

DISCUSSION PAPER SERIES

IZA DP No. 18249

**The Causal Effects of Alcohol Minimum
Unit Pricing on Drinking Behaviour
in the UK**

Erkal Ersoy
Javid Karimli
Cristina Tealdi

NOVEMBER 2025

DISCUSSION PAPER SERIES

IZA DP No. 18249

The Causal Effects of Alcohol Minimum Unit Pricing on Drinking Behaviour in the UK

Erkal Ersoy

Heriot-Watt University

Javid Karimli

Heriot-Watt University

Cristina Tealdi

Heriot-Watt University and IZA

NOVEMBER 2025

Any opinions expressed in this paper are those of the author(s) and not those of IZA. Research published in this series may include views on policy, but IZA takes no institutional policy positions. The IZA research network is committed to the IZA Guiding Principles of Research Integrity.

The IZA Institute of Labor Economics is an independent economic research institute that conducts research in labor economics and offers evidence-based policy advice on labor market issues. Supported by the Deutsche Post Foundation, IZA runs the world's largest network of economists, whose research aims to provide answers to the global labor market challenges of our time. Our key objective is to build bridges between academic research, policymakers and society.

IZA Discussion Papers often represent preliminary work and are circulated to encourage discussion. Citation of such a paper should account for its provisional character. A revised version may be available directly from the author.

ISSN: 2365-9793

IZA – Institute of Labor Economics

Schaumburg-Lippe-Straße 5–9
53113 Bonn, Germany

Phone: +49-228-3894-0
Email: publications@iza.org

www.iza.org

ABSTRACT

The Causal Effects of Alcohol Minimum Unit Pricing on Drinking Behaviour in the UK

This paper evaluates the impact of Minimum Unit Pricing (MUP) on alcohol consumption in the UK using a difference-in-differences (DiD) framework, leveraging rich individual-level survey data. We estimate Average Treatment Effects on the Treated (ATET) using both standard and staggered DiD approaches. Although we find no significant change in the share of individuals drinking at least monthly following MUP implementation, we document meaningful reductions in drinking intensity: binge drinking declined by up to 18 percentage points among younger cohorts, and the share of individuals consuming more than two drinks on a typical day also fell significantly. Among those under 25, average weekly alcohol consumption decreased by nearly 34%. These results suggest that while MUP had a limited impact on drinking frequency, it was effective in curbing harmful patterns of alcohol use, particularly among younger individuals.

Corresponding author:

Cristina Tealdi
Edinburgh Business School
Heriot-Watt University
EH14 4AS Edinburgh
United Kingdom
E-mail: c.tealdi@hw.ac.uk

1 Introduction

Harmful alcohol consumption is a pressing public health issue worldwide, accounting for an estimated 4.7% of the global burden of disease (World Health Organisation 2024). In addition to its health consequences, alcohol misuse generates substantial economic costs, with wide-ranging implications for productivity, labour market outcomes, and long-run economic growth. Excessive drinking contributes to avoidable healthcare expenditure, absenteeism, reduced labour supply, and diminished human capital accumulation (Hashemi S. et al. 2022, Pintor et al. 2024). These effects are particularly pronounced among working-age individuals, where alcohol misuse can undermine educational attainment, employment stability, and earnings potential (Lindo et al. 2012, Baktash et al. 2022). Scotland has long recorded higher alcohol-specific death rates than England and Wales, and in recent years these have climbed to their highest levels in over a decade, raising urgent concerns over the adequacy of existing alcohol control policies.

In an attempt to address this important issue, the Scottish Government implemented a Minimum Unit Pricing (MUP) policy in May 2018, establishing a legally mandated floor price of £0.50 per unit of alcohol. The explicit objective was to reduce access to inexpensive, high-strength beverages, thereby discouraging harmful consumption. With this policy, Scotland became the second country globally to introduce a comprehensive MUP after Armenia’s adoption in 2016. In September 2024, amid a 15-year high in alcohol-related deaths and with the aim of restoring the effectiveness of the policy eroded by inflation, the Scottish Government raised the minimum price from £0.50 to £0.65 per unit. To illustrate the magnitude of the intervention, a two-litre bottle of 7.5% alcohol cider that could be purchased for as little as £1.99 prior to MUP rose to a minimum legal price of £7.50 in 2018 and £9.75 in 2024. Following Scotland, Wales introduced its own MUP policy on 2 March 2020, set at £0.50 per unit.

This study evaluates the impact of MUP on alcohol consumption behaviours in the UK. Using longitudinal panel data from the *Understanding Society* survey covering 2015–2022, we first estimate a difference-in-differences model comparing Scotland (treated) with England (control). To exploit the staggered introduction of MUP across regions, we then estimate a

staggered difference-in-differences model, treating Scotland and Wales as adopters at different points in time, with England as the control throughout. This approach enables us to capture variation in policy timing and to test the robustness and external validity of our results across settings. Our estimates suggest that MUP reduced average alcohol consumption by around 6% among adults, with substantially larger effects—up to 23%—among younger individuals. These effects are concentrated on intensive margins of drinking behaviour (binge episodes, typical quantities consumed) rather than on overall drinking prevalence.

Traditional instruments, such as excise taxation, licensing restrictions, and public health campaigns, have had mixed success in curbing excessive consumption. Excise duties raise the overall cost of alcohol, but because they apply uniformly across beverage types and price ranges, they tend to have a proportionally larger effect on more expensive products and on moderate consumers, while leaving the relative affordability of very cheap, high-strength drinks largely unchanged (Angus et al. 2016, Holmes 2023). This uniformity dilutes their effectiveness in targeting the sub-population most at risk of alcohol-related harm. Licensing restrictions, such as limiting opening hours or controlling outlet density, can reduce availability but are often politically contentious and unevenly enforced (Popova et al. 2009). Public health campaigns, meanwhile, can raise awareness of drinking risks but generally produce modest and short-lived behavioural changes, particularly among heavy drinkers who are least responsive to information (Anderson et al. 2009, Elder et al. 2004).

By contrast, minimum unit pricing directly addresses a market failure inherent in the alcohol market: the widespread availability of cheap, high-strength beverages disproportionately consumed by harmful and dependent drinkers. By setting a price floor per unit of alcohol, MUP ensures that the cheapest products increase most in price, while leaving the cost of mid-range and premium products largely unaffected. This design feature makes MUP a more targeted intervention than general taxation, as it narrows its impact on moderate consumers while exerting stronger price pressure on the high-risk group.

While the bulk of the empirical literature on MUP has focused on retail sales and purchasing patterns, consistently documenting a decline in alcohol purchases following implementation (Stockwell et al. 2012, Holmes 2023), relatively little is known about how MUP

affects actual drinking behaviour at the individual level. By leveraging longitudinal data, our paper makes three contributions. First, we provide a causal analysis of how MUP influences alcohol consumption, directly linking the policy to individual-level drinking outcomes rather than aggregate sales. Second, we account for unobserved individual heterogeneity and track behavioural adjustments over time, offering insights into the dynamics of responses to the policy. Third, we highlight important heterogeneity, showing that young adults are particularly responsive to the policy, consistent with its objective of reducing harmful drinking in high-risk groups.

The rest of the paper is organised as follows. Section 2 reviews the related literature, while Section 3 describes the institutional background. Section 4 illustrates the data and outcome variables, while Section 5 presents the empirical strategy. Sections 6 and 7 discuss the results and robustness checks. Section 8 discusses the effectiveness of the reform. Finally, Section 9 concludes with a discussion of policy implications and avenues for future research.

2 Literature Review

The literature examining the effects of Minimum Unit Pricing (MUP) for alcohol remains relatively limited but has expanded in recent years to cover a broad range of outcomes.

A first strand of the literature investigates the impact of MUP on health outcomes, with a general consensus that the policy leads to reductions in alcohol-related hospital admissions and mortality. Studies in Scotland and Canada have found significant declines in alcohol-related deaths and emergency department visits following MUP implementation, though the magnitude of these effects varies across settings and methodologies (Stockwell et al. 2013, Zhao et al. 2017, So et al. 2021, Wyper et al. 2023). Several studies have extended this focus to include secondary harms such as drink-driving offences, alcohol-related traffic fatalities, and violent crime. The evidence in this area is more mixed, with some studies reporting reductions in harm (Stockwell et al. 2017), while others find no statistically significant effects or note substantial heterogeneity across regions and populations (Francesconi and James 2022, Haghpanahan et al. 2019, Cooper et al. 2020).

A second prominent body of research examines how alcohol consumption patterns and sales volumes respond to price-based interventions. A consistent finding across these studies is that increasing the price of alcohol, whether through Minimum Unit Pricing or excise taxation, is associated with a reduction in overall alcohol purchases. This literature, which predominantly focuses on retail alcohol sales, highlights that MUP policies are particularly effective in reducing the purchase of inexpensive, high-strength alcoholic beverages, which are disproportionately consumed by heavy and dependent drinkers (Purshouse et al. 2010, Stockwell et al. 2012, Burton et al. 2017, O'Donnell et al. 2019, Coomber et al. 2020, Robinson et al. 2021, Griffith et al. 2022, Holmes 2023). These empirical findings are supported by simulation-based modelling studies, which project substantial public health benefits from MUP policies (Purshouse et al. 2009, Boyd et al. 2024). To our knowledge, the only study that directly examines patterns of alcohol consumption in response to MUP is Nguyen et al. (2024), which uses cross-sectional health survey data to assess changes in drinking rates across different categories of drinkers. Their findings suggest a decline in consumption among moderate drinkers, with no significant effect observed among harmful drinkers. However, the use of repeated cross-sections limits the ability to track individual behavioural changes over time or to account for unobserved heterogeneity. Our study addresses this gap by using longitudinal panel data and several indicators of drinking patterns to provide causal evidence on how individual drinking behaviour evolves following the introduction of MUP.

Finally, a related area of research explores the determinants of excessive alcohol consumption, offering insights into the socioeconomic and demographic drivers of risky drinking. Some studies suggest that alcohol consumption is pro-cyclical, increasing during periods of economic growth and decreasing with unemployment (Boden et al. 2017). However, other work finds more nuanced dynamics, with short- and long-term unemployment exerting contrasting effects on drinking behaviour (Khan et al. 2002). Socioeconomic status also plays a central role: lower neighbourhood income levels are predictive of higher alcohol use among adolescents, suggesting that alcohol-related harm is deeply intertwined with social deprivation (Lowe et al. 2023). Similarly, high-risk drinking is most common among young adults with lower levels of education, and there is strong evidence that parental alcohol use disorders

significantly influence children’s behavioural trajectories and long-term alcohol consumption patterns (Chaiyasong et al. 2018, McCutcheon et al. 2018, Casswell et al. 2023).

3 Institutional background

The United Kingdom has long experienced high levels of alcohol consumption relative to many other high-income countries, with associated burdens on health systems and mortality. The World Health Organization estimated that in 2010 adults in the UK consumed on average 11.6 litres of pure alcohol per capita annually, well above the global average (World Health Organisation 2018). Alcohol-related harm represents a major public health challenge across the UK, but the problem has been particularly acute in Scotland, where morbidity and mortality attributable to alcohol are among the highest in Western Europe (Murray et al. 2012, Giles et al. 2019). The affordability of alcohol increased markedly in the early 2000s as supermarket competition drove down the price of high-strength, low-cost beverages such as cider, beer, and spirits (Beeston et al. 2013). As a consequence, Scotland experienced persistently high rates of alcohol-attributable hospitalisations and deaths, with sharp rises in liver disease mortality observed between the 1990s and mid-2000s (Leyland et al. 2007, McCartney et al. 2012). To address these challenges, the Scottish Government implemented in 2018 a novel public health intervention in the form of a national minimum unit pricing policy.

A minimum unit pricing (MUP) for alcohol is a targeted fiscal instrument intended to reduce harmful drinking by raising the floor price of very cheap, high-strength products. Under MUP, a statutory minimum price is set per unit of pure alcohol (one UK unit is equal to approximately 10 ml or 8g of ethanol)¹ such that, for example, a 50 pence (£0.50) MUP means alcohol cannot be sold below that price per unit. Unlike general excise taxation, MUP disproportionately impacts the cheapest products favoured by heavier and hazardous drinkers, while minimally affecting prices for moderate consumers.

Scotland was the first jurisdiction in the UK to implement MUP at scale. The policy was

¹See Table 16 in the Appendix for details.

first proposed in 2012 as part of Scotland’s broader alcohol strategy, but its implementation was delayed for several years due to legal challenges. Industry groups, led by the Scotch Whisky Association (SWA), argued that MUP violated European Union trade and competition law and would unfairly distort markets. The case was litigated up to the European Court of Justice and later the UK Supreme Court, with the final ruling in favour of the Scottish Government only delivered in late 2017. This prolonged period of uncertainty meant that, despite the policy being on the political agenda for years, firms and consumers had little incentive to change their behaviour in advance of its implementation. The industry’s sustained lobbying and legal opposition not only delayed the policy but also ruled out the case of anticipation effects prior to its introduction. Scotland implemented a statutory MUP of £0.50 per unit on 1 May 2018, yielding a large-scale natural experiment for evaluating public health effects in a high-income setting. Wales followed with an identical floor price of £0.50 per unit through the Public Health Minimum Price for Alcohol Wales Act 2018, which came into effect on 2 March 2020.

