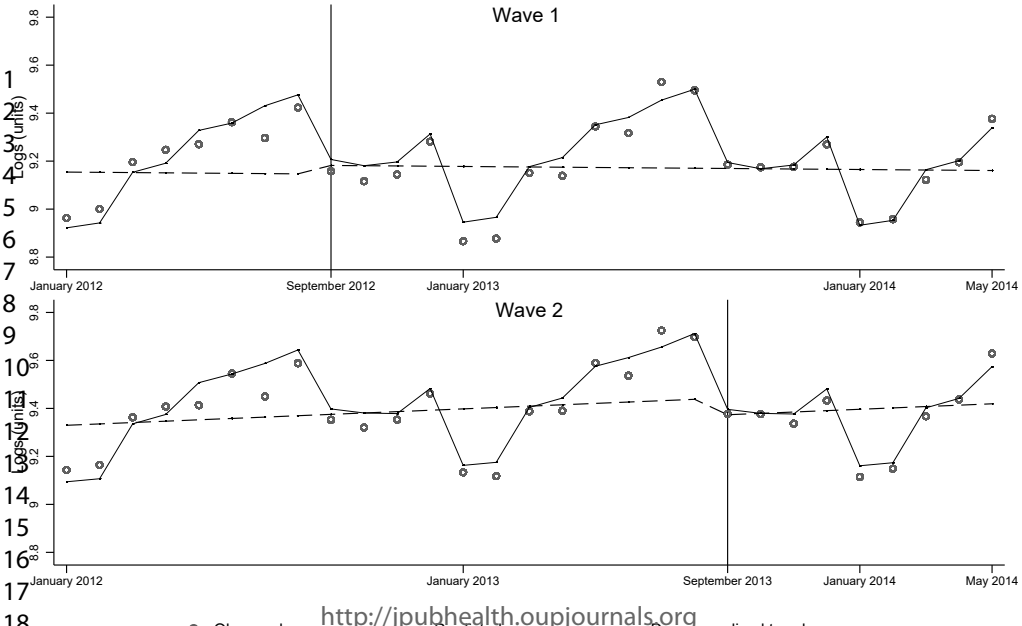
Figure S4-8 Impact of RtS initiative on log transformed sales for high-strength premium products that were not removed as part of the RtS initiative. Wave 1 stores started implementation by September 2012. Wave 2 stores started implementation by September 2013.

Figure S4-9 Impact of RtS initiative on log transformed sales for spirits. Wave 1 stores started implementation by September 2012. Wave 2 stores started implementation by September 2013.

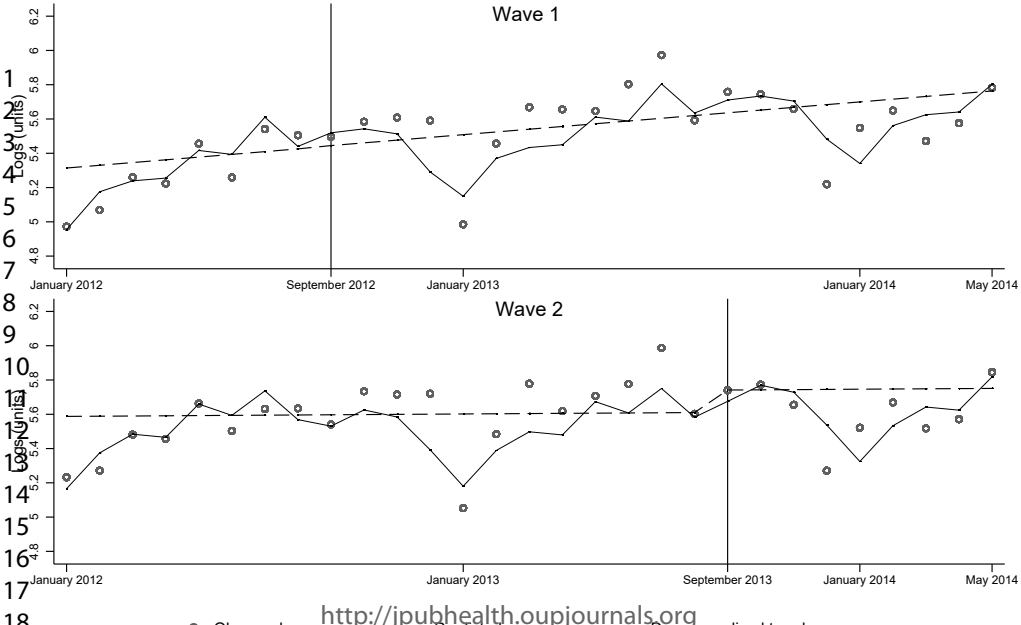
Figure S4-10 Impact of RtS initiative on log transformed sales for affordable sparkling and low alcohol wines. Wave 1 stores started implementation by September 2012. Wave 2 stores started implementation by September 2013.

Figure S4-11 Impact of RtS initiative on log transformed sales for wines. Wave 1 stores started implementation by September 2012. Wave 2 stores started implementation by September 2013.

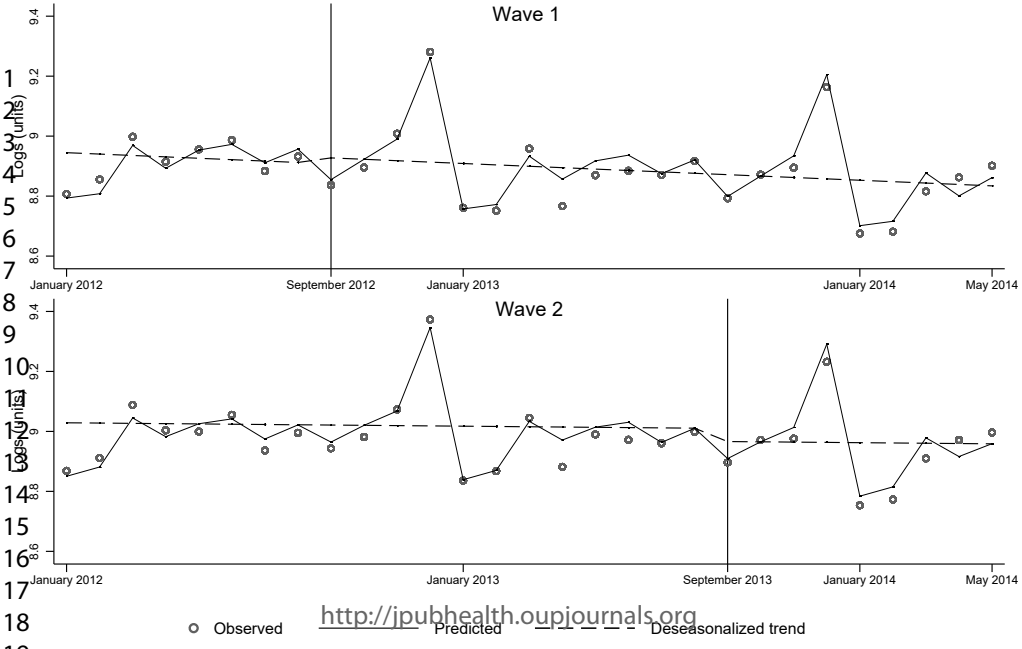
Figure S4-12 Impact of RtS initiative on log transformed sales for all alcohol products. Wave 1 stores started implementation by September 2012. Wave 2 stores started implementation by September 2013.



