Evaluation of the impact of alcohol minimum unit pricing (MUP) on crime and disorder, public safety and public nuisance

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Executive summary

To combat a set of health and social harms associated with alcohol, the Scottish Parliament passed legislation in 2012 to allow for the implementation of Minimum Unit Pricing (MUP). Secondary legislation set the level of MUP at 50 pence per unit (ppu). The Scottish Government implemented MUP on 1 May 2018. This report evaluates the impact of MUP on crime and disorder, public safety and public nuisance, as required by the legislation.

A robust international evidence base consistently finds that as alcohol consumption increases, so too does the prevalence of a multitude of societal harms including crime and disorder, public safety and public nuisance. Alcohol consumption is moderated by its affordability, availability and promotion. Over the last thirty years, alcohol in the UK has become more affordable as disposable income has increased. The international evidence base suggests a high price per unit of alcohol serves to reduce affordability and lower consumption. Based on this literature, and following consultation with policing and health experts, a theory of change was developed to guide the current study. The theory of change identifies the factors known to moderate and mediate (such as deprivation, age and gender) alcohol consumption, and the crime-related intended and unintended impacts and outcomes of the introduction of MUP. In this theory of change, the intended outcomes are a fall in crime, disorder and public nuisance, while the unintended outcome is a rise in drug-related offences. The evaluation extends to a period in which alcohol sales have fallen in Scotland.

The study set out to address the following research questions:

- What impact has MUP had on alcohol-related crime and disorder, public nuisance and public safety?
- How have any MUP-related changes in crimes and offences varied by type of crime and offence?

- To what extent have any MUP-related impacts on crime and disorder, public safety and public nuisance varied by sex, age group, geographic location and socio-economic position?

The evaluation uses recorded crime, incident and nominal data made available under licence by Police Scotland and Greater Manchester Police. These data were used to generate various alcohol-related, non-alcohol-related and drug-related crime, disorder and public nuisance output measures, at a variety of geographical and temporal scales. These data were also used to identify the age and sex of victim and offender populations. The evaluation deployed a range of statistical methods, including change point detection analysis, uncontrolled interrupted time series analysis (regression with ARIMA errors), Integrated Nested Laplace Approximation (INLA) and a synthetic control.

The study found that the long-term decline in all recorded crime and disorder in Scotland had ceased prior to the introduction of MUP. The trend in all recorded crime and disorder was shaped by the volume of all non-alcohol-related crime, which underwent a statistically significant increase prior to the introduction of MUP. In contrast, all alcohol-related crime and disorder