A critical development occurred in 2024, when Scotland’s original MUP legislation, which contained a sunset clause set to expire on 30 April 2024, was renewed and updated. Following a public consultation (September–November 2023) and parliamentary scrutiny, the Scottish Parliament voted in April 2024 to both continue MUP beyond its sunset and raise the price to £0.65 per unit, a 30% increase effective from 30 September 2024 with no official expiry date. This decision reflected growing evidence that inflation had eroded the real value of the original £0.50 threshold, thereby weakening its effectiveness in reducing alcohol-related harm. Independent evaluations had attributed substantial health gains to the initial policy, including reductions in alcohol-attributable deaths and hospitalisations, but highlighted that without adjustment, these benefits would likely diminish.

4 Data and Descriptive Statistics

For this study, we use survey data from the Understanding Society dataset (Buck and McFall 2012). The dataset is a rich longitudinal survey that collects data annually from a nationally

representative sample of households in the UK. It includes both individual- and household-level information, exploring various domains such as education, employment, family, civic engagement, income, health, and more. Crucially for this study, it also collects information on alcohol consumption and drinking habits. As this study aims to identify how drinking behaviour and habit formation are shaped by the policy in question, we exploit the longitudinal panel structure of the dataset to investigate the causal link between MUP and the long-term effects on individuals’ drinking habits.

Our analysis draws on waves 7, 9, 11, and 13 of the dataset, which nominally correspond to the calendar years 2015, 2017, 2019, and 2021, respectively. However, the actual interview dates indicate that data collection for each wave extended up to two years beyond the nominal year. Minimum Unit Pricing was introduced in May 2018. All interviews in wave 7 were conducted prior to policy implementation, while interviews in waves 11 and 13 occurred wholly after it. In contrast, wave 9 contains a mix of pre- and post-policy observations. To ensure clear separation between pre- and post-intervention periods, we exclude all wave 9 interviews conducted after May 2018 from our analysis. We also exclude from our sample all individuals who moved across regions during the observation period, as well as those whose reported gender changed.² We restrict our sample to respondents who were of legal drinking age at the first interview in our sample (i.e., aged 18 or older). This is to ensure that our sample consists of individuals who are of legal drinking age on the date of policy implementation.

To assess the impact of the Minimum Unit Pricing (MUP) policy on drinking behaviour, we construct four complementary measures of alcohol consumption that are explicitly designed to capture and distinguish between the frequency and intensity of drinking.³ We construct three binary indicators to capture different dimensions of drinking behaviour. The first reflects drinking frequency, equal to one if the respondent consumed alcohol more than once per month in the past year (*Monthly drinking*). The other two indicators capture drinking intensity: the first of these takes the value one if the respondent engaged in binge

²Table 21 in the Appendix presents summary statistics for the excluded individuals. Overall, these excluded observations do not differ significantly from the main sample.

³Variable construction follows the Understanding Society codebook; full derivations described in Section A.1 in the Appendix.

drinking at least monthly (*Binge drinking*), where binge drinking is defined as consuming six or more units of alcohol on a single occasion for women and eight or more for men (Buck and McFall 2012). The second drinking intensity indicator equals one if the respondent typically consumes more than two drinks on a typical drinking day (*Two drinks/day*). In addition to these binary indicators, we construct a continuous measure of overall alcohol consumption. This is calculated by combining information on how frequently (in days) the respondent drank alcohol in the past 12 months and the typical number of drinks consumed per occasion. From these responses, we derive an estimate of the average number of alcohol units consumed per week, which captures both frequency and intensity in a single metric (*Units/week*). Together, these measures allow us to assess whether MUP affects how often people drink, how much they drink when they do, or both.

Table 1: Descriptive statistics.

	England	Wales	Scotland
<i>Alcohol consumption</i>			
Monthly drinking	0.590 (0.492)	0.550 (0.498)	0.605 (0.489)
Binge drinking	0.204 (0.403)	0.217 (0.412)	0.233 (0.423)
Two drinks/day	0.306 (0.461)	0.366 (0.482)	0.392 (0.488)
Units/week	4.295 (6.590)	4.393 (6.891)	4.204 (6.053)
<i>Socio-demographic characteristics</i>			
Age	52.0 (17.656)	54.1 (17.373)	53.9 (16.896)
Male	0.464 (0.499)	0.418 (0.493)	0.433 (0.496)
Non-Native	0.069 (0.254)	0.032 (0.176)	0.056 (0.230)
University degree	0.416 (0.493)	0.346 (0.476)	0.467 (0.499)
Employed	0.586 (0.492)	0.530 (0.499)	0.575 (0.494)
Unemployed	0.033 (0.178)	0.032 (0.177)	0.021 (0.144)
Retired	0.282 (0.450)	0.328 (0.470)	0.310 (0.463)
Student	0.019 (0.137)	0.011 (0.106)	0.019 (0.137)
Other employment status	0.080 (0.271)	0.098 (0.298)	0.074 (0.262)
Married/partnership	0.664 (0.472)	0.654 (0.476)	0.625 (0.484)
Life satisfaction	5.117 (1.538)	5.012 (1.607)	5.181 (1.528)
Monthly Income (gross, in £)	2,019 (1,699)	1,717 (1,312)	1,949 (1,537)
N	32,427 (86.3%)	1,796 (4.8%)	3,355 (8.9%)

Notes: The sample includes observations from Waves 7, 9, 11 and 13. All the variables are weighted using UKHLS survey weights.

Table 1 presents descriptive statistics for the sample in Wave 7. The sample consists of 32,427 observations from England (86.3%), 1,796 from Wales (4.8%), and 3,355 from Scotland (8.9%). The share of individuals drinking at least monthly is higher in England and Scotland compared to Wales, while binge drinking at least monthly and drinking more than

two drinks a day appear to be more prevalent in Scotland and Wales. On average, weekly alcohol consumption (measured in units) is highest in Wales. Demographic characteristics also vary across the three regions. The sample population is slightly older in Wales, while the proportion of males is higher in England. Scotland has a larger share of individuals with a tertiary degree, whereas employment rates and average monthly income are higher in England.

We complement these variables with two region-level control variables, the unemployment rate and GDP per capita, which we source from the Office for National Statistics (ONS).

5 Empirical strategy

To estimate the causal effect of MUP, we exploit variation over time and across regions in its implementation, which produced exogenous differences in alcohol prices and drinking behaviour. We begin with a difference-in-differences (DiD) framework, comparing changes in drinking outcomes between Scotland, where MUP was introduced in 2018 and England, which did not adopt the policy. Separate DiD specifications are estimated for each alcohol consumption measure. We then extend the analysis to a staggered DiD design that incorporates the sequential roll-out of MUP, first in Scotland (2018) and subsequently in Wales (2020).

5.1 Difference in differences: Scotland versus England

In the first phase of our analysis, we study relative changes in drinking habits before and after the introduction of MUP in Scotland, where MUP came into effect in 2018, and England, where the policy was not adopted. To this end, we estimate the following model:

$$Y_{irt} = \alpha + \beta Treat_r \times MUP_t + \gamma X_{it} + \delta Z_{rt} + \mu_i + \eta_w t \epsilon_{irt} \quad (1)$$

where i is the individual, r is the region and t is the year. In this model, Y_{irt} refers to the alcohol consumption outcomes discussed above. The vector X_{it} includes individual-level

characteristics such as gender, age, marital status, employment status, educational attainment, monthly income, and life satisfaction. The vector Z_{rt} includes region-level control variables such as unemployment rate and GDP per capita. The individual and time fixed effects are captured by μ_i and η_t , respectively. These variables control for potentially confounding effects that are time invariant within a region or are common to each survey wave across regions, respectively. The variable $Treat_r$ is equal to one for individuals living in the treated region (Scotland), while the variable MUP_t equals one after the implementation of MUP. The coefficient of interest, β , is the average treatment on the treated parameter (ATET) under the standard parallel trend assumption. Standard errors are clustered at the individual level.

The causal interpretation of ATET in the DiD setting relies on the use of covariates and the comparability of the treated and control groups along with the plausibility of the assumptions of no-anticipation and conditional parallel trend assumptions (Callaway and Sant’Anna 2021). Due to violations of these assumptions in the survey-weighted sample, we match the observations in the treatment group with the re-weighted subsample of the control group based on Propensity Score Matching (PSM). We implement a five nearest neighbours matching method (Leuven and Sianesi 2003), and estimate the propensity scores and corresponding weights based on logistic regression using individual characteristics⁴ in the pre-treatment periods as covariates. The matched sample consists of 839 individuals residing in Scotland matched with 1059 residents of England (Table 2).

Following propensity score matching, we confirm formally via balance tests on the covariates of the treatment and control groups in the pre-treatment period that the Scottish sample is comparable to the matched English sample (Table 2).

To support the parallel trend assumption, we present event study estimates for the four outcome variables in Scotland and England. These event studies are computed by estimating dynamic treatment effects in a difference-in-differences framework, where we replace the post-treatment dummy with a series of leads and lags of the MUP implementation indicator, normalised to zero in the period immediately preceding the policy change. This approach

⁴Individual characteristics include gender, age, education level, marital status, employment status, monthly income and life satisfaction.

Table 2: Descriptive statistics: Balanced sample

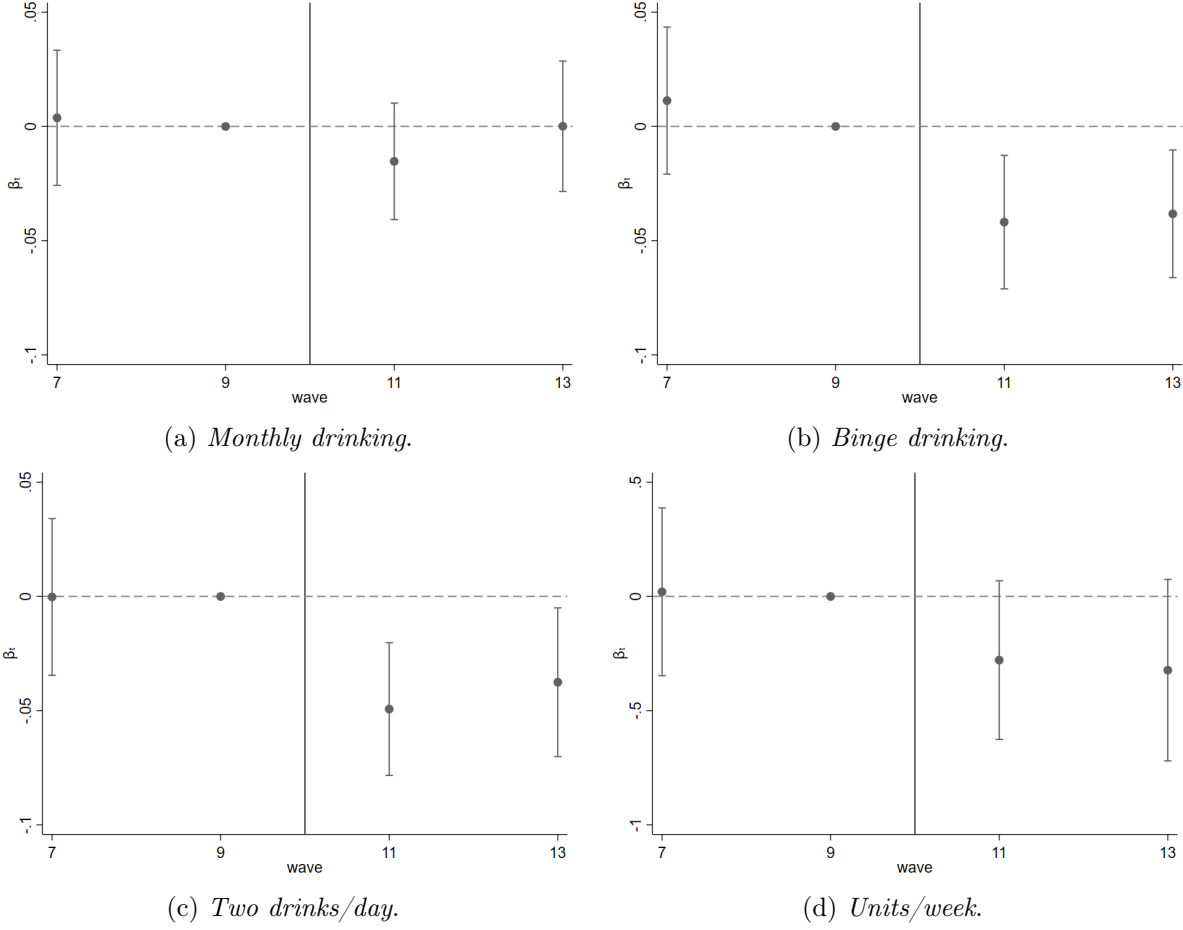
	England mean (sd)	Scotland mean (sd)	Normalised Difference
Age	51.7 (17.266)	51.0 (16.750)	0.351
Male	0.467 (0.499)	0.433 (0.496)	0.095
University or Higher degree	0.427 (0.495)	0.446 (0.497)	0.348
Employed	0.612 (0.487)	0.610 (0.488)	0.899
Unemployed	0.025 (0.155)	0.022 (0.146)	0.655
Retired	0.275 (0.446)	0.260 (0.439)	0.385
Student	0.024 (0.154)	0.034 (0.182)	0.246
Other employment status	0.064 (0.246)	0.075 (0.263)	0.383
Married or in partnership	0.641 (0.480)	0.633 (0.482)	0.692
Life satisfaction	5.349 (1.434)	5.243 (1.562)	0.115
Monthly Income (in £)	1,923 (1,558.021)	1,853 (1,443.873)	0.225
Observations	1,061 (55.8%)	839 (44.2%)	