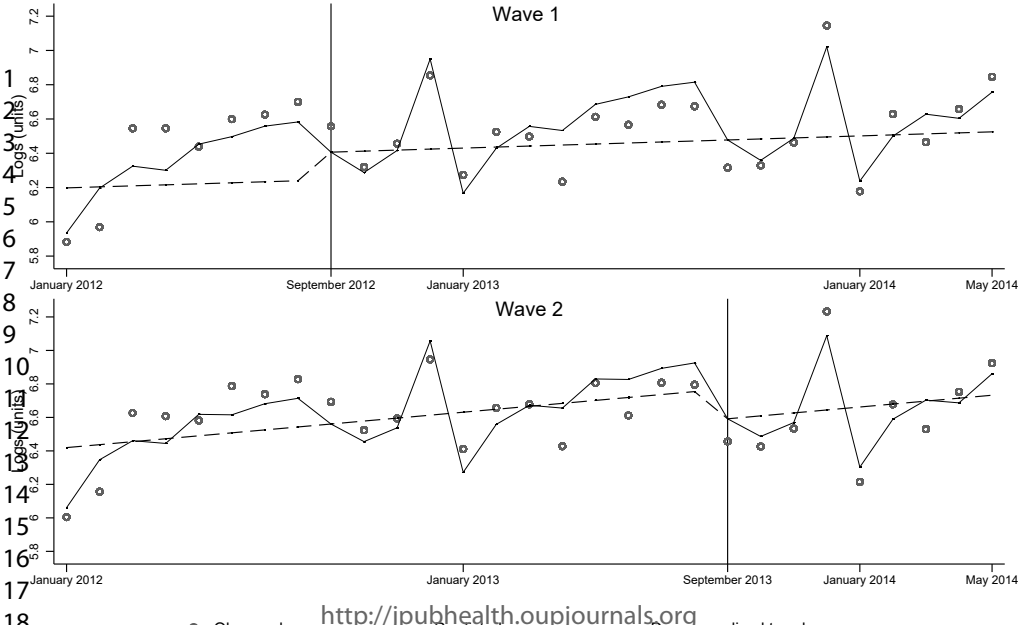
Introduction of the RtS initiative - Wave 1: September 2012, Wave 2: September 2013

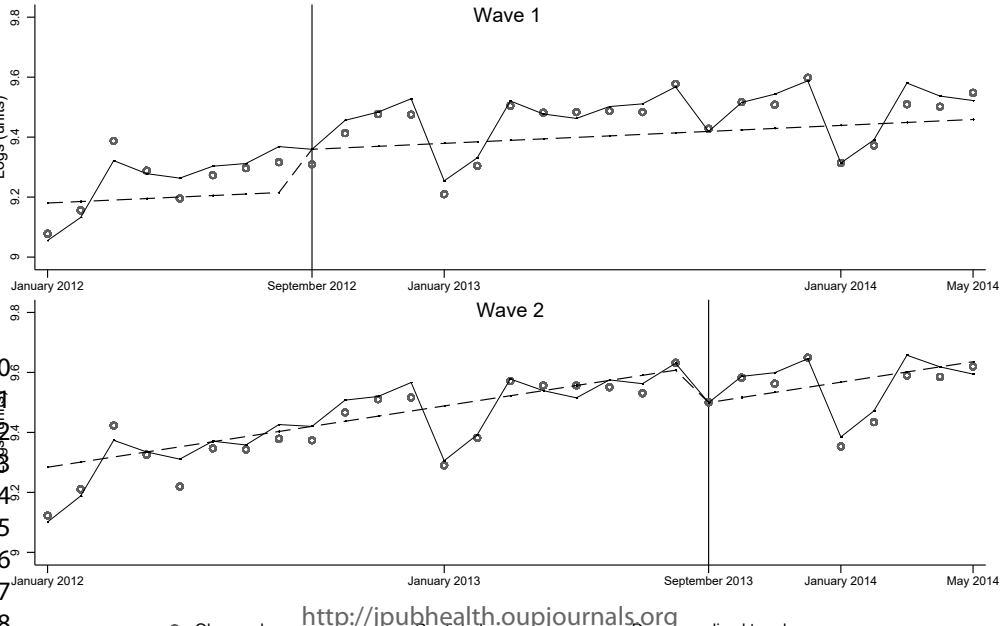


Introduction of the RtS initiative - Wave 1: September 2012, Wave 2: September 2013

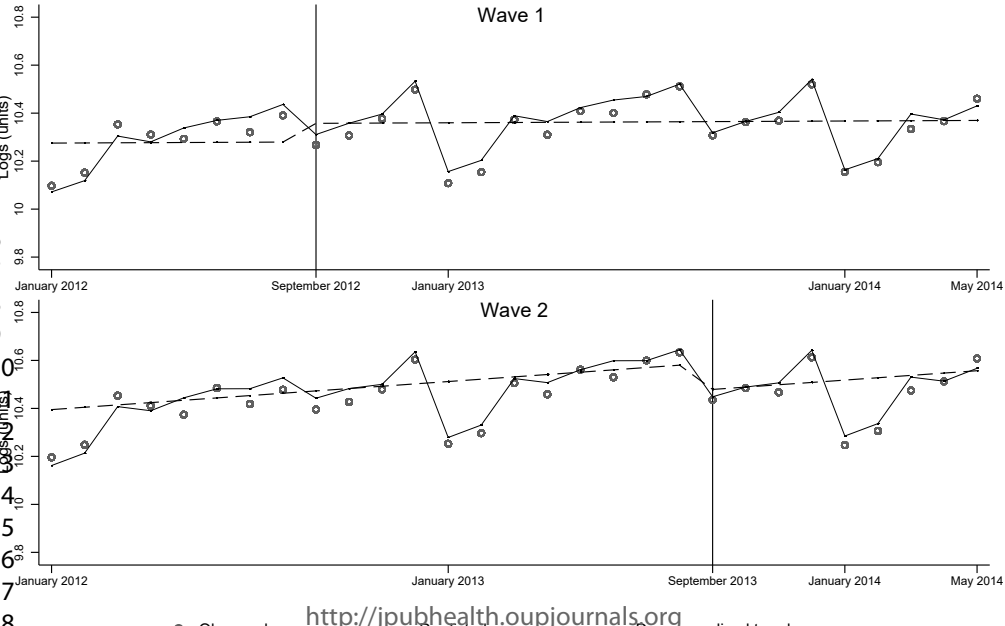


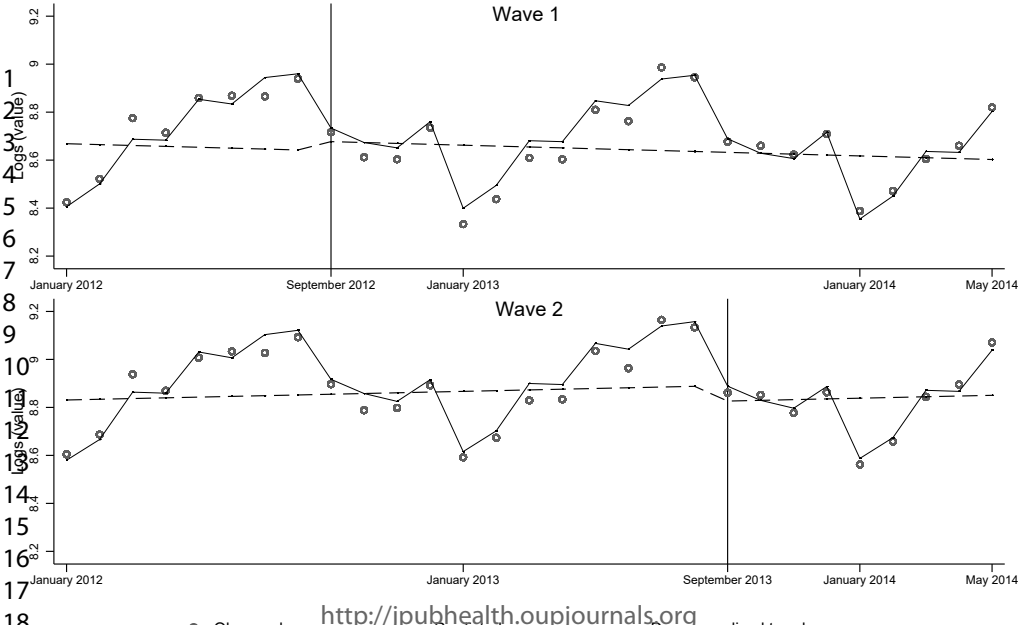
Introduction of the RtS initiative - Wave 1: September 2012, Wave 2: September 2013