Notes: Descriptive statistics are computed using data from Wave 7 (pre-intervention) using survey and propensity score matching weights to rebalance variables between treated and control units. Standard deviations are given in parentheses. Normalised differences are calculated as in Baker et al. (2025). *Source:* authors' calculations using the Understanding Society dataset.

allows us to trace out the evolution of treatment effects over time and to formally test for the presence of pre-trends. We estimate these models for the four outcome variables: the percentage of individuals drinking more than once a month (Figure 1a), the proportion of individuals engaging in binge drinking at least monthly (Figure 1b), the proportion of individuals drinking at least two drinks per day (Figure 1d), and average weekly alcohol consumption (Figure 1d). These figures provide visual evidence consistent with the conditional parallel trend assumption, as the pre-treatment coefficients are statistically indistinguishable from zero. We formally assess this condition by testing for significant differences in the pre-treatment periods. The absence of statistically significant pre-trends (Table 17 in the Appendix) further reinforces the credibility of our identification strategy.

Another potential threat to identification is the presence of anticipation effects. Figures 1 suggest that no such effects occurred in Scotland in the years leading up to MUP, a finding further supported by a Granger causality test (Table 18 in the Appendix). This is consistent with the policy environment: although MUP was first proposed in 2012, its implementation was repeatedly delayed due to legal challenges and strong opposition from whisky lobbies, making it unlikely that consumers or retailers would adjust their behaviour in anticipation of the reform.

Figure 1: Event studies for the four outcome variables.



Note: Figures show the event-study estimates in treatment (Scotland) and control (England) groups. 90% confidence interval around the point estimates are given in each case. Percentage of people drinking more frequently than once a month shown in panel (a), percentage of individuals engaging in binge drinking monthly in panel (b), percentage of individuals having more than two drinks on a typical drinking day in panel (c), and average units of alcohol per week given in panel (d) in treatment (Scotland) and control (England) regions before and after the policy change in 2018.

5.2 Staggered difference in differences: Scotland and Wales vs England

While a standard difference-in-differences (DiD) design compares outcomes before and after a treatment between treated and untreated groups, it assumes a single treatment time and may be vulnerable to biases when external shocks or dynamic treatment effects are present. To address these limitations, we implement a staggered DiD design, taking advantage of the differential timing in the adoption of MUP across UK nations: Scotland introduced MUP in 2018 followed by Wales in 2020, while England has not adopted it to date and serves as a

never-treated control group. This variation in timing allows us to more credibly identify the causal impact of MUP by comparing treated units (Scotland or Wales) not only to untreated units but also to units treated later or earlier. As highlighted by Athey and Imbens (2022), staggered adoption provides a more robust identification strategy by mitigating the risk that contemporaneous national or regional shocks drive the estimated effects.

To estimate treatment effects in this staggered setting, we follow the Callaway and Sant’Anna (2021) approach, which allows for treatment effect heterogeneity across groups and time. We then estimate the following equation:

$$Y_{irt} = \alpha + \sum_{g \in \mathcal{G}} \beta_g \mathbf{1}\{Group_r = g\} \cdot \mathbf{1}\{t \geq g\} + \gamma X_{it} + \delta Z_{rt} + \mu_i + \lambda_t + \varepsilon_{irt}, \quad (2)$$

where Y_{irt} is one of the four aforementioned outcome variables for individual i in region r at time t ; $\mathbf{1}\{Group_r = g\}$ is an indicator that region r belongs to the cohort treated in period g , with $\mathcal{G}$ denoting the set of treatment dates, i.e., 2018 and 2020; $\mathbf{1}\{t \geq g\}$ is an indicator that equals 1 for all periods t on or after the cohort’s treatment date g ; β_g captures the average treatment effect for cohort g ; X_{it} and Z_{rt} are individual and region level covariates, respectively; μ_i are individual fixed effects; λ_t are time fixed effects; and ε_{irt} is the error term. Specifically, we compute group (g)-time (t) average treatment effects ($ATT_{g,t}$), where each group is defined by its treatment cohort (e.g., Wales in 2020), and each time period reflects the post-treatment dynamics:

$$ATT_{g,t} = \mathbb{E}[Y_t(1) - Y_t(0) \mid Group_r = g], \quad (3)$$

where $Y_t(1)$ and $Y_t(0)$ denote the potential outcomes under treatment and control. These estimates can then be aggregated into overall treatment effect measures (e.g., average treatment effect on the treated, $ATT_{overall}$), while explicitly accounting for dynamic effects and treatment timing as:

$$ATT_{overall} = \sum_g \sum_{t \geq g} w_{g,t} \cdot ATT(g, t), \quad (4)$$

where $w_{g,t}$ are weights proportional to the number of individuals matched in our sample in each region.

To ensure the comparability of the treated and control groups, we matched the observations in the treatment group (Scotland and Wales) with the re-weighted subsample of the control group (England) based on Propensity Score Matching. Balance tests on the covariates of the treatment and control groups in the pre-treatment period, following the application of propensity score matching, indicate that the Scotland and Wales samples are comparable to the matched English sample (Table 3).

Table 3: Descriptive statistics: Balanced sample.

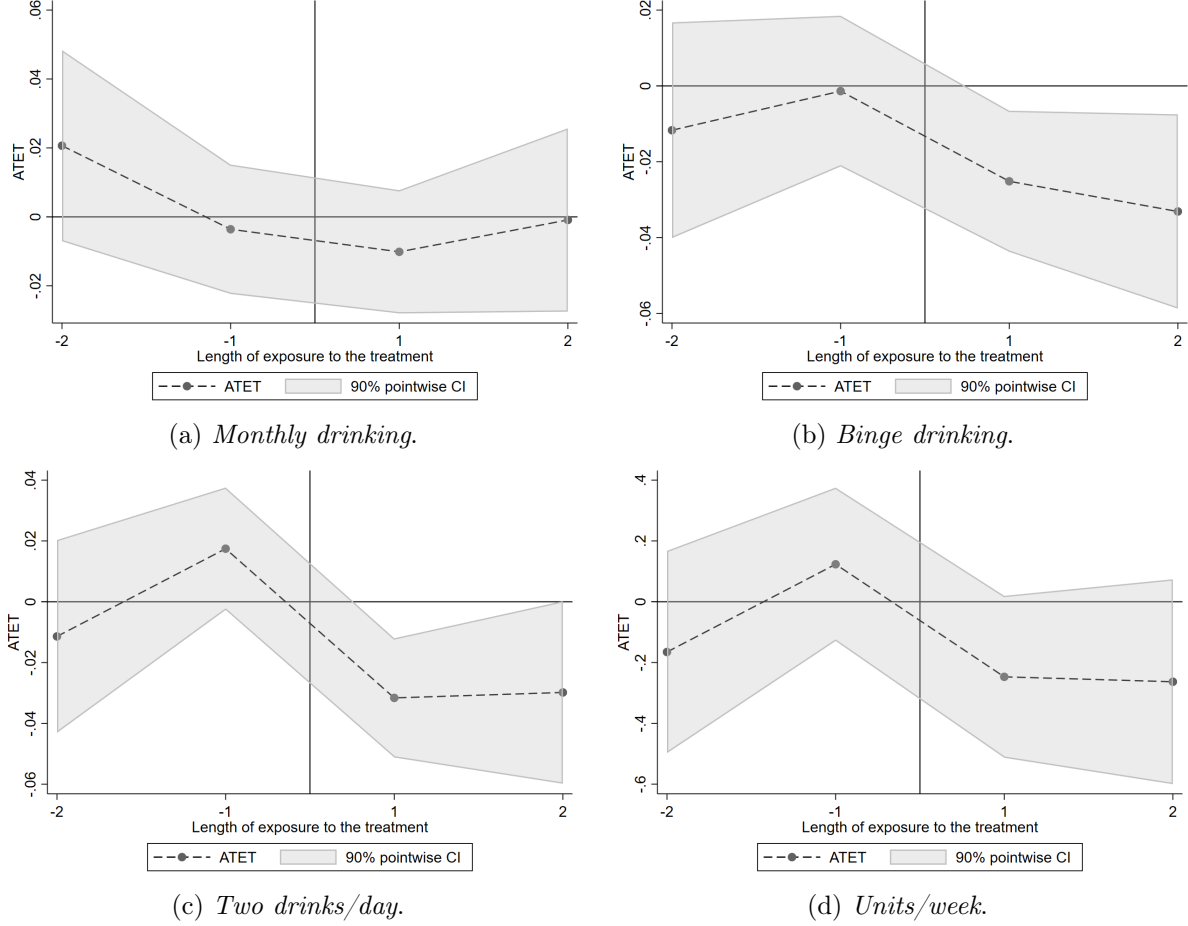
	England mean (sd)	Scotland and Wales mean (sd)	Normalised Difference
Age	51.5 (17.439)	51.0 (16.908)	0.446
Male	0.456 (0.498)	0.428 (0.495)	0.083
University or Higher degree	0.395 (0.489)	0.406 (0.491)	0.495
Employed	0.598 (0.490)	0.592 (0.492)	0.739
Unemployed	0.023 (0.151)	0.027 (0.161)	0.595
Retired	0.283 (0.450)	0.267 (0.443)	0.274
Student	0.022 (0.147)	0.030 (0.170)	0.235
Other employment status	0.074 (0.263)	0.084 (0.278)	0.318
Married or in partnership	0.640 (0.480)	0.642 (0.479)	0.915
Life satisfaction	5.255 (1.528)	5.184 (1.590)	0.190
Monthly Income (in £)	1,818 (1,450.804)	1,776 (1,394.204)	0.330
Observations	1,795 (58.2%)	1,288 (41.8%)	

Notes: Descriptive statistics are computed using data from Wave 7 (pre-intervention) using survey and propensity score matching weights to rebalance variables between treated and control units. *Source:* authors' calculations using the Understanding Society dataset.

We assess the validity of the parallel trends assumption—that in the absence of MUP, outcomes in the treated units (Wales after 2020) would have evolved similarly to those in the comparison units (England or not-yet-treated Wales before 2020)—using event-study estimates. Establishing parallel trends is particularly important in a staggered DiD framework, where treatment is introduced at different times across regions, since violations in the pre-treatment period could bias the Goodman–Bacon decomposition and yield spurious estimates of the policy effect (Goodman-Bacon 2021). The pre-treatment coefficients are not statistically different from zero, consistent with the evidence provided by the event studies (Figure 2). Complementary formal tests, reported in Table 19 in the Appendix, support this

conclusion.

Figure 2: Event study in staggered difference in differences estimation. Dynamic effect of exposure.



Note: Individuals drinking more frequently than once a month (a), individuals engaging in binge drinking at least monthly (b), individuals having more than two drinks on a typical drinking day (c), and average units of alcohol per week (d) in treatment (Scotland) and control (England) regions before and after the policy change in 2018.

6 Results

Table 4 reports our estimates of the Average Treatment Effect on the Treated (ATET) based on the difference-in-differences specification (Equation 1). The results indicate that the implementation of MUP in Scotland was not associated with a statistically significant change in the proportion of individuals who consume alcohol more frequently than once a month. However, we observe a 4.4 percentage point reduction in the share of individuals

who engage in binge drinking at least monthly, alongside a 4.3 percentage point decline in those who typically consume at least two alcoholic drinks per day. Additionally, MUP is associated with a reduction of 0.31 units in weekly alcohol consumption, which corresponds to a 6.3% decrease relative to the average number of units consumed in Scotland.

Table 4: Difference-in-differences estimates.

	Monthly drinking	Binge drinking	Two drinks/ day	Units/ week
DiD	-0.009 (0.013)	-0.044*** (0.014)	-0.043*** (0.015)	-0.308* (0.187)
Observations	18816	18816	18816	18816

Notes: The table reports difference-in-differences estimates of MUP on four measures of alcohol consumption using individual-level panel data from the UKHLS survey, 2015-21.

Outcomes: *Monthly drinking* = 1 if the individual reports drinking more often than once per month; *Binge drinking* = 1 for consuming ≥ 6 units on a typical occasion if female or 8 or more units if male at least monthly; *Two drinks/day* = 1 for drinking more than two drinks per day; *Units/week* = average weekly alcohol units consumed. Controls include individual characteristics (gender, age, marital status, employment status, education, gross monthly income, life satisfaction) and regional characteristics (unemployment rate, GDP per capita). Standard errors clustered at the individual level in parentheses. Significance: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

These findings suggest that the implementation of MUP in Scotland was effective in reducing overall alcohol consumption. While the policy did not significantly alter the frequency of alcohol use, such as the proportion of individuals drinking more than monthly, it had a notable impact on the intensity of consumption. Specifically, MUP led to meaningful reductions in the frequency of monthly binge drinking and the typical quantity consumed on drinking occasions.

To assess treatment effect heterogeneity, we examine whether the implementation of Minimum Unit Pricing (MUP) had differential impacts across groups defined by gender, age, and country of birth (natives vs. non-natives).

These dimensions are important because drinking patterns, elasticities of demand, and associated health risks vary systematically across demographic groups (Table 5). For example, men in Scotland consistently report higher alcohol consumption than women: male drinkers consume on average 6 units per week, compared to 3 units for female drinkers. Men are also more likely to engage in binge drinking, with 35% consuming 8 or more units

Table 5: Pre-intervention consumption of alcohol in Scotland by age, gender, and immigration status.

	Age <25	Age 25–35	Age 35+	Males	Females	Natives	Non-Natives
Monthly drinking	0.676	0.551	0.630	0.715	0.554	0.631	0.492
Binge drinking	0.508	0.367	0.241	0.349	0.205	0.266	0.293
Two drinks/day	0.713	0.604	0.391	0.493	0.383	0.436	0.335
Units/week	5.654	2.843	4.451	5.787	3.218	4.308	4.689

Notes: The table reports the mean values of alcohol consumption outcomes in Scotland across Waves 7 and 9 (pre-treatment) of different subsamples of individuals. Outcomes: *Monthly drinking* = 1 if the individual reports drinking more often than once per month; *Binge drinking* = 1 for consuming ≥ 6 units on a typical occasion if female or 8 or more units if male at least monthly; *Two drinks/day* = 1 for drinking more than two drinks per day; *Units/week* = average weekly alcohol units consumed.

in a typical drinking day, versus 19% in the UK population more broadly, in line with the statistics reported by Drinkaware (2022), Public Health Scotland (2022). Age differences in drinking patterns are also pronounced. About 61% of individuals over 35 consume alcohol at least monthly, compared to 53% of those aged 25–35. In contrast, younger individuals under 25 tend to drink more heavily on a typical day: 69% report consuming at least two drinks, compared to 37% among individuals older than 35. Country of birth also shapes alcohol consumption patterns. Fewer non-natives drink alcohol more than monthly (50% vs. 61%) or consume more than two drinks on a typical occasion (31% vs. 42%) compared to natives. Exploring heterogeneity along these dimensions allows us to identify which subgroups benefit most from MUP and evaluate the distributional consequences of the policy.

Table 6 presents the Average Treatment Effect on the Treated (ATET) estimates derived from a triple difference-in-differences specification, which allows us to isolate the impact of the policy intervention across different population subgroups.

Column (1) reports the effect of MUP on individuals who were under the age of 25 at the time of MUP implementation. The results indicate that, for this younger cohort, the frequency of alcohol consumption remained largely unchanged. However, the intensity of alcohol use declined substantially: the proportion of individuals engaging in binge drinking at least monthly fell by 18.3 percentage points, and the share of those consuming more than two drinks on a typical day decreased by 16.1 percentage points. Furthermore, young individuals experienced a reduction in average weekly alcohol consumption of 1.95 units, equivalent to a 33.9% decrease relative to their pre-treatment levels in Scotland. These findings suggest

Table 6: Triple difference-in-differences estimations.

	Age <25	Age 25–35	Males	Non-Natives
Monthly drinking	-0.147 (0.109)	0.027 (0.046)	0.029 (0.025)	-0.007 (0.035)
Binge drinking	-0.183* (0.096)	-0.140** (0.058)	-0.005 (0.027)	-0.038 (0.062)
Two drinks/day	-0.161* (0.081)	-0.102* (0.058)	-0.007 (0.028)	0.019 (0.055)
Units/week	-1.950** (0.932)	0.536 (0.406)	-0.079 (0.340)	-0.441 (0.563)
Observations	18816	18816	18816	18816

Notes: The table reports difference-in-differences estimates of MUP on four measures of alcohol consumption using individual-level panel data from the UKHLS survey, 2015–21.

Outcomes: *Monthly drinking* = 1 if the individual reports drinking more often than once per month; *Binge drinking* = 1 for consuming ≥ 6 units on a typical occasion if female or 8 or more units if male at least monthly; *Two drinks/day* = 1 for drinking more than two drinks per day; *Units/week* = average weekly alcohol units consumed. Controls include individual characteristics (gender, age, marital status, employment status, education, gross monthly income, life satisfaction) and regional characteristics (unemployment rate, GDP per capita). Standard errors clustered at the individual level in parentheses. Significance:

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

that MUP was particularly effective in reducing harmful drinking behaviours among younger adults.

Column (2) of Table 6 reports the results for individuals who were between the ages of 25 and 35 at the time of MUP implementation. The frequency of alcohol consumption remained largely unchanged for this cohort as well. However, the intensity of alcohol use declined notably: the proportion of individuals engaging in binge drinking at least monthly decreased by 14 percentage points, and the share of those consuming more than two drinks on a typical day fell by 10.2 percentage points. Unlike the younger cohort, however, we do not observe a statistically significant reduction in average weekly alcohol consumption for this age group. Lastly, columns (3) and (4) in Table 6 present our triple DiD findings on males and natives, respectively. We find no evidence that these sub-groups of the population changed their alcohol consumption behaviour substantially compared to the rest of the population following the MUP implementation.

Next, we report the ATET estimates based on a difference-in-differences framework with staggered adoption (Callaway and Sant’Anna 2021), incorporating Wales, where MUP was implemented in March 2020, as an additional treatment group (Table 7).

Table 7: Staggered difference-in-differences estimates.

	Monthly drinking	Binge drinking	Two drinks/ day	Units/ week
DiD	-0.007 (0.011)	-0.028** (0.011)	-0.031*** (0.012)	-0.253* (0.148)
Observations	27404	27404	27404	27404

Notes: The table reports staggered difference-in-differences estimates of MUP on four measures of alcohol consumption using individual-level panel data from the UKHLS survey, 2015-21.

Outcomes: *Monthly drinking* = 1 if the individual reports drinking more often than once per month; *Binge drinking* = 1 for consuming ≥ 6 units on a typical occasion if female or 8 or more units if male at least monthly; *Two drinks/day* = 1 for drinking more than two drinks per day; *Units/week* = average weekly alcohol units consumed. Controls include individual characteristics (gender, age, marital status, employment status, education, gross monthly income, life satisfaction) and regional characteristics (unemployment rate, GDP per capita). Standard errors clustered at the individual level in parentheses. Significance: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

The estimated effects at the population level closely mirror those obtained in the baseline analysis. Specifically, we find no statistically significant change in the proportion of individuals drinking alcohol more frequently than monthly. However, we observe a reduction in the proportion of individuals engaging in binge drinking at least monthly by 2.8 percentage points, and a 3.1 percentage point decline in the share of those consuming at least two drinks on a typical day. The average weekly alcohol consumption in Scotland and Wales decreased by 0.25 units following the implementation of MUP, a reduction that is statistically significant at the 10% level.

Looking at heterogeneity, we observe that older individuals (aged 35 and above), males, and natives exhibit the highest frequency of alcohol consumption. However, it is younger individuals (under the age of 35) who stand out in terms of drinking intensity, with more than 40% engaging in binge drinking and nearly 70% consuming more than two drinks per day. Overall, when considering total average consumption, males emerge as the group with the highest alcohol intake (Table 22 in the Appendix).

We then repeat our estimation focusing on specific groups defined by gender, age, and immigration status (Table 8). Using staggered difference-in-differences models on these subsamples, we find patterns consistent with the DDD results comparing Scotland and England. Young individuals under the age of 25 exhibit the largest response to the MUP policy: the

share of individuals binge drinking at least once a month decreased by 16 percentage points, and weekly alcohol consumption declined by 1.9 units. Among individuals aged 25 to 35, we observe a significant reduction in binge drinking (-13.3 percentage points) and in the proportion drinking two or more drinks per day (-13.6 percentage points). We do not find any significant effects on monthly drinking frequency in either age group. Older individuals show no significant changes in either the intensity or frequency of alcohol consumption, indicating limited responsiveness to the policy in this cohort.

Table 8: Staggered difference-in-differences estimates: heterogeneity by age, gender, and immigration status.

	Age <25	Age 25–35	Age 35+	Males	Females	Natives	Non-Natives
Monthly drinking	-0.066 (0.096)	0.004 (0.046)	-0.003 (0.010)	0.016 (0.017)	-0.023 (0.015)	-0.006 (0.011)	0.007 (0.038)
Binge drinking	-0.160** (0.081)	-0.133** (0.053)	-0.007 (0.010)	-0.031 (0.019)	-0.026* (0.013)	-0.026** (0.011)	-0.047 (0.106)
Two drinks/day	-0.051 (0.071)	-0.136*** (0.048)	-0.014 (0.012)	-0.037* (0.019)	-0.025* (0.014)	-0.030** (0.012)	-0.020 (0.079)
Units/week	-1.950** (0.823)	-0.156 (0.594)	-0.172 (0.152)	-0.172 (0.267)	-0.296* (0.162)	-0.188 (0.147)	-1.441 (1.114)
Observations	784	2,096	24,524	11,416	15,988	24,912	2,492

Notes: The table reports staggered difference-in-differences estimates of MUP on four measures of alcohol consumption using individual-level panel data from the UKHLS survey, 2015–21 on different subsamples of individuals.

Outcomes: *Monthly drinking* = 1 if the individual reports drinking more often than once per month; *Binge drinking* = 1 for consuming ≥ 6 units on a typical occasion if female or 8 or more units if male at least monthly; *Two drinks/day* = 1 for drinking more than two drinks per day; *Units/week* = average weekly alcohol units consumed. Controls include individual characteristics (gender, age, marital status, employment status, education, gross monthly income, life satisfaction) and regional characteristics (unemployment rate, GDP per capita). Standard errors clustered at the individual level in parentheses. Significance: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

Interesting patterns emerge when examining the response to MUP by gender. Among females, the share of individuals who binge drink at least once a month decreased by 2.6 percentage points, weekly alcohol consumption declined by 0.3 units, and the proportion of individuals drinking more than two drinks per day decreased by 2.5 percentage points. For males, the only significant effect observed is a reduction in the share drinking more than two drinks per day, which decreased by 3.7 percentage points. While non-natives do not seem to respond to the MUP reform, natives reduced the intensity of their drinking habits: binge drinking is down by 2.6 percentage points, and the percentage of individuals consuming at least two drinks a day is down by 3 percentage points.

7 Robustness tests

To assess the credibility of our difference-in-differences design, we conduct a series of placebo exercises that exploit either alternative implementation dates or alternative control groups. If the placebo estimates are not statistically significant, this increases confidence that our baseline results are genuinely attributable to the introduction of MUP. In particular, the absence of significant placebo effects would suggest that our findings are unlikely to be driven by spurious correlations, pre-existing differential trends between treatment and the control regions, or contemporaneous shocks unrelated to the policy.

Table 9: Placebo tests.

	Scotland vs England	Scotland vs Wales	Scotland & Wales vs England
Monthly drinking	-0.027 (0.022)	-0.042 (0.027)	-0.001 (0.016)
Observations	9408	3402	13702
Binge drinking	-0.015 (0.023)	0.003 (0.025)	-0.016 (0.016)
Observations	9408	3402	13702
Two drinks/day	0.002 (0.018)	0.022 (0.024)	-0.004 (0.014)
Observations	9408	3402	13702
Units/week	-0.319 (0.247)	-0.009 (0.293)	-0.170 (0.172)
Observations	9408	3402	13702

Notes: Placebo tests of Minimum Unit Pricing (MUP) between waves 7 and 9, Column (1): Scotland vs. England, Column (2): Scotland vs. Wales, Column (3): Scotland and Wales vs. England. The table reports difference-in-differences estimates of MUP on four measures of alcohol consumption using individual-level panel data from the UKHLS survey, 2015–2017 (pre-policy period).