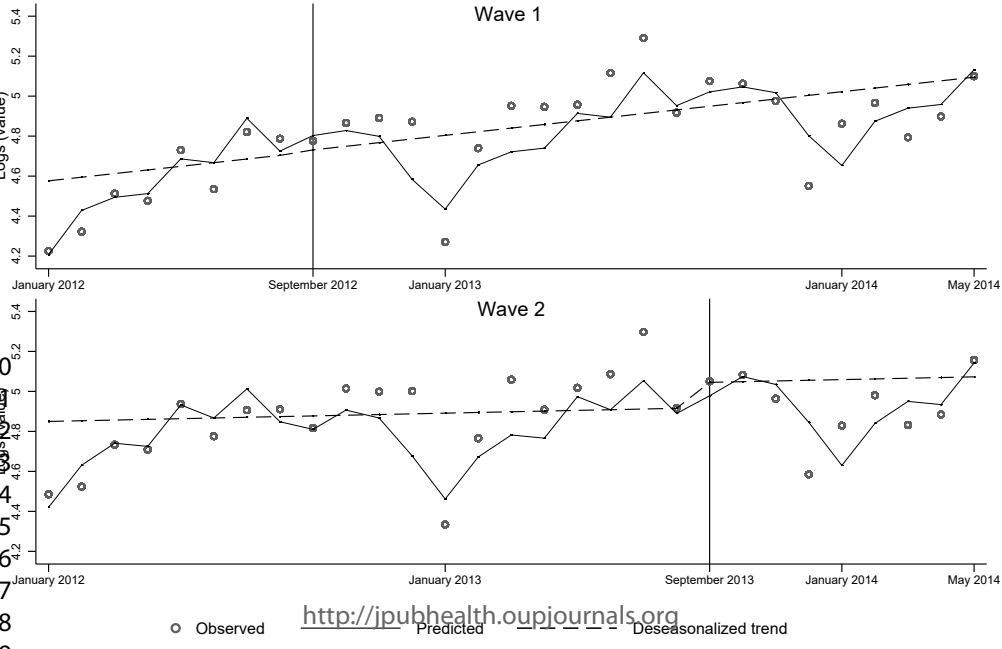


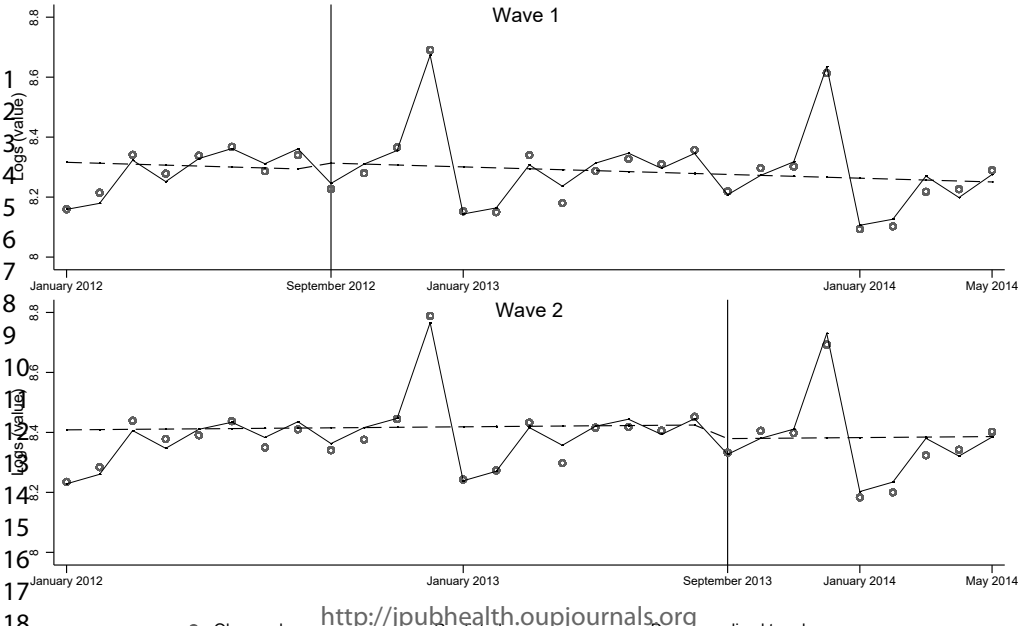
Introduction of the RtS initiative - Wave 1: September 2012, Wave 2: September 2013