Outcomes: *Monthly drinking* = 1 if the individual reports drinking more often than once per month; *Binge drinking* = 1 for consuming ≥ 6 units on a typical occasion if female or 8 or more units if male at least monthly; *Two drinks/day* = 1 for drinking more than two drinks per day; *Units/week* = average weekly alcohol units consumed. Controls include individual characteristics (gender, age, marital status, employment status, education, gross monthly income, life satisfaction) and regional characteristics (unemployment rate, GDP per capita). Standard errors clustered at the individual level in parentheses. Significance: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

First, we re-estimate the Scotland–England specification, assigning a placebo treatment date prior to the actual reform. Specifically, we assume that MUP was introduced in Scotland between waves 7 and 9 of the UKHLS (2015–2017), well before the true policy implementation in 2018. This allows us to test whether our identification strategy would erroneously detect

any effects in periods where no reform had yet occurred. If our model were simply picking up pre-trends in alcohol consumption or spurious regional differences, we would expect to observe significant coefficients even under this false timing. As shown in Table 9, Column (1), all placebo estimates are statistically insignificant, supporting the absence of differential pre-trends between Scotland and England. Second, we estimate a placebo difference-in-differences specification that compares Scotland and Wales, treating one as “treated” and the other as “control” before either country had actually implemented MUP. This test addresses the concern that contemporaneous differences between the two regions, such as divergent social or economic trends, could be driving our main findings. If this were the case, we would expect to detect spurious effects even when the treatment is assigned prior to 2018. Table 9, Column (2) shows no such evidence, suggesting that differential dynamics between Scotland and Wales are not confounding our estimates. Finally, we extend the analysis to the staggered setting that includes Wales, which introduced MUP in 2020. Here we assign both Scotland and Wales a placebo reform date before 2018 and jointly compare them to England. This specification allows us to test whether our staggered design could mechanically generate “effects” in periods where no policy was active. Across all outcome variables (Table 9, Column (3)), the coefficients are consistently insignificant, indicating that the staggered estimators do not artificially create treatment effects under placebo assignments. These results provide strong reassurance about the credibility of our research design. The absence of significant effects across multiple placebo estimations indicates that our main findings are unlikely to be driven by unobserved confounders or pre-existing differential trends.

Another possible concern is that our results could, in principle, be confounded by the high cost of housing in the UK, and in particular by the sharp increase in housing expenses faced by a typical household in the period of our analysis. Individuals on tight budgets may be constrained in how much they can spend on alcohol and may therefore reduce their drinking in response to rising living costs rather than to the MUP policy. Although we control for monthly income, this concern could be relevant if housing inflation evolved differently across regions in our study. Moreover, given that our effects are particularly pronounced among younger individuals, they may be disproportionately affected by rising rents.

Table 10: Controlling for Rent Inflation.

	Total	Age <25	Age 25–35	Males	Non-Natives
Monthly drinking	-0.014 (0.015)	-0.148 (0.109)	0.027 (0.046)	0.029 (0.025)	-0.006 (0.035)
Binge drinking	-0.046** (0.017)	-0.183* (0.096)	-0.140** (0.058)	-0.005 (0.027)	-0.037 (0.062)
Two drinks/day	-0.037** (0.017)	-0.160** (0.081)	-0.103* (0.058)	-0.007 (0.028)	0.017 (0.055)
Units/week	-0.414** (0.211)	-1.959** (0.931)	0.545 (0.405)	-0.078 (0.340)	-0.423 (0.562)
Observations	18816	18816	18816	18816	18816

Notes: The table reports difference-in-differences (column (1)) and triple difference in differences estimates (columns (2)–(5)) of MUP on four measures of alcohol consumption using individual-level panel data from the UKHLS survey, 2015–21.

Outcomes: *Monthly drinking* = 1 if the individual reports drinking more often than once per month; *Binge drinking* = 1 for consuming ≥ 6 units on a typical occasion if female or 8 or more units if male at least monthly; *Two drinks/day* = 1 for drinking more than two drinks per day; *Units/week* = average weekly alcohol units consumed. Controls include individual characteristics (gender, age, marital status, employment status, education, gross monthly income, life satisfaction) and regional characteristics (unemployment rate, GDP per capita and the index of private housing rental prices). Standard errors clustered at the individual level in parentheses. Significance: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

To address this concern, we re-estimate our models controlling for rent inflation across the UK, using the Index of Private Housing Rental Prices provided by the ONS for Scotland and the ten regions of England. The results remain virtually unchanged (Table 10). For the whole population (Table 10, column (1)), we continue to find a 4.6 percentage point decrease in binge drinking, a 3.7 percentage point reduction in the likelihood of consuming more than two drinks per day, and a decline of 0.42 weekly units of alcohol. Furthermore, when we estimate triple-differences models by population subgroups (Table 10, columns (2)–(5)), our findings remain robust. This is particularly relevant for young individuals, who might otherwise have reduced alcohol consumption in response to rising rental costs. The evidence therefore suggests that the observed reductions in drinking behaviour are indeed attributable to the MUP policy, rather than to housing cost inflation. From a broader perspective, this robustness check also highlights the external validity of our results: while affordability constraints such as housing costs may interact with alcohol consumption, our evidence shows that the policy’s impact persists even in a high-cost environment. This strengthens the case for MUP as a targeted tool for reducing harmful drinking behaviours in settings where households face multiple competing budget pressures.

8 Effectiveness of the reform

In this section, we assess the effectiveness of the reform in achieving its intended objectives, while also examining the potential for unintended consequences, thus allowing for a broader understanding of the overall impact of the MUP intervention on individuals and society.

8.1 Drinker types

In line with the guidelines outlined in Chief Medical Officers of the United Kingdom (2016), drinkers can be broadly classified into three groups based on their weekly alcohol consumption and drinking patterns. Moderate or low-risk drinkers are those who consume no more than 14 units of alcohol per week, equivalent to roughly six pints of beer or six glasses of wine spread across the week. Hazardous or increasing-risk drinkers regularly exceed this threshold, often consuming 2–3 pints of beer or 2–3 glasses of wine per day, which increases the likelihood of longer-term health risks. Harmful or higher-risk drinkers engage in heavy and frequent drinking episodes, such as consuming 4–5 pints of beer or 4–5 glasses of wine in a single session, often combined with repeated binge drinking. This group faces the highest probability of alcohol-related harm, including both physical and social consequences (Table 20 in the Appendix).

By directly increasing the price of low-cost, high-strength alcohol, the MUP reform was explicitly designed to target hazardous and harmful drinkers, who are disproportionately likely to consume these products. According to the Scottish Government’s policy rationale for introducing MUP, the measure sought to reduce alcohol-related harms by curbing consumption among the heaviest drinkers, while having minimal impact on moderate consumers (Scottish Government 2018).

Following these definitions, we classify individuals in our sample as either moderate (≤ 14 units per week) or harmful (> 14 units per week) drinkers, based on their reported alcohol consumption. Descriptive statistics for the two groups are reported in Table 11.⁵ All hazardous drinkers in our sample report drinking at least once per month and consuming

⁵Descriptive statistics for the sample including individuals living in Scotland, Wales and Scotland are reported in Table 23 in the Appendix.

Table 11: Descriptive statistics: Hazardous vs Moderate Drinkers

	Moderate mean (sd)	Hazardous mean (sd)	Normalised Difference
Monthly drinking	0.585 (0.493)	1.000 (0.000)	<0.001
Binge drinking	0.190 (0.393)	0.765 (0.424)	<0.001
Two drinks/day	0.312 (0.463)	1.000 (0.000)	<0.001
Units/week	2.995 (3.450)	23.078 (7.018)	<0.001
<i>Socio-demographic characteristics</i>			
Age	53.4 (17.247)	53.3 (14.512)	0.950
Male	0.429 (0.495)	0.736 (0.442)	<0.001
Non-Native	0.060 (0.237)	0.081 (0.273)	0.538
University or Higher degree	0.447 (0.497)	0.485 (0.501)	0.353
Employed	0.592 (0.492)	0.584 (0.494)	0.836
Unemployed	0.020 (0.140)	0.037 (0.188)	0.198
Retired	0.302 (0.459)	0.285 (0.452)	0.591
Student	0.020 (0.141)	0.007 (0.086)	0.114
Other employment status	0.066 (0.248)	0.087 (0.283)	0.370
Married or in partnership	0.640 (0.480)	0.627 (0.484)	0.749
Life satisfaction	5.201 (1.518)	5.242 (1.424)	0.699
Monthly Income (in £)	1,905 (1,512.874)	2,320 (2,108.261)	0.007
Observations	1,760 (92.7%)	140 (7.3%)	

Notes: Descriptive statistics are computed using data from Wave 9 (pre-intervention), covering Scotland and England, using survey and propensity score matching weights to rebalance variables between treated and control units. Standard deviations are given in parentheses. Normalised differences are calculated as in Baker et al. (2025). *Source:* authors' calculations using the Understanding Society dataset.

more than two drinks on a typical occasion. On average, they engage in binge drinking and consume approximately 23 units of alcohol per week. Demographically, hazardous drinkers are predominantly male and, on average, have higher incomes relative to moderate drinkers. However, across other socio-economic characteristics included in our controls, no statistically significant differences are observed between the two groups.

We then estimate a triple difference-in-differences (DDD) model to compare the outcomes between these two groups, allowing us to capture the differential effects of the policy intervention on drinking intensity. Column (1) of Table 12 presents the results of the triple difference-in-differences estimation, comparing hazardous and moderate drinkers across Scotland and England. We do not observe any statistically significant differences between the two groups for any of the four outcomes, suggesting that the intervention had similar effects on both moderate and high-risk drinkers in this context. When we extend the analysis to the staggered difference-in-differences estimation, comparing Scotland, Wales, and England,

Table 12: Moderate and hazardous drinkers.

	DDD	Staggered DD	
	Hazardous	Moderate	Hazardous
Monthly drinking	0.034 (0.022)	-0.007 (0.012)	0.011 (0.025)
Binge drinking	0.001 (0.053)	-0.029** (0.011)	-0.016 (0.053)
Two drinks/day	0.060 (0.057)	-0.034*** (0.012)	0.011 (0.042)
Units/week	-0.808 (1.428)	-0.215* (0.121)	-0.571 (1.134)
Observations	18,816	25,436	1,968

Notes: The table reports difference-in-differences estimates of MUP on four measures of alcohol consumption using individual-level panel data from the UKHLS survey, 2015-21.

Outcomes: *Monthly drinking* = 1 if the individual reports drinking more often than once per month; *Binge drinking* = 1 for consuming ≥ 6 units on a typical occasion if female or 8 or more units if male at least monthly; *Two drinks/day* = 1 for drinking more than two drinks per day; *Units/week* = average weekly alcohol units consumed. Controls include individual characteristics (gender, age, marital status, employment status, education, gross monthly income, life satisfaction) and regional characteristics (unemployment rate, GDP per capita). Standard errors clustered at the individual level in parentheses. Significance: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

and estimate the model separately for moderate and hazardous drinkers, significant differences emerge. Specifically, moderate drinkers exhibit consistent reductions in monthly binge drinking, daily intake, and weekly alcohol units, suggesting a measurable adjustment in their drinking behaviour. In contrast, hazardous drinkers show minimal changes in drinking frequency and only modest reductions in total weekly consumption, indicating that high-risk drinking behaviours are more resistant to change and display inelastic demand with respect to the policy intervention.

8.2 Income effects

Understanding how individuals at the lower end of the income distribution respond to the Minimum Unit Pricing (MUP) policy is particularly important from both an equity and policy effectiveness perspective. Low-income consumers are often the most exposed to the regressive effects of price-based health interventions, as they spend a larger share of their income on consumption goods, including alcohol. Therefore, even if MUP successfully re-

duces harmful drinking at the population level, it could unintentionally worsen the financial situation of poorer households if they do not adjust their consumption in response to higher prices. Although our earlier results show that hazardous drinkers are not systematically poorer than moderate drinkers, examining behavioural responses among low-income individuals helps assess whether the reform had any unintended income effects. Specifically, if poorer individuals did not change their drinking behaviour following MUP, the policy may have reduced their real disposable income without improving health outcomes.

Table 13: Descriptive statistics: bottom quartile of income distribution.

	Q4-Q2 income	Q1 income	Normalised Difference
Monthly drinking	0.623 (0.485)	0.544 (0.499)	0.013
Binge drinking	0.239 (0.427)	0.168 (0.375)	0.005
Two drinks/day	0.374 (0.484)	0.256 (0.437)	<0.001
Units/week	4.494 (6.422)	4.252 (7.102)	0.656
<i>Socio-demographic characteristics</i>			
Age	52.8 (16.950)	58.7 (17.189)	<0.001
Male	0.476 (0.500)	0.219 (0.414)	<0.001
Non-Native	0.062 (0.242)	0.049 (0.216)	0.298
University or Higher degree	0.476 (0.499)	0.202 (0.402)	<0.001
Employed	0.632 (0.482)	0.208 (0.406)	<0.001
Unemployed	0.019 (0.137)	0.043 (0.203)	0.039
Retired	0.282 (0.450)	0.478 (0.500)	<0.001
Student	0.016 (0.126)	0.051 (0.220)	0.088
Other employment status	0.051 (0.221)	0.220 (0.415)	<0.001
Married or in partnership	0.628 (0.483)	0.749 (0.434)	<0.001
Life satisfaction	5.198 (1.508)	5.255 (1.543)	0.557
Monthly Income (in £)	2,088 (1,569)	483 (287)	<0.001
Observations	1,719 (90.5%)	180 (9.5%)	

Notes: Descriptive statistics are computed using data from Wave 9 (pre-intervention), covering Scotland and England, using survey and propensity score matching weights to rebalance variables between treated and control units. Standard deviations are given in parentheses. Normalised differences are calculated as in Baker et al. (2025). *Source:* authors' calculations using the Understanding Society dataset.

Table 13 reports descriptive statistics for individuals who were in the first quartile of the income distribution before the introduction of MUP and remained in that quartile afterwards. We observe a lower alcohol consumption for this group, both in frequency and intensity, although the average total number of units consumed per week remains comparable to that of wealthier individuals. In terms of socio-demographic characteristics, individuals at the bottom of the income distribution display a substantially lower gross monthly income,

approximately one quarter of that of individuals in higher quartiles. They also tend to be older, more likely to be female, married, and, perhaps unsurprisingly, less educated and less likely to be employed. A considerable share of this group is retired, which may further limit their economic flexibility in responding to price changes.

We next estimate our models separately for individuals in the bottom quartile of the income distribution and those in the top three quartiles. The triple-difference estimates comparing Scotland and England (Table 14, Column 1) show no statistically significant differences in alcohol consumption, either in intensity or frequency, between the two income groups, except for a small positive effect on binge drinking among low-income individuals. When we extend the analysis to a staggered difference-in-differences framework including Scotland, Wales, and England (Table 14, Columns 2 and 3), we find a significant reduction in drinking intensity among individuals in the upper three quartiles, whereas no significant response is observed among those in the bottom quartile. This heterogeneity in responses confirms that the demand for alcohol among low-income individuals is less price-elastic. Consequently, the MUP reform may have generated an income effect: despite facing higher prices, poorer individuals did not substantially reduce their consumption, implying a relative decline in their disposable income. These findings highlight the potential regressive nature of price-based health interventions and raise the importance of considering these unintended welfare losses among low-income groups when evaluating the effectiveness of the policy.

8.3 Alternative risky behaviours

One possible spillover effect of the MUP intervention is the substitution of alcohol consumption with other risky behaviours. For instance, individuals may reduce their alcohol intake but increase tobacco use instead. Such behavioural substitution would undermine the overall effectiveness of the policy, as individuals would replace one health risk with another. To assess this possibility, we estimate the same models using smoking-related outcomes, distinguishing between cigarette and vape use (Table 15). Specifically, we consider the share of individuals who smoke (Columns 1–2), the number of cigarettes smoked per day (Columns

Table 14: Bottom income quartile.

	DDD	Staggered DD	
	Q1 income	Q4-Q2 income	Q1 income
Monthly drinking	-0.027 (0.046)	-0.007 (0.012)	-0.011 (0.038)
Binge drinking	0.056* (0.034)	-0.027** (0.012)	-0.032 (0.032)
Two drinks/day	0.010 (0.037)	-0.030** (0.012)	-0.042 (0.030)
Units/week	-0.696 (0.582)	-0.211 (0.155)	-0.619 (0.511)
Observations	18,816	24,692	2,712

Notes: The table reports difference-in-differences estimates of MUP on four measures of alcohol consumption using individual-level panel data from the UKHLS survey, 2015-21.

Outcomes: *Monthly drinking* = 1 if the individual reports drinking more often than once per month; *Binge drinking* = 1 for consuming ≥ 6 units on a typical occasion if female or 8 or more units if male at least monthly; *Two drinks/day* = 1 for drinking more than two drinks per day; *Units/week* = average weekly alcohol units consumed. Controls include individual characteristics (gender, age, marital status, employment status, education, gross monthly income, life satisfaction) and regional characteristics (unemployment rate, GDP per capita). Standard errors clustered at the individual level in parentheses. Significance: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

3–4), and the share of individuals who vape (Columns 5–6).⁶

The results show a significant negative effect on the share of cigarette smokers (extensive margin), consistent with complementarities between drinking and smoking documented in previous studies (Jackson et al. 2025, Simonavičius et al. 2025, Beard et al. 2023, Kim et al. 2024, Vallée et al. 2023). By contrast, we find no significant effect on the number of cigarettes smoked per day (intensive margin) or on vaping⁷. These findings alleviate concerns about substitution away from alcohol toward tobacco or other risky behaviours.

⁶Event-study estimates for all smoking outcomes are reported in Figures 3 and 5 in the Appendix.

⁷The UKHLS survey changed the format of the e-cigarette consumption questionnaire from Wave 9 onwards, from a binary response to a categorical one. For comparability of variables from Wave 7 to Waves 9–13, the responses were standardised to a binary format

Table 15: Smoking behaviour.

	Smoking Cigarettes		Number of Cigarettes		Smoking e-cigarettes	
	DD	Staggered DD	DD	Staggered DD	DD	Staggered DD
DiD	-0.019** (0.009)	-0.013** (0.006)	-0.166 (0.124)	-0.145 (0.110)	0.003 (0.007)	0.000 (0.006)
Observations	18,816	27,404	18,816	27,404	18,816	27,404

Notes: The table reports difference-in-differences and staggered difference-in-differences estimates of MUP on smoking patterns (both cigarettes and vapes) using individual-level panel data from the UKHLS survey, 2015-21 on different subsamples of individuals. The outcome variables are (a) percentage of people smoking cigarettes. The relevant survey question is "Do you smoke cigarettes?" (b) number of cigarettes smoked per day. The relevant survey question is "Approximately how many cigarettes a day do you usually smoke, including those you roll yourself?" (c) percentage of people who vape. The relevant survey question is "Do you ever use electronic cigarettes (e-cigarettes)". Controls include individual characteristics (gender, age, marital status, employment status, education, gross monthly income, life satisfaction) and regional characteristics (unemployment rate, GDP per capita). Standard errors clustered at the individual level in parentheses. Significance: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

9 Conclusions

This paper provides new evidence on the causal impact of Scotland's Minimum Unit Pricing (MUP) policy on alcohol consumption using individual-level panel data from the UK. Exploiting variation across regions and over time within a difference-in-differences framework, complemented by staggered DiD estimators, we show that MUP has not significantly reduced the overall prevalence of drinking but has led to a meaningful decrease in the intensity of drinking and in harmful drinking behaviours. In particular, we find strong effects on binge drinking and on the likelihood of consuming more than two drinks per occasion, with the largest reductions observed among individuals under the age of 25.

A central insight from our analysis is the distinction between drinking frequency and drinking intensity. Across the population, MUP appears to leave the frequency of alcohol use largely unchanged—monthly drinking prevalence is unaffected in almost all groups. Instead, the policy operates mainly through reducing the intensity of consumption among those who do drink, leading to fewer episodes of binge drinking, lower daily intake, and reductions in total weekly alcohol units.

Our heterogeneous analysis further shows that these effects are uneven across the population. Younger individuals respond the most, with marked reductions in binge drinking

and weekly units, while older individuals show little change, consistent with more entrenched habits. Gender differences are modest but noteworthy: women reduce both binge drinking and daily intake, while men show significant declines only in the probability of drinking more than two drinks per day. We also find variation by immigration status: natives primarily reduce binge and daily drinking, while immigrants do not have a strong response to the policy. Differences by drinking risk reveal that moderate drinkers are more responsive, whereas hazardous drinkers, whose demand is less elastic, show only limited adjustments, highlighting the challenge of changing entrenched high-risk behaviours through pricing alone.

Importantly, our results indicate that individuals in the lowest income quartile did not significantly reduce their alcohol consumption following the introduction of MUP. This suggests that, for these groups, the policy may have had limited behavioural impact while still increasing expenditure on alcohol, effectively reducing disposable income. Such distributional implications are relevant, as they raise concerns about the regressive nature of unit-based pricing and its potential to exacerbate economic hardship among low-income drinkers. Finally, we find no evidence of substitution into alternative risky behaviours. Estimates for smoking outcomes show a significant decline in cigarette consumption and no change in vaping, consistent with complementarities between drinking and smoking and ruling out a behavioural swap from alcohol to other substances.

Taken together, these findings suggest that unit-based pricing is an effective complement to public health interventions aimed at reducing alcohol-related harms. By shifting drinking intensity rather than frequency, MUP targets the behaviours most closely linked to negative health and social outcomes. The policy's strongest effects among young people imply potential long-term benefits through shaping healthier drinking trajectories. At the same time, the muted response of hazardous and low-income drinkers highlights the importance of combining pricing measures with targeted support and treatment programmes, as well as broader policies to mitigate potential regressivity. From a policy perspective, MUP should therefore be viewed not as a stand-alone solution but as part of a broader portfolio of interventions designed to promote healthier and more responsible patterns of alcohol use.

References

- Anderson, P., D. Chisholm, and D. C. Fuhr (2009). Effectiveness and cost-effectiveness of policies and programmes to reduce the harm caused by alcohol. *The lancet* 373(9682), 2234–2246.
- Angus, C., J. Holmes, R. Pryce, P. Meier, and A. Brennan (2016). Model-based appraisal of the comparative impact of minimum unit pricing and taxation policies in Scotland. *Sheffield: ScHARR, University of Sheffield*.
- Athey, S. and G. W. Imbens (2022). Design-based analysis in difference-in-differences settings with staggered adoption. *Journal of Econometrics* 226(1), 62–79.
- Baker, A., B. Callaway, S. Cunningham, A. Goodman-Bacon, and P. H. Sant’Anna (2025). Difference-in-differences designs: A practitioner’s guide. *Journal of Economic Literature*.
- Baktash, M. B., J. S. Heywood, and U. Jirjahn (2022). Performance pay and alcohol use in germany. *Industrial Relations: A Journal of Economy and Society* 61(4), 353–383.
- Beard, E., J. Brown, R. West, S. Michie, and S. E. Jackson (2023). Prevalence and characteristics of co-occurrence of smoking and increasing- and higher-risk drinking in england: April 2020 to march 2022. *Drug and Alcohol Dependence* 248, 110853.
- Beeston, C., G. Reid, M. Robinson, N. Craig, G. McCartney, L. Graham, and I. Grant (2013). Monitoring and evaluating Scotland’s alcohol strategy (mesas).
- Boden, J. M., J. O. Lee, L. J. Horwood, C. V. Grest, and G. F. McLeod (2017). Modelling possible causality in the associations between unemployment, cannabis use, and alcohol misuse. *Social science & medicine* 175, 127–134.
- Boyd, J., J. Holmes, N. Gibbs, C. Buckley, R. Purshouse, and P. Meier (2024). How can agent-based modelling provide new insights into the impact of minimum unit pricing in Scotland? *Drug and alcohol review* 43(7), 1657–1661.

- Buck, N. and S. McFall (2012). Understanding society: design overview. *Longitudinal and Life Course Studies* 3(1), 5–17.
- Burton, R., C. Henn, D. Lavoie, R. O’Connor, C. Perkins, K. Sweeney, F. Greaves, B. Ferguson, C. Beynon, A. Belloni, et al. (2017). A rapid evidence review of the effectiveness and cost-effectiveness of alcohol control policies: an english perspective. *The Lancet* 389(10078), 1558–1580.
- Callaway, B. and P. H. Sant’Anna (2021). Difference-in-differences with multiple time periods. *Journal of Econometrics* 225(2), 200–230.
- Casswell, S., T. Huckle, K. Parker, T. Graydon-Guy, J. Leung, C. Parry, P. Torun, G. Sengee, C. Pham, G. Gray-Phillip, et al. (2023). Effective alcohol policies are associated with reduced consumption among demographic groups who drink heavily. *Alcohol: Clinical and Experimental Research* 47(4), 786–795.
- Chaiyasong, S., T. Huckle, A.-M. Mackintosh, P. Meier, C. D. Parry, S. Callinan, P. Viet Cuong, E. Kazantseva, G. Gray-Phillip, K. Parker, et al. (2018). Drinking patterns vary by gender, age and country-level income: Cross-country analysis of the international alcohol control study. *Drug and alcohol review* 37, S53–S62.
- Chief Medical Officers of the United Kingdom (2016). UK chief medical officers’ low risk drinking guidelines: Advice on low risk drinking. Technical report, UK Departments of Health.
- Coomber, K., P. Miller, N. Taylor, M. Livingston, J. Smith, P. Buykx, et al. (2020). Investigating the introduction of the alcohol minimum unit price in the northern territory: final report. *Prepared for the Northern Territory Department of Health: Deakin University, Geelong Australia.*
- Cooper, B., M. Gehrsitz, and S. G. McIntyre (2020). Drink, death, and driving: Do blood alcohol content limit reductions improve road safety? *Health economics* 29(7), 841–847.
- Drinkaware (2022). Drinkaware scotland nations report 2022.