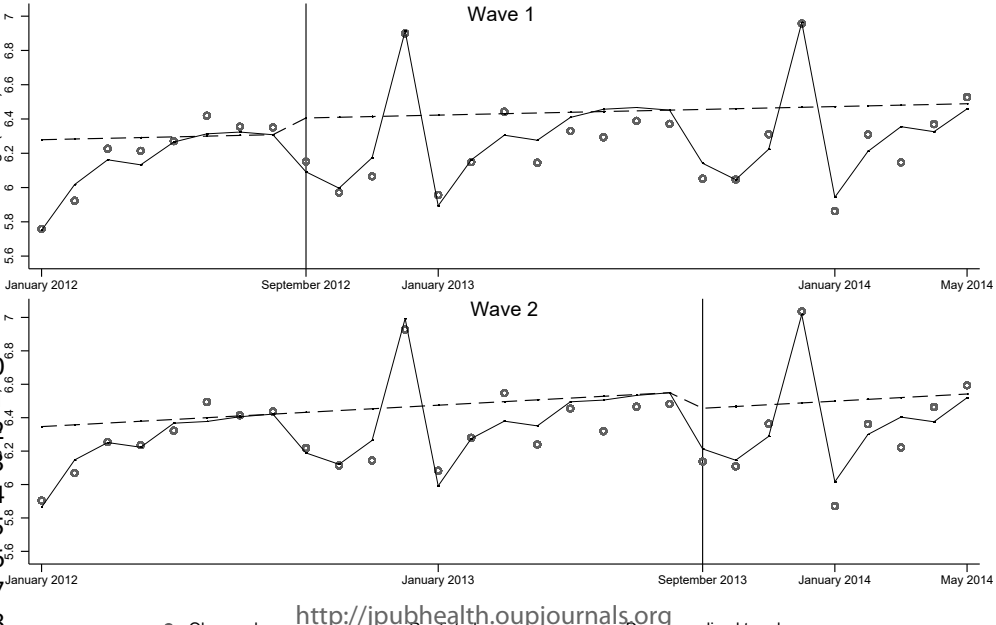


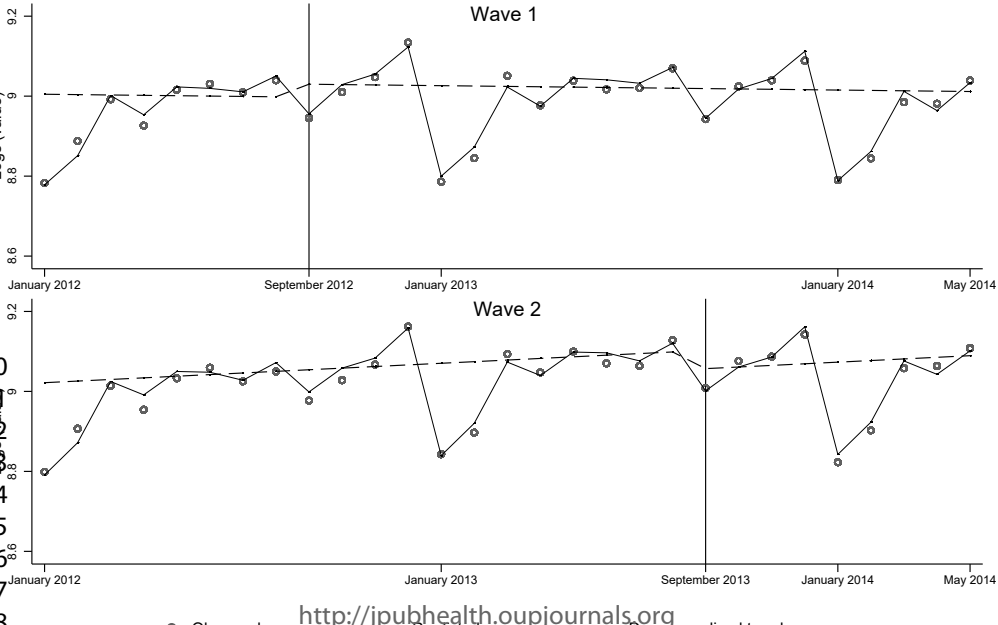


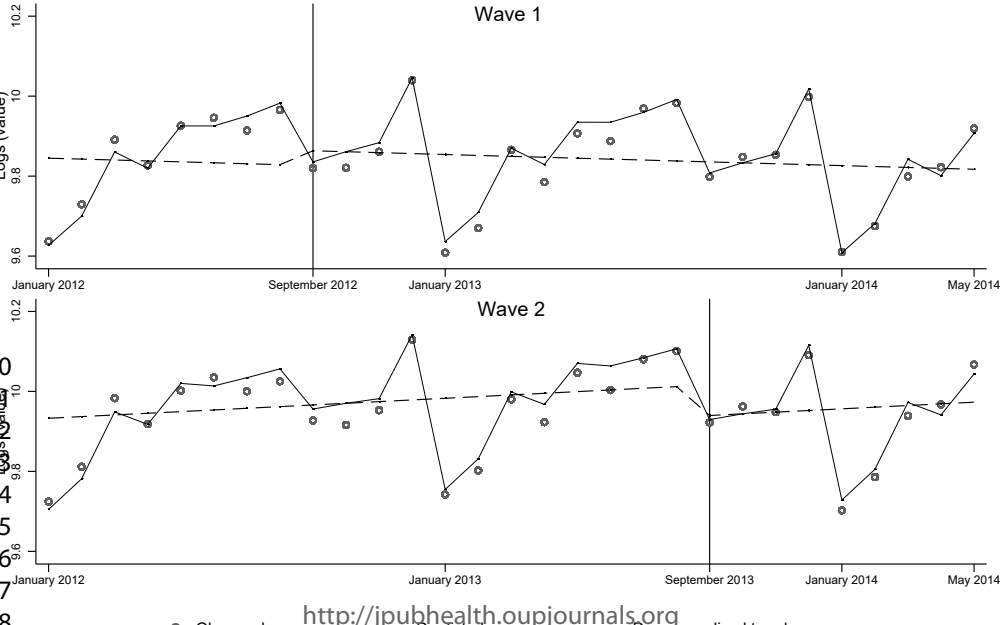
Introduction of the RtS initiative - Wave 1: September 2012, Wave 2: September 2013











Abstract

Background

'*Reducing the Strength*' (RtS) is a public health initiative encouraging retailers to voluntarily stop selling cheap, strong beers/ciders (≥6·5% alcohol by volume). This study evaluates the impact of RtS initiatives on alcohol availability and purchasing in three English counties with a combined population of 3,62 million people.

Methods

We used a multiple baseline time-series design to examine retail data over 298 months from a supermarket chain that experienced a two-wave, area-based role out of RtS: initially 54 stores (W1), then another 77 stores (W2). We measured impacts on units of alcohol sold (primary outcome: beers/ and ciders only; secondary outcome: all alcoholic beveragesproducts). We measured economic impacts on alcohol sales (£)and substitution effects.

Results

We observed a non-significant W1 increase (+3.7%, 95% CI = -11.2, 21.0) and W2 decrease (-6.8%, 95% CI = -20.5, 9.4) in the primary outcome. We observed a significant W2 decrease in units sold across all alcohol beverages products (-10.5%, 95% CI =-19.2, -0.9), but the The direction of effect between waves was inconsistent for all outcomes, including alcohol sales, with no evidence of substitution effects.

Conclusions

In the UK, voluntary RtS initiatives appear to have little or no impact on reducing alcohol availability and purchase from the broader population of supermarket customers.

Introduction

Modifying the availability of commercial products (e.g. alcohol, ~~food,~~ food~~tobacco~~) is a widely advocated public health strategy. [1, 2] ~~For example, t~~The World Health Organization~~'s global strategy to reduce the harmful use of alcohol~~ has proposed~~s~~ a number of interventions and policies to reduce availability including interventions reducing~~that reduce~~ the alcoholic strength of ~~available beverages~~products.[3] ~~National policies affecting different types of product availability have been advocated but regulating the sale and consumption of such products in jurisdictions around the world takes place at sub-national levels. Studies~~ Research from ~~the~~ North America, Australia and Europe has~~ve~~ examined ~~different~~ ways in which modifying local food availability ~~may impact~~impacts on health ~~related~~ outcomes,[4-7] but there are relatively fewer evaluations of local alcohol availability interventions ~~evaluations in the academic literature~~.[1, 6, 8-14]

Alcohol is a causal factor in more than 200 disease and injury conditions accounting for 5.9% of ~~all~~ deaths worldwide.[2] Social costs attributable to alcohol, including crime and disorder, representing ~~between~~ 1.3% to 3.3% of gross domestic product globally.[2] Interventions modifying alcohol availability have been seen to reduce both alcohol consumption and alcohol related harm.[2, 15-19] In ~~man~~many countries, including the United Kingdom (UK), attempts to modify availability through national government regulation, such as minimum unit pricing, have been met with political and legal barriers. Regulating the sale and consumption of alcohol products often takes place at sub-national levels.[6, 8, 20] L~~Concurrently, l~~ocal government initiatives to reduce alcohol availability have been implemented, involving both statutory and voluntary approaches, the latter often targeting specific population groups.[15, 21-24]

Evaluative research of natural policy experiments is important because innovative practices can diffuse to new settings, including across national boundaries, sometimes before they have beenhad a chance to be robustly evaluated.[25, 26] Reducing the strength of alcoholic beverages products or modifying high strength product availability by alcoholic strength have been proposed as 'best practices' of policies to regulate physical availability.[3, 27] This, however, stems from an interpretation of availability theory rather than a synthesis of empirical evidence assessing impacts of reducing availability of high strength beers and ciders (so-called 'superstrength' products) and the evidence base around this is under-developed. Superstrength products and their marketing have been said to encourage alcohol misuse and harmful behaviours among vulnerable populations.[28] In the UK, the term 'Reducing the Strength' (RtS) is now widely used to refer to area-based public health initiatives that involve removing low price, superstrength alcoholic products from sale in stores through voluntary agreements with local retailers and off-licenses. RtS has been originally designed to tackle problems associated with alcohol social harms, often with a focused on street drinking.[22] Suffolk was the first UK area in the UK to adopt the initiative in 2012 as part of a multi-intervention approach to tackling street drinking. S, and since then at least 30 schemes have been implemented in the UK.[29] The approach varies, but most RtS initiatives tend to target alcohol products above 6.5% alcohol by volume (ABV), although some have focused on a slightly lower ABV or lower cost products.[22] In this RtS, the products targeted were lower cost products above 7.5% ABV. Superstrength products vary by price, brand and strength. The least expensive products (e.g. 'white ciders') are amongst the lowest cost per unit alcohol products in UK stores, purchased for as little as 11.1 pence per unit.[30, 31] UK local and regional governments have complained to the alcohol industry that specific superstrength products sold in 500ml cans encourage rapid consumption of high quantities of alcohol causing population harms; although this isese are refuted by the industry.[32]

It has been argued that targeted interventions, such as RtS, offer local and regional government authorities a potential means of tackling ~~some of the more~~ publicly visible social and health problems associated with alcohol consumption.[21, 22, 29] Retailers and the alcohol industry have raised concerns about RtS that have included questioning its evidence base, legal status (in terms of competition law) and its potential financial impact.[22, 33-35] On the other hand, some retailers arguably demonstrate a degree of support for RtS by voluntarily participating in ~~the~~ initiatives, although their reasons for doing so may vary. For example, some retailers saw street drinking as a problem in their area and hoped that participation would reduce anti-social behaviour within their own shops while others saw this as an opportunity to co-operate with the licensing authorities.[35] An intervention that is designed to deter anti-social customers could potentially improve shops' image with the wider customer base ~~as well as within~~ in addition to licensing authorities and other ~~relevant~~ stakeholders.[22, 33, 36, 37]

From a public health perspective, it remains unclear to what extent local-level voluntary interventions, such as RtS, can play an effective role in reducing alcohol consumption ~~and alcohol-related health harms~~ at the population level.[12] Retail sales data routinely collected by shops provides one means of measuring the impact of alcohol interventions. Such data can provide an objective and accurate estimate of alcohol purchase and proxy consumption, particularly in the case of larger supermarket and shop chains that have invested heavily in data collection.[38] However, shop-level data are hard to obtain due to commercial sensitivity.[39] T~~and t~~here are few published evaluations of alcohol interventions in the UK using retail data ~~specifically intended~~ to assess changes in physical and economic availability of specific alcohol products for ~~public~~ health improvement.[18, 40]

The RtS studied here was originally launched as a joint initiative between Suffolk Police, Ipswich Borough Council, Suffolk County Council and the National Health Service (Suffolk) in September 2012.[41] Following interviews with local practitioners and policymakers who designed and implemented the RtS in Suffolk, we hypothesised several possible mechanisms for RtS impacts on alcohol availability and sales. These include a potential 'nudge' effect where the impact of reducing physical availability of alcohol products by removing super-strength products ~~, together with marketing of the RtS in local media and within stores~~ helped discourage and denormalise the practice of purchasing cheap products ~~for the purpose of immediate intoxication~~. The RtS was also theorised as an economic availability intervention: customers with finite resources wishing to purchase low cost per unit super-strength products may, on finding those products removed, substitute for products with lower alcohol content or for different alcohol products.[29, 35] This study aims to evaluate the impact of the introduction of a RtS initiative on alcohol availability in the form of overall availability of alcohol units and purchasing in one national retail chain across three English counties using time-series analyses of retail sales data.