- Elder, R. W., R. A. Shults, D. A. Sleet, J. L. Nichols, R. S. Thompson, W. Rajab, T. F. on Community Preventive Services, et al. (2004). Effectiveness of mass media campaigns for reducing drinking and driving and alcohol-involved crashes: a systematic review. *American journal of preventive medicine* 27(1), 57–65.
- Francesconi, M. and J. James (2022). Alcohol price floors and externalities: the case of fatal road crashes. *Journal of Policy Analysis and Management* 41(4), 1118–1156.
- Giles, L., M. Robinson, and C. Beeston (2019). Alcohol-related deaths and deprivation in Scotland: inequalities continue to widen. *Scottish Health and Inequalities Report*.
- Goodman-Bacon, A. (2021). Difference-in-differences with variation in treatment timing. *Journal of Econometrics* 225(2), 254–277.
- Griffith, R., M. O’Connell, and K. Smith (2022). Price floors and externality correction. *The Economic Journal* 132(646), 2273–2289.
- Haghpanahan, H., J. Lewsey, D. F. Mackay, E. McIntosh, J. Pell, A. Jones, N. Fitzgerald, and M. Robinson (2019). An evaluation of the effects of lowering blood alcohol concentration limits for drivers on the rates of road traffic accidents and alcohol consumption: a natural experiment. *The Lancet* 393(10169), 321–329.
- Hashemi S., Skogen, J. C., A. Sevic, M. M. Thørrisen, S. L. Rimstad, H. Sagvaag, H. Riper, and R. W. Aas (2022). A systematic review and meta-analysis uncovering the relationship between alcohol consumption and sickness absence. when type of design, data, and sickness absence make a difference. *PLoS One* 17(1), e0262458.
- Holmes, J. (2023). Is minimum unit pricing for alcohol having the intended effects on alcohol consumption in Scotland? *Addiction* 118(9), 1609–1616.
- Jackson, S. E., J. Brown, L. Shahab, C. Garnett, A. K. Stevely, and E. Beard (2025). Associations between tobacco use, nicotine product use and alcohol consumption: a population-based study in great britain. *Scientific Reports* 15(1), 11722.

- Khan, S., R. P. Murray, and G. E. Barnes (2002). A structural equation model of the effect of poverty and unemployment on alcohol abuse. *Addictive behaviors* 27(3), 405–423.
- Kim, M. K., S. Lee, H.-Y. Park, H.-J. Kim, M. Kang, and E. Park (2024). The combined effects of alcohol consumption and smoking on cancer risk by exposure level: A systematic review and meta-analysis. *Journal of Korean Medical Science* 39(e177).
- Leuven, E. and B. Sianesi (2003, April). PSMATCH2: Stata module to perform full Mahalanobis and propensity score matching, common support graphing, and covariate imbalance testing. Statistical Software Components, Boston College Department of Economics.
- Leyland, A. H., R. Dundas, P. McLoone, and F. A. Boddy (2007). Cause-specific inequalities in mortality in Scotland: two decades of change. a population-based study. *BMC Public Health* 7(1), 172.
- Lindo, J. M., I. D. Swensen, and G. R. Waddell (2012). Are big-time sports a threat to student achievement? *American Economic Journal: Applied Economics* 4(4), 254–274.
- Lowe, R. D., R. L. Monk, A. W. Qureshi, J. Fernandez-Montalvo, and D. Heim (2023). A cross-national study of predrinking motives in Spain and the UK: Cross-sectional associations with risk-taking and alcohol consumption. *Addictive Behaviors* 141, 107641.
- McCartney, G., L. Mahmood, A. H. Leyland, G. D. Batty, and K. Hunt (2012). Contribution of smoking-related and alcohol-related deaths to the gender gap in mortality: evidence from 30 european countries. *Tobacco Control* 20(2), 166–168.
- McCutcheon, V. V., A. Agrawal, S. I.-C. Kuo, J. Su, D. M. Dick, J. L. Meyers, H. J. Edenberg, J. I. Nurnberger, J. R. Kramer, S. Kuperman, et al. (2018). Associations of parental alcohol use disorders and parental separation with offspring initiation of alcohol, cigarette and cannabis use and sexual debut in high-risk families. *Addiction* 113(2), 336–345.
- Murray, C. J. L. et al. (2012). UK health performance: findings of the Global Burden of Disease Study 2010. *The Lancet* 381(9871), 997–1020.

- Nguyen, D. T., M. Donnelly, M. V. Hoang, and C. O'Neill (2024). An investigation into patterns of alcohol drinking in Scotland after the introduction of minimum unit pricing. *PLoS one* 19(8), e0308218.
- O'Donnell, A., P. Anderson, E. Jané-Llopis, J. Manthey, E. Kaner, and J. Rehm (2019). Immediate impact of minimum unit pricing on alcohol purchases in Scotland: controlled interrupted time series analysis for 2015-18. *bmj* 366.
- Pintor, M. P., E. Fumagalli, and M. Suhrcke (2024). The impact of health on labour market outcomes: a rapid systematic review. *Health policy*, 105057.
- Popova, S., N. Giesbrecht, D. Bekmuradov, and J. Patra (2009). Hours and days of sale and density of alcohol outlets: impacts on alcohol consumption and damage: a systematic review. *Alcohol & Alcoholism* 44(5), 500–516.
- Public Health Scotland (2022). Scottish health survey 2022, volume 1: Main report.
- Purshouse, R., A. Brennan, N. Latimer, Y. Meng, R. Rafia, R. Jackson, and P. Meier (2009). Modelling to assess the effectiveness and cost-effectiveness of public health related strategies and interventions to reduce alcohol attributable harm in england using the sheffield alcohol policy model version 2.0. *Sheffield: University of Sheffield*.
- Purshouse, R. C., P. S. Meier, A. Brennan, K. B. Taylor, and R. Rafia (2010). Estimated effect of alcohol pricing policies on health and health economic outcomes in england: an epidemiological model. *The Lancet* 375(9723), 1355–1364.
- Robinson, M., D. Mackay, L. Giles, J. Lewsey, E. Richardson, and C. Beeston (2021). Evaluating the impact of minimum unit pricing (mup) on off-trade alcohol sales in Scotland: an interrupted time-series study. *Addiction* 116(10), 2697–2707.
- Scottish Government (2018). Minimum unit pricing of alcohol in Scotland: Final business and regulatory impact assessment. Technical report, Scottish Government, Edinburgh.

- Simonavičius, E., E. Beard, J. Brown, L. Shahab, and S. E. Jackson (2025). Psychological distress, tobacco smoking and alcohol use: A population survey in great britain. *Addictive Behaviors Reports* 22, 101843.
- So, V., A. D. Millard, S. V. Katikireddi, R. Forsyth, S. Allstaff, P. Deluca, C. Drummond, A. Ford, D. Eadie, N. Fitzgerald, et al. (2021). Intended and unintended consequences of the implementation of minimum unit pricing of alcohol in Scotland: a natural experiment. *Public Health Research* 9(11).
- Stockwell, T., M. C. Auld, J. Zhao, and G. Martin (2012). Does minimum pricing reduce alcohol consumption? the experience of a canadian province. *Addiction* 107(5), 912–920.
- Stockwell, T., J. Zhao, G. Martin, S. Macdonald, K. Vallance, A. Treno, W. Ponicki, A. Tu, and J. Buxton (2013). Minimum alcohol prices and outlet densities in british columbia, canada: estimated impacts on alcohol-attributable hospital admissions. *American journal of public health* 103(11), 2014–2020.
- Stockwell, T., J. Zhao, A. Sherk, R. C. Callaghan, S. Macdonald, and J. Gatley (2017). Assessing the impacts of saskatchewan’s minimum alcohol pricing regulations on alcohol-related crime. *Drug and Alcohol Review* 36(4), 492–501.
- Vallée, A., N. Thorin-Trescases, J. Bérubé, and E. Thorin (2023). Association between tobacco smoking and alcohol consumption with arterial stiffness: a cross-sectional study. *The Journal of Clinical Hypertension* 25(7), 784–792.
- World Health Organisation (2018). Global status report on alcohol and health 2018.
- World Health Organisation (2024). Global status report on alcohol and health and treatment of substance use disorders.
- Wyper, G. M., D. F. Mackay, C. Fraser, J. Lewsey, M. Robinson, C. Beeston, and L. Giles (2023). Evaluating the impact of alcohol minimum unit pricing on deaths and hospitalisations in Scotland: a controlled interrupted time series study. *The Lancet* 401(10385), 1361–1370.

Zhao, J., T. Stockwell, A. Roemer, T. Naimi, and T. Chikritzhs (2017). Alcohol consumption and mortality from coronary heart disease: an updated meta-analysis of cohort studies. *Journal of studies on alcohol and drugs* 78(3), 375–386.

A Appendix

A.1 Outcome variable construction

This section describes how the four primary alcohol outcomes used in the analysis were derived from the survey questions.

The variable *Monthly drinking* is an indicator for whether the respondent consumed alcohol more than once per month on average during the last 12 months. The survey question is “Thinking about the past 12 months, how often do you have a drink containing alcohol?”. The answer includes categorical frequency (e.g., ‘Monthly or less’, ‘2-4 times per month’, etc.). We mapped the categories to the binary variable *Monthly drinking* as:

$$\text{MonthlyDrinking}_i = \begin{cases} 1 & \text{if ‘2-4 times per month’, ‘2-3 times per week’ and ‘4+ times per week’,} \\ 0 & \text{if ‘Never’, ‘Monthly or less’}. \end{cases}$$

We report a missing value if the response is ‘Refused’, ‘Don’t know’ or in case of non-response.

The variable *Two drinks/day* is an indicator for whether the respondent consumed more than two drinks on a typical drinking day. The survey question is “How many drinks do you have on a typical day when you are drinking?”. The answer includes categorical frequency (e.g., ‘1-2’, ‘3-4’, ‘5-6’). We mapped the categories to the binary variable *Monthly drinking* as:

$$\text{Two drinks/day}_i = \begin{cases} 1 & \text{if ‘3-4’, ‘5-6’, ‘7-9’, ‘10+’,} \\ 0 & \text{if ‘1-2’}. \end{cases}$$

We report a missing value if the response is ‘Refused’, ‘Don’t know’ or in case of non-response.

The variable ‘Binge drinking’ is an indicator for whether the respondent consumed alcohol

more than once per month on average during the last 12 months. The survey question is “How often have you had 6 or more units of alcohol if female (or 8 or more units if male) on a single occasion in the last year?”. The answer includes categorical frequency (e.g., ‘Never’, ‘Less than monthly’, ‘Monthly’). We mapped the categories to the binary variable as:

$$\text{Binge drinking}_i = \begin{cases} 1 & \text{if 'Monthly', 'Weekly', 'Daily or almost daily',} \\ 0 & \text{if 'Never', 'Less than monthly'}. \end{cases}$$

We report a missing value if the response is ‘Refused’, ‘Don’t know’ or in case of non-response.

Finally, the variable *Units/week* is an index for the average number of alcohol units individuals consume per week. It is constructed by combining the answers to the two questions: (1) “How many drinks do you have on a typical day when you are drinking?” and (2) “Thinking about the past 12 months, how often do you have a drink containing alcohol?”.

We convert the categorical variable of the number of drinks consumed on a typical occasion (‘0’, ‘1-2’, ‘3-4’, ‘5-6’, ‘7-9’ and ‘10+’) to the following units of alcohol: 0, 1.5, 3.5, 5.5, 8, and 10. Similarly, we map the categorical variable of the frequency of drinking (‘Never’, ‘Monthly or less’, ‘2-4 times per month’, ‘2-3 times per week’ and ‘4+ times per week’) to the following weekly frequency measures: 0, 0.25, 0.75, 2.5 and 5.5. The product of these two variables is the measure of units of alcohol consumed on average per week, ranging from zero units if a person does not consume alcohol at all, up to 55 units per week if a person reports extreme frequency and number of drinks consumed.

A.2 Definitions

Table 16: Calculation of Alcohol Units.

Element	Description
ABV (Alcohol by Volume)	The percentage of alcohol in the drink.
Volume (ml)	The total amount of the drink.
Formula	$(\text{ABV } \% \times \text{Volume in ml}) \div 1000 = \text{Units}$

A.3 Further identification tests: Scotland vs England

A.3.1 Parallel trend test

We also carried out pre-trend tests (Table 17) to check whether alcohol consumption patterns in Scotland and England evolved similarly prior to the introduction of MUP. The results show no significant differences, reassuring that the post-2018 divergence reflects the impact of the policy rather than pre-existing trends.

Table 17: Tests for mean differences across groups (treated vs control) pre-treatment.