Methods

Setting and intervention

A major supermarket chain (East of England Co-operative Society, known commonly as 'Co-op') voluntarily joined RtS in Suffolk and consequently ensured that its stores in that county cleared their stock of all their low-priced brands of high--strength beers/lagers and ciders in the month leading up to September 2012. These consisted of four superstrength products (7.5% to 9.0% ABV) but did not include any ~~of the~~ more expensive 'craft' or 'premium' high-strength products as the implementers did not associate such products with street drinking (Table 1). The same chain required stores in Essex and Norfolk to begin a similar

process of withdrawing those products from sale by September 2013. Every shop from the chain participated in the intervention although a minority of stores, 6% from wave 1 and 36% from wave 2, took longer than one month to stop selling superstrength products (~~see~~ Appendix S1).

[Table 1 here]

Data

~~This evaluation is based on m~~Monthly retail sales data were provided for the period January 2012 to May 2014 obtained for 131 stores in one retail chain in the three English counties. We used the full range of data that East of England Co-operative Society provided us with for this analysis: the researchers did not have direct access to the company's internal data systems but rather were sent data pertaining only to the intervention period and localities so that the researchers could analyse them independently. ~~The data detailed s~~Shop-level characteristics and sales data were available including~~such as~~ prices, quantities, product brands, alcohol content, and sales for the following drink categories: beer/ lager and cider, wines, affordable sparkling and low alcohol wines, and spirits. Our primary outcome was units of alcohol sold for beer/lager and cider. Secondary outcomes included units of alcohol sold for two high strength premium products (ABV over 7.5%) not removed as part of the RtS (Table 1), the remaining drink categories and for all products in order to examine substitution effects and in line with qualitative findings on drinkers' responses to RtS. We looked at sales value to assess the potential economic impact of RtS on stores. Stores in Suffolk (n=54) were regarded as stores participating in wave 1 (W1) of the intervention and stores in Norfolk and Essex (n=77) as stores participating in wave 2 (W2) a year later.

Statistical analysis

We used a quasi-experimental multiple baseline time-series design[42] to study changes in units of alcohol sold and sales value for beer/lager and cider, wines, sparkling and low alcohol wines, spirits and for total alcohol products after the introduction of the RtS initiative. The RtS was introduced in a staggered approach, implemented at two different time points (~~wave~~ W1 and ~~wave~~ W2) across three different geographical areas with a combined population of 3,62 million people.[43] We examined the impact of implementing RtS separately for the two waves in order to identify whether the intervention produced similar effects in the entire population of interest (ie. whether the impact of the intervention was consistent in the two waves).[42, 44] The repeated pattern of a reduction in the measured outcome following the implementation of the intervention in each geographical area (i.e. wave) would suggest that the intervention is having an effect.[42] An appropriate statistical approach to evaluate such impacts is the use of segmented linear regression, which divides a time series into pre- and post-intervention segments,[44] with panel-corrected standard errors.[45, 46] We took autocorrelation into account by means of a common autoregressive first order (AR(1)) model and we included the calendar month as a term to adjust for seasonality.[44, 47] Details of the assumptions and model specification are available in Appendix S2.

The intervention effect was assumed to occur immediately after implementation, so no transition period was taken into account in the analysis. We log-transformed our dependent variables as these were highly skewed. For ease of interpretation, regression coefficients (β) were converted into per cent change in sales and units of alcohol sold using the formula [exp(β)-1]*100. This approach was used to ensure data confidentiality when using commercially sensitive information, such as sales of specific alcohol products and brands. We therefore examined substitution effects at a product category level ~~(e.g. beers/ciders,~~

~~wines, spirits, etc)~~ and for high-strength premium products that were not removed rather than at the level of specific products or brands. ~~All a~~Analysis was carried out in Stata 14.1.

Results

Stores in ~~wave~~ W1 and ~~wave~~ W2 were similar in terms of size, area-level deprivation score and urban vs semi-urban location. Stores in ~~wave~~ W1 were open on average for fewer hours compared to those in ~~wave~~ W2 (Appendix S3). Mean units of alcohol sold per store per month were lower in ~~wave~~ W1 compared to ~~wave~~ W2 stores in all products. Overall, beer/lager and cider accounted for 32.4% of total units of alcohol sold during the study period. Super-strength products removed had previously accounted for 6.5% and 3.6% of total units sold for beer/lager and cider in ~~wave~~ W1 and ~~wave~~ W2 stores, respectively (Table 2). In terms of sales, these four products accounted for 2.1% and 1.3% of total revenue for ~~wave~~ W1 and W2 stores, respectively, before the intervention (data not shown).

[Table 2 here]

Our analysis indicates that the impact of RtS on units of alcohol sold for beer/lager and cider was not significant in the two waves (Fig. 1 and Appendix S4). More specifically, following RtS implementation, ~~wave~~ W1 stores experienced a non significant increase (3.7%, 95% Confidence Intervals (CI) = -11.2 – 21.0, P=0.647) whereas ~~wave~~ W2 stores experienced a non significant decrease (-6.8%, 95% CI =-20.5 – 9.4, P =0.390) (Figure 1). In terms of all alcohol products, the introduction of RtS was associated with a non significant increase in ~~wave~~ W1 stores (8.0%, 95% CI = -1.3 – 18.3, P =0.094). In contrast, a significant decrease (-10.5%, 95% CI =-19.2 – -0.9, P =0.034) was observed in ~~wave~~ W2 stores (Fig. 2 and Appendix S4). Similar patterns for beer/cider and lager were observed for sales value~~, which indicate that the RtS had a minimal impact on revenue generated from beer/lager and cider by all stores~~ (Fig. 2).

[Figure 1 and Figure 2 here]

In order to examine substitution effects we repeated the analysis for high-strength premium products, spirits, affordable sparkling and low alcohol wines and wines. We found that all product categories experienced similar changes in units of alcohol sold and sales value during this time period in ~~wave~~ W1 and ~~wave~~ W2 to those observed for beer/lager and cider. None of them were significant except for units of alcohol sold for wines, which appeared to drive the significant decrease observed in units of alcohol sold for all products. We found no evidence of substitution effects for high-strength premium products (Fig. 1 and Appendix S4). ~~This suggests that there has been no observable substitution effects of alcohol products attributable to the RtS intervention in the 131 stores.~~

Discussion

Main findings of this study

We used retail sales data to evaluate the introduction of RtS, a public health initiative targeted at supermarkets and off-licenses to remove low cost, super-strength beers and ciders from sale in three English counties. Our results show that this RtS had no significant impact on total units of alcohol sold and sales value for beer/lager and cider. We also found no observable substitution effects of alcohol products attributable to the RtS intervention in the 131 stores.

What is already know on the topic

Only a small number of previous studies have ~~previously~~ used retail sales data in ~~similar~~ quasi-experimental designs to evaluate alcohol interventions. Evaluation of the Scottish Alcohol Act 2010 showed that banning alcohol multi-buy promotions did not reduce alcohol purchasing at the household level,[18] and the introduction of the Alcohol Act was not

associated with any changes in off-trade beer sales.[40] In our study, the majority of results were non significant. The small significant decrease in units and value of alcohol sales of all products in ~~wave~~ W2 stores appears to be driven by declining wine (rather than beer/cider) sales.[48] Furthermore, the changes observed in the two waves were not consistent and so the overall findings showed no intervention attributable impact.[42]

An Australian evaluation of local alcohol availability restrictions (~~relating to~~ cask wines and products over 2.7% ABV) found that some participants ~~were prepared to travel~~travelled further to access non-participating shops.[13, 14] In our study we theorise that overall alcohol purchases could be influenced by whether or not customers changed where they purchased alcohol (i.e. shops not participating in RtS), or if they substituted products within participating stores.[14] Our study focused on one retail chain which maintained compliance with RtS[22] and we found no substitution effects between categories of alcohol products within study stores attributable to the intervention. Customers in the study areas had the ability to access other local stores that did not participate in the RtS but we did not detect any sudden or sustained loss of income in participating stores that might be expected if substantial numbers of customers had started shopping elsewhere for alcohol. The availability of alternative stores not participating may vary within and between the three counties studied.

Limitations of this study

The retail data we had available related to one retail supermarket chain and the data available could not be used to consider ~~(for example)~~ overall area effects, shop-level or brand/product-level substitution effects, individual or sub-group level purchasing or consumption.[14, 18, 37] Our results cannot be generalized to RtS initiatives that have removed products with >6.5% or lower ABV. We did not have the data to measure long term impacts on purchasing and consumption, although we theorised that RtS should impact on availability as soon as shops

stopped selling superstrength products.[13, 14] The confidence intervals for our findings were wide and statistical precision might have been improved with inclusion of a greater number of stores, and/or time points.[44, 46] Stores in ~~waves~~ W1 and W2 had different rates of compliance, which may compromise internal validity.[42] In addition, RtS is only one intervention targeting alcohol consumption and harms, and we are aware that there are a range of local alcohol policies routinely implemented in local government which we were unable to adjust for. Such unmeasured events may introduce confounding and compromise internal validity.[49] Finally, segmented regression analysis has its own limitations, allowing only linear trends to be examined but changes may follow non-linear patterns.[44]

What this study adds

~~Despite these limitations, o~~Our study makes an important contribution to the evidence-base ~~evaluation~~ for local ~~of public health~~ voluntary retail alcohol interventions~~, particularly voluntary retail initiatives, and adds to the limited evidence base~~.[18, 40] The use of retail data is ~~relatively~~ novel for ~~conducting evaluation~~evaluating ~~of~~ alcohol initiatives and it has been advocated as ~~one of the best~~an important means to monitor alcohol consumption[40, 50] despite the~~ir~~ limitations.[38] In this study, we used a retail sales time series panel data set, that contains far more information than single cross-sectional data allowing for an increased precision in estimation.[46] Panel difference-in-differences analysis has been used in a previous study,[18] but we opted to use panel-corrected standard errors within a regression framework, because ignoring possible correlation of regression disturbances over time and between panels may lead to overly optimistic standard errors and lead to biased statistical inference.[46]

~~*What this study adds*~~

The RtS initiative[21] was originally developed as part of a strategy that also involved alcohol and drug treatment services and street policing to tackle street drinking and anti-social

behavior due to excess alcohol consumption, and there is some evidence that this targeted, multi-intervention approach led to reductions in police call outs and other indicators of social problems related to street drinking.[21, 41] This evaluation does not test RtS's impact on wider~~these~~ aims~~aims~~ of tackling alcohol social harms ~~and~~including street drinking. ~~It should be noted that~~The RtS was not originally expected to have impacts on reducing overall population alcohol ~~purchasing and intake~~consumption. Potential secondary effects of RtS on the broader population of alcohol consumers are ~~, however,~~ of interest to the public health community ~~which has for some time raised concerns about the rise in alcohol health harms across the whole population~~.

Voluntary agreements between governments and the private sector have previously been used to ~~persuade~~ encourage businesses to take actions.[36] However, there is little evidence to suggest such approaches are more (cost-) effective, particularly if they are unaccompanied by monitoring, and appropriate incentives and sanctions.[36] The alcohol industry and retail sector may be more willing to participate in voluntary initiatives targeting selected population groups (i.e. street drinkers) that have minimal impact on their profits. Our ~~and our~~ analysis suggests that RtS ha~~d~~s no impact on revenues~~businesses~~. Addressing alcohol related harms and drinking behaviours in 'high-risk'~~these~~ groups is important~~crucial~~ ~~and should be encouraged~~ but our analysis suggests that RtS may not be ~~an~~ effective ~~instrument~~ for addressing ~~those broader population level~~ alcohol harms across the whole population. The ~~There is a pattern of support from the~~ evidence base recommends ~~for~~ regulatory or statutory enforcement interventions restricting alcohol availability are more effective than ~~over~~ local non-regulatory or ~~/~~ voluntary approaches targeting specific groups.[12, 51-54]

Conclusion

This evaluation did not specifically test impacts on target~~ed~~ groups, such as~~ homeless and~~ street drinkers, but~~ rather~~ examined~~looked at~~ impacts on all consumers' alcohol purchasing patterns from one retail supermarket chain~~ of store~~. Our findings suggest that voluntary RtS initiatives, have little or no impact on reducing alcohol availability and purchase amongst a broader population of customers~~ at a participating supermarket chain~~. The research literature suggests that more effective regulatory public health interventions will be required to achieve substantial population health benefits in reducing~~elation to~~ alcohol consumption and alcohol-related harms.

Acknowledgements

We would like to acknowledge the invaluable input of and the helpful comments of Professor Mark Petticrew. We would also like to thank Mark Lewenz of East of England Co-operative Society who provided the retail sales data. Antonio Gasparrini provided expert advice on our analysis. The evaluation of the Reducing the Strength initiative is part of the programme of the School for Public Health Research (http://sphr.lshtm.ac.uk/). This is an independent research unit based at the London School of Hygiene and Tropical Medicine, funded by the National Institute for Health Research School for Public Health Research (NIHR SPHR). Sole responsibility for this research lies with the authors and the views expressed are not necessarily those of the NHS, the NIHR SPHR or the Department of Health. The East of England Co-operative Society supplied the retail sales data but played no role in the funding of the study. The East of England Co-operative Society, the NHS, the NIHR and the Department of Health played no role in the design of the study, the interpretation of the findings, the writing of the paper or the decision to submit. The views expressed are those of the author(s) and not necessarily those of the East of England Co-operative Society, NHS, the NIHR or the Department of Health.

References

1. World Health Organization. Global action plan for the prevention and control of noncommunicable diseases 2013−2020. Geneva2013.
2. World Health Organization. Global status report on alcohol and health. Geneva: World Health Organization; 2014; Available from: Available at: http://www.who.int/substance_abuse/publications/global_alcohol_report/en/ (accessed 10 December 2015). Archived at: http://www.webcitation.org/6dh7lvC4k on 11 December 2015.
3. World Health Organization. Global strategy to reduce the harmful use of alcohol. Geneva: World Health Organization; 2010; Available from: Available at: http://www.who.int/substance_abuse/activities/gsrhua/en/ (accessed 10 December 2015). Archived at: http://www.webcitation.org/6dh7so88i on 11 December 2015.
4. Morland KB. An evaluation of a neighborhood-level intervention to a local food environment. American journal of preventive medicine. 2010; 39:e31-8.
5. Gase LN, McCarthy WJ, Robles B, Kuo T. Student receptivity to new school meal offerings: assessing fruit and vegetable waste among middle school students in the Los Angeles Unified School District. Prev Med. 2014; 67 Suppl 1:S28-33.
6. Soler RE, Whitten KL, Ottley PG. Communities putting prevention to work: Local evaluation of community-based strategies designed to make healthy living easier. Preventive Medicine. 2014; 67, Supplement 1:S1-S3.
7. Valdivia Espino J, Guerrero N, Rhoads N, Simon N, Escaron A, Meinen A, et al. Community-Based Restaurant Interventions to Promote Healthy Eating: A Systematic Review. Prev Chronic Dis. 2015; 12.
8. Nelson TF, Xuan Z, Babor TF, Brewer RD, Chaloupka FJ, Gruenewald PJ, et al. Efficacy and the Strength of Evidence of U.S. Alcohol Control Policies. American journal of preventive medicine. 2013; 45:19-28.
9. Rammohan V, Hahn RA, Elder R, Brewer R, Fielding J, Naimi TS, et al. Effects of Dram Shop Liability and Enhanced Overservice Law Enforcement Initiatives on Excessive Alcohol Consumption and Related Harms: Two Community Guide Systematic Reviews. American journal of preventive medicine. 2011; 41:334-43.
10. Campbell CA, Hahn RA, Elder R, Brewer R, Chattopadhyay S, Fielding J, et al. The Effectiveness of Limiting Alcohol Outlet Density As a Means of Reducing Excessive Alcohol Consumption and Alcohol-Related Harms. American journal of preventive medicine. 2009; 37:556-69.
11. Stockwell T, Zhao J, Giesbrecht N, Macdonald S, Thomas G, Wettlaufer A. The Raising of Minimum Alcohol Prices in Saskatchewan, Canada: Impacts on Consumption and Implications for Public Health. American journal of public health. 2012; 102:e103-e10.
12. Martineau F, Tyner E, Lorenc T, Petticrew M, Lock K. Population-level interventions to reduce alcohol-related harm: an overview of systematic reviews. Preventive Medicine. 2013; 57:278-96.
13. Kinnane S, Farringdon F, Henderson-Yates L, Parker H. Fitzroy Valley Alcohol Restriction Report: An evaluation of the effects of a restriction on take-away alcohol relating to measurable health and social outcomes, community perceptions and behaviours after a two year period. 2010; Available from: Available at: http://www.dao.health.wa.gov.au/DesktopModules/Bring2mind/DMX/Download.aspx?EntryId=680&Command=Core_Download&PortalId=0&TabId=211 (accessed 10 December 2015). Archived at: http://www.webcitation.org/6dhBDi59v on 11 December 2015.
14. National Drug Research Institute. Restrictions on the Sale and Supply of Alcohol: Evidence and Outcomes. Perth: National Drug Research Institute, Curtin University of Technology; 2007; Available from: Available at:

http://ndri.curtin.edu.au/local/docs/pdf/publications/R207.pdf (accessed 10 December 2015). Archived at: http://www.webcitation.org/6dhAzukmG on 11 December 2015.
15. Maclennan B, Kypri K, Room R, Langley J. Local government alcohol policy development: case studies in three New Zealand communities. Addiction. 2013; 108:885-95.
16. Ahern J, Margerison-Zilko C, Hubbard A, Galea S. Alcohol outlets and binge drinking in urban neighborhoods: the implications of nonlinearity for intervention and policy. American journal of public health. 2013; 103:e81-7.
17. Fone D, Dunstan F, White J, Webster C, Rodgers S, Lee S, et al. Change in alcohol outlet density and alcohol-related harm to population health (CHALICE). BMC Public Health. 2012; 12:428.
18. Nakamura R, Suhrcke M, Pechey R, Morciano M, Roland M, Marteau TM. Impact on alcohol purchasing of a ban on multi-buy promotions: a quasi-experimental evaluation comparing Scotland with England and Wales. Addiction. 2014; 109:558-67.
19. Purshouse RC, Meier PS, Brennan A, Taylor KB, Rafia R. Estimated effect of alcohol pricing policies on health and health economic outcomes in England: an epidemiological model. Lancet. 2010; 375:1355-64.
20. Han D, Gorman DM. Evaluating the Effects of the Introduction of Off-Sale Alcohol Outlets on Violent Crime. Alcohol and Alcoholism (Oxford, Oxfordshire). 2013; 48:370-4.
21. Alcohol Concern. Guide to Alcohol for Councillors. London2014; Available from: Available at: http://www.alcoholconcern.org.uk/wp-content/uploads/woocommerce_uploads/2014/12/Guide-to-Alcohol-160813-APPROVED.pdf (accessed 10 December 2015). Archived at: http://www.webcitation.org/6dh8ZwRom on 11 December 2015.
22. Local Government Association. Reducing the Strength schemes: Guidance for councils considering setting up a scheme. 2014; Available from: Available at: http://www.local.gov.uk/regulatory-services-and-licensing/-/journal_content/56/10180/6793034/ARTICLE (accessed 10 December 2015). Archived at: http://www.webcitation.org/6dh8jYS00 on 11 December 2015.
23. Nicholls J. The Government Alcohol Strategy 2012: Alcohol policy at a turning point? Drugs: Education, Prevention, and Policy. 2012; 19:355-9.
24. Hughes K, Bellis MA, Leckenby N, Quigg Z, Hardcastle K, Sharples O, et al. Does legislation to prevent alcohol sales to drunk individuals work? Measuring the propensity for night-time sales to drunks in a UK city. Journal of epidemiology and community health. 2014; 68:453-6.
25. McGill E, Egan M, Petticrew M, Mountford L, Milton S, Whitehead M, et al. Trading quality for relevance: non-health decision-makers' use of evidence on the social determinants of health. BMJ open. 2015; 5.
26. Dolowitz D, Marsh D. Learning from abroad: The role of policy transfer in contemporary policy□making. . Governance. 2000; 13:5-23.
27. Alcohol, Public Policy G. Alcohol: No Ordinary Commodity – a summary of the second edition. Addiction. 2010; 105:769-79.
28. Goodall T. White Cider and Street Drinkers: Recommendations to Reduce Harm. London: Alcohol Concern UK2011 Contract No.: http://www.webcitation.org/6ZYIecFEw.
29. McGill E, Marks D, Sumpter C, Egan M. Consequences of removing cheap, super-strength beer and cider: a qualitative study of a UK local alcohol availability intervention. BMJ open. 2016; 6:e010759.
30. Sweeting H. Alcohol units at pocket money prices [e-letter]. Bmj. 2006; 333:825-b.
31. Gornall J. Doctors and the alcohol industry: an unhealthy mix? Bmj. 2013; 346:f1889.
32. Portman Group. K Cider, Complaint decision details. 2017 [cited 2017 24 January]; Available from: Available at: http://www.portmangroup.org.uk/complaints/complaint-

decisions/complaint-decision-details/2017/01/12/k-cider (accessed 24 January 2017). Archived at: http://www.webcitation.org/6nkoGttF8 on 24 January 2017. .

33. Association of Convenience Stores. Reducing the Strength: Retailer Guidance. 2015 [cited 2015 5 November]; Available from: Available at: http://www.acs.org.uk/advice/reducing-the-strength/ (accessed 10 December 2015). Archived at: http://www.webcitation.org/6dh7Gcc5S on 11 December 2015.

34. Competition and Markets Authority. High-strength alcohol schemes: competition law advice for retailers. 2015 [cited 2015 5 November]; Available from: Available at: https://www.gov.uk/government/publications/high-strength-alcohol-schemes-competition-law-advice-for-retailers (accessed 10 December 2015). Archived at: http://www.webcitation.org/6dh7NK9Rb on 11 December 2015.

35. Sumpter C, McGill E, Dickie E, Champo E, Romeri E, Egan M. Reducing the Strength: a mixed methods evaluation of alcohol retailers' willingness to voluntarily reduce the availability of low cost, high strength beers and ciders in two UK local authorities. BMC Public Health. 2016; 16:448.

36. Bryden A, Petticrew M, Mays N, Eastmure E, Knai C. Voluntary agreements between government and business - a scoping review of the literature with specific reference to the Public Health Responsibility Deal. Health policy. 2013; 110:186-97.

37. Community Alcohol Partnerships. About Community Alcohol Partnerships. 2015 [cited 2015 5 November]; Available from: Available at: http://www.communityalcoholpartnerships.co.uk/ (accessed 10 December 2015). Archived at: http://www.webcitation.org/6dh622qSP on 11 December 2015.

38. Robinson M, Thorpe R, Beeston C, McCartney G. A review of the validity and reliability of alcohol retail sales data for monitoring population levels of alcohol consumption: a Scottish perspective. Alcohol and alcoholism. 2013; 48:231-40.

39. Egan M, Pliakas T, Grace D, McGill E, Jones A, Wong J, et al. Use of retail data in the assessment of natural experiments: the case of Reducing the Strength, an intervention to reduce alcohol availability. Lancet. 2014; 384:S30.

40. Robinson M, Geue C, Lewsey J, Mackay D, McCartney G, Curnock E, et al. Evaluating the impact of the alcohol act on off-trade alcohol sales: a natural experiment in Scotland. Addiction. 2014; 109:2035-43.

41. Suffolk Constabulary. Reducing the Strength Ipswich - One year on. 2012 [cited 2015 5 November]; Available from: Available at: http://www.suffolk.police.uk/safetyadvice/personalsafety/alcoholawareness/reducingthestrength/oneyearon.aspx (accessed 10 December 2015). Archived at: http://www.webcitation.org/6dh6n05NZ on 11 December 2015.

42. Hawkins NG, Sanson-Fisher RW, Shakeshaft A, D'Este C, Green LW. The multiple baseline design for evaluating population-based research. American journal of preventive medicine. 2007; 33:162-8.

43. Office for National Statistics. Population Estimates for UK, England and Wales, Scotland and Northern Ireland, Mid-2014. 2015 [cited 2015 5 November]; Available from: Available at: http://www.ons.gov.uk/ons/publications/re-reference-tables.html?edition=tcm%3A77-368259 (accessed 10 December 2015). Archived at: http://www.webcitation.org/6dh6SoR4s on 11 December 2015.

44. Wagner AK, Soumerai SB, Zhang F, Ross-Degnan D. Segmented regression analysis of interrupted time series studies in medication use research. Journal of clinical pharmacy and therapeutics. 2002; 27:299-309.