Outcome	F-statistic	p-value
Monthly drinking	$F(1, 4703) = 0.19$	0.67
Two drinks/day	$F(1, 4703) = 0.03$	0.87
Binge drinking	$F(1, 4703) = 0.13$	0.72
Units/week	$F(1, 4703) = 0.01$	0.90

A.3.2 No anticipation test

To further examine the identifying assumption, we conducted Granger causality tests for each outcome. The test statistics (Table 18) show that none of the alcohol measures Granger-cause treatment assignment, with all p-values well above the significance thresholds of 10%. This provides additional reassurance that our estimates are not confounded by reverse causality.

Table 18: Granger causality tests for drinking outcomes

Outcome	F-statistic	p-value
Units/week	$F(1, 4703) = 0.01$	0.90
Binge drinking	$F(1, 4703) = 0.13$	0.72
Monthly drinking	$F(1, 4703) = 0.19$	0.67
Two drinks/day	$F(1, 4703) = 0.03$	0.87

A.4 Parallel trend test: Scotland and Wales vs England

We also carried out pre-trend tests (Table 19) to check whether alcohol consumption patterns in Scotland, Wales and England evolved similarly prior to the introduction of MUP. The results show no significant differences, reassuring that the post-implementation divergence reflects the impact of the policy rather than pre-existing trends.

Table 19: Tests for mean differences across groups (treated vs never treated) pre-treatment.

Outcome	χ^2 -statistic	p-value
Monthly drinking	$\chi^2(3) = 1.92$	0.59
Two drinks/day	$\chi^2(3) = 1.82$	0.61
Binge drinking	$\chi^2(3) = 0.76$	0.86
Units/week	$\chi^2(3) = 1.06$	0.79

A.5 Types of drinkers

Table 20: Classification of drinkers and associated health risks.

Drinkers type	Weekly Units	Examples	Short-term health risks	Long-term health risks
Moderate Low-Risk	≤ 14	6 pints of beer, or 6 glasses of wine per week	Minimal Minimal Minimal	Low risk of chronic disease
Hazardous Increasing Risk	>14	2–3 pints of beer or 2–3 glasses of wine per day	Hangovers, reduced coordination	Increased risk of liver disease, hypertension
Harmful Higher Risk	Regular binge episodes or > 14 units/week + frequent heavy sessions	4–5 pints of beer or 4–5 glasses of wine per session	Accidents, acute intoxication	High risk of alcohol dependence, liver disease, cardiovascular disease

A.6 Attrition rates and statistics

Table 21: In sample vs Excluded

	Sample Mean	Excluded Mean	Normalised Difference
Age	50.4 (18.1)	51.2 (18.2)	0.070
Male	0.457 (0.498)	0.466 (0.499)	0.432
University or Higher degree	0.402 (0.490)	0.411 (0.492)	0.389
Employed	0.589 (0.492)	0.575 (0.494)	0.197
Unemployed	0.033 (0.178)	0.034 (0.182)	0.799
Retired	0.264 (0.441)	0.274 (0.446)	0.297
Student	0.034 (0.182)	0.032 (0.177)	0.651
Other employment status	0.080 (0.271)	0.085 (0.279)	0.416
Married or in partnership	0.641 (0.480)	0.630 (0.483)	0.334
Life satisfaction	5.109 (1.573)	5.055 (1.662)	0.150
Monthly Income (in £)	1,917 (1,647)	1,954 (1,687)	0.288
N	9,680 (69.1%)	4,321 (30.9%)	

Notes: Descriptive statistics are computed using data from Wave 9 (pre-intervention) using survey weights. *Source:* authors' calculations using the Understanding Society dataset.

A.7 Descriptive statistics for alcohol consumption by groups of individuals in Scotland and Wales.

Table 22: Pre-intervention consumption of alcohol in Scotland and Wales by age, gender, and immigration status.

	Age <25	Age 25–35	Age 35+	Males	Females	Natives	Non-Natives
Monthly drinking	0.589	0.527	0.613	0.709	0.522	0.607	0.502
Binge drinking	0.423	0.369	0.233	0.346	0.193	0.259	0.252
Two drinks/day	0.688	0.596	0.374	0.482	0.366	0.421	0.312
Units/week	4.876	3.328	4.442	6.019	3.078	4.330	4.436

Notes: The table reports the mean values of alcohol consumption outcomes in Scotland and Wales across Waves 7 and 9 (pre-treatment) of different subsamples of individuals. Outcomes: *Monthly drinking* = 1 if the individual reports drinking more often than once per month; *Binge drinking* = 1 for consuming ≥ 6 units on a typical occasion if female or 8 or more units if male at least monthly; *Two drinks/day* = 1 for drinking more than two drinks per day; *Units/week* = average weekly alcohol units consumed.

A.8 Descriptive statistics for hazardous and moderate drinkers: Scotland, Wales and England.

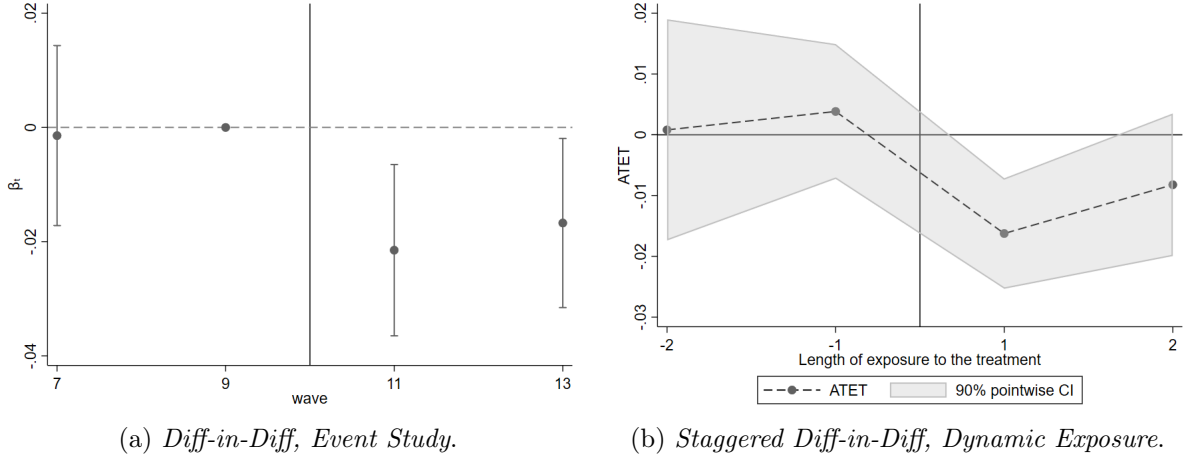
Table 23: Descriptive statistics: Hazardous vs Moderate Drinkers

	Moderate mean (sd)	Hazardous mean (sd)	Normalised Difference
Monthly drinking	0.569 (0.495)	1.000 (0.000)	<0.001
Binge drinking	0.182 (0.386)	0.781 (0.414)	<0.001
Two drinks/day	0.299 (0.458)	1.000 (0.000)	<0.001
Units/week	2.926 (3.430)	22.876 (7.006)	<0.001
<i>Socio-demographic characteristics</i>			
Age	53.3 (17.419)	53.3 (14.842)	0.978
Male	0.423 (0.494)	0.722 (0.449)	<0.001
Non-Native	0.058 (0.235)	0.056 (0.231)	0.931
University or Higher degree	0.409 (0.492)	0.438 (0.497)	0.366
Employed	0.574 (0.495)	0.590 (0.492)	0.587
Unemployed	0.022 (0.146)	0.035 (0.183)	0.216
Retired	0.308 (0.462)	0.292 (0.455)	0.516
Student	0.017 (0.129)	0.008 (0.090)	0.125
Other employment status	0.079 (0.270)	0.076 (0.265)	0.840
Married or in partnership	0.643 (0.479)	0.646 (0.479)	0.908
Life satisfaction	5.135 (1.577)	5.195 (1.506)	0.493
Monthly Income (in £)	1,827 (1,459.505)	2,256 (1,917.887)	<0.001
Observations	2,861 (92.8%)	221 (7.2%)	

Notes: Descriptive statistics are computed using data from Wave 9 (pre-intervention), covering Scotland, Wales and England, using survey and propensity score matching weights to rebalance variables between treated and control units. Standard deviations are given in parentheses. Normalised differences are calculated as in Baker et al. (2025). *Source:* authors' calculations using the Understanding Society dataset.

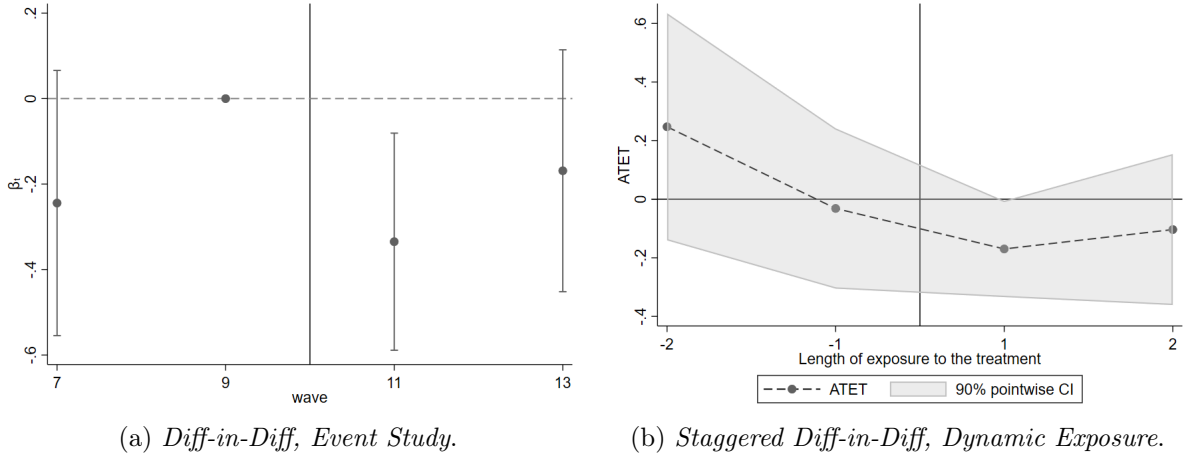
A.9 Alternative risky behaviours.

Figure 3: Event studies: cigarette smoking.



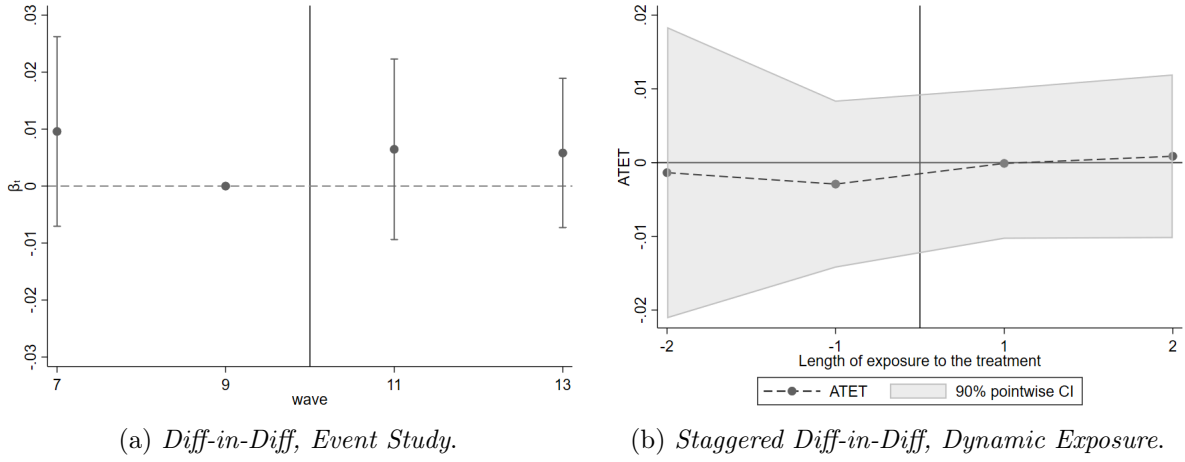
Note: Figures show (a) event-study estimates in treatment (Scotland) and control (England) groups and (b) dynamic event-study estimates in treatment (Scotland and Wales) and control (England) groups. 90% confidence intervals around the point estimates are given in each case. The outcome variable is the percentage of people smoking cigarettes. The survey question is "Do you smoke cigarettes?".

Figure 4: Event studies: Number of cigarettes.



Note: Figures show (a) event-study estimates in treatment (Scotland) and control (England) groups and (b) dynamic event-study estimates in treatment (Scotland and Wales) and control (England) groups. 90% confidence intervals around the point estimates are given in each case. The survey question is "Approximately how many cigarettes a day do you usually smoke, including those you roll yourself?".

Figure 5: Event studies: vape smoking.



Note: Figures show (a) event-study estimates in treatment (Scotland) and control (England) groups and (b) dynamic event-study estimates in treatment (Scotland and Wales) and control (England) groups. 90% confidence intervals around the point estimates are given in each case. The survey question is "Do you ever use electronic cigarettes (e-cigarettes)?".