45. Beck N, Katz JN. What to do (and not to do) with Time-Series Cross-Section Data. The American Political Science Review. 1995; 89:634-47.

46. Hoechle D. Robust standard errors for panel regressions with cross-sectional dependence. The Stata Journal. 2007; 7:281-312.
47. Linden A. Conducting interrupted time-series analysis for single- and multiple-group comparisons. The Stata Journal. 2015; 15:480-500.
48. The Drinks Report. UK alcohol market returns to growth. 2015 [cited 2015 5 November]; Available from: Available at: http://www.thedrinksreport.com/news/2015/16101-uk-alcohol-market-returns-to-growth.html (accessed 10 December 2015). Archived at: http://www.webcitation.org/6dh702Jz8 on 11 December 2015.
49. Craig P, Cooper C, Gunnell D, Haw S, Lawson K, Macintyre S, et al. Using natural experiments to evaluate population health interventions: new Medical Research Council guidance. Journal of epidemiology and community health. 2012; 66:1182-6.
50. Robinson M, Shipton D, Walsh D, Whyte B, McCartney G. Regional alcohol consumption and alcohol-related mortality in Great Britain: novel insights using retail sales data. BMC Public Health. 2015; 15:1.
51. de Vocht F, Heron J, Angus C, Brennan A, Mooney J, Lock K, et al. Measurable effects of local alcohol licensing policies on population health in England. Journal of epidemiology and community health. 2016; 70:231-7.
52. de Vocht F, Heron J, Campbell R, Egan M, Mooney JD, Angus C, et al. Testing the impact of local alcohol licencing policies on reported crime rates in England. Journal of epidemiology and community health. 2017; 71:137-45.
53. Knai C, Petticrew M, Durand MA, Scott C, James L, Mehrotra A, et al. The Public Health Responsibility deal: has a public-private partnership brought about action on alcohol reduction? Addiction. 2015; 110:1217-25.
54. de Vocht F, Tilling K, Pliakas T, Angus C, Egan M, Brennan A, et al. The intervention effect of local alcohol licensing policies on hospital admission and crime: a natural experiment using a novel Bayesian synthetic time-series method. Journal of epidemiology and community health. 2017.
55. Department of Health. Health risks from alcohol: new guidelines. 2016; Available from: Available at: https://www.gov.uk/government/consultations/health-risks-from-alcohol-new-guidelines (accessed 2 August 2017). Archived at: http://www.webcitation.org/6sQ3CIIWX on 2 August 2017. .

List of titles for all figures

Figure 1 Percent change in units of alcohol sold after the introduction of the *Reducing the Strength* initiative. Wave 1 stores started implementation by September 2012. Wave 2 stores started implementation by September 2013.

Figure 2 Percent change in sales value after the introduction of the *Reducing the Strength* initiative. Wave 1 stores started implementation by September 2012. Wave 2 stores started implementation by September 2013.

Table 1 List of ~~super strength~~ beer and cider products over 6.5% ABV sold during the 'Reducing the Strength' initiative.

EAN	ABV	Description	Size	Units	Price (£)[a]	Price per unit (£)[a]
5010079105150	7.5	~~7.5% WHITE STAR~~White Star[b]	2Ltr	15.0	2.50 to 5.23	0.17 to 0.35
5010153737048	9.0	~~9% CARLSBERG SPEC BREW~~ Carlsberg special brew[b]	4x440ml	15.8	1.52 to 9.75	0.10 to 0.62
5000128393041	7.5	~~7.5% CP S/STRENGTH LAGER~~Co-op superstrength lager[b]	4x440ml	13.2	1.39 to 7.25	0.11 to 0.55
5010017012526	9.0	~~9.0%~~ Tennent's super strong lager~~TENNENTS SUPER~~[b]	4x440ml	15.8	2.08 to 9.59	0.13 to 0.61
5014201655414	8.2	Special vintage cider~~8.2% SPEC VINTAG~~[c]	500ml	4.1	1.73 to 2.13	0.42 to 0.52
5012845198120	8.2	~~8.2% IMPERIAL CYDER~~Imperial cider[c]	500ml	4.1	2.15 to 2.61	0.52 to 0.64
5016878000207	6.7	Adnams Jack brand innovation	500ml	3.4	1.42 to 2.94	0.42 to 0.88
5012845172809	7.0	Aspall dry Suffolk cider premier cru	500ml	3.5	1.31 to 2.84	0.37 to 0.81
5012845177101	7.0	Aspall premier cru Suffolk cider pack	4x330ml	9.2	1.78 to 6.17	0.19 to 0.67
5012845172830	7.0	Aspall organic Suffolk cider	500ml	3.5	1.15 to 2.79	0.33 to 0.80
8594403110159	7.4	Budweiser Budvar Czech premium lager	330ml	2.4	0.88 to 2.28	0.36 to 0.93
5014201203554	6.5	Westons - Wyld Wood Classic cider	500ml	3.3	1.88 to 2.52	0.58 to 0.78
609722874786	7.0	NSB dry cider	750ml	5.3	1.80 to 3.78	0.34 to 0.72
609722874793	7.0	NSB medium cider	750ml	5.3	1.40 to 3.78	0.27 to 0.72
609722874809	7.0	NSB 7sweet cider	750ml	5.3	0.90 to 3.78	0.17 to 0.72
5020628002809	7.4	Thatchers Katy cider	500ml	3.7	1.78 to 2.51	0.48 to 0.68
5020628006685	7.4	Thatchers vintage cider	500ml	3.4	1.82 to 2.37	0.49 to 0.64
5010327658544	6.6	Innis & Gunn original oak aged beer	330ml	2.2	1.00 to 2.11	0.46 to 0.97
5410228102762	6.6	Leffe blonde	750ml	5.0	2.94 to 4.49	0.59 to 0.91
5410228190424	6.6	Leffe blonde pack	4x330ml	8.7	1.46 to 7.83	0.16 to 0.85
609224793127	7.0	Carter's Essex cider 7%	500ml	3.5	1.25 to 2.49	0.36 to 0.71
5011348010953	7.4	Banks's Barley Gold	4x330ml	9.8	4.42 to 5.7	0.48 to 0.62
5000264004184	7.3	McEwans champion ale	500ml	3.7	2.02 to 2.14	0.55 to 0.58
5010549302348	6.5	Old crafty hen	500ml	3.3	1.93 to 2.4	0.59 to 0.74

[a]: Range of values during the period of study.
[b]: Superstrength products (over 7.5% ABV) removed as part of the Reducing the Strength initiative.
[b]: High strength premium products (over 7.5% ABV) not removed as part of the Reducing the Strength initiative.
[d]: High strength premium products (over 6.5% but below 7.5% ABV) still available during the study period.
EAN: European Article Number (also called International Article Number)
ABV: Alcohol by volume (ABV) (%)
Recommended weekly limit of 14 units of alcohol for men and women[55]

Table 2 Summary statistics for units of alcohol sold per store per month.

	Stores in wave 1 (n=54)			Stores in wave 2 (n=77)			All stores (n=131)		
Product categories	**Mean (SD)**	**Median**	**Min - Max**	**Mean (SD)**	**Median**	**Min - Max**	**Mean (SD)**	**Median**	**Min - Max**
Beer/lager & cider	11,641 (8,364)	9,189	2,566 – 61,692	14,159 (9,330)	11,646	884 – 71,467	13,120 (9,029)	10,489	884 – 71,467
Of which super-strength products removed [a]	761 (680)	547	13 - 4782	512 (614)	305	13 - 5165			
Of which super-strength products not removed	334 (273)	246	4 – 1,816	388 (344)	279	4 – 2,325	365 (317)	258	4 – 2,325
Spirits	9,002 (8,261)	6,602	1,984 – 62,816	9,903 (8,279)	7,280	334 – 72,664	9,531 (8,282)	6,967	334 – 72,664
Affordable sparkling and low alcohol wines	951 (1,047)	643	66 – 13,151	1,080 (1,089)	711	35 – 9,819	1,026 (1,074)	680	35 – 13,151
Wines	16,280 (16,722)	11,334	2,485 – 133,557	17,147 (15,134)	12,786	668 – 102,783	16,790 (15,812)	12,087	668 –133,557
All products	37,873 (33,311)	28,273	10,314 – 262,238	42,277 (32,390)	33,023	1,920 –221,608	40,462 (32,840)	30,944	1,920 –262,238

[a]: Only for the period up until September 2012 for wave 1 and September 2013 for wave 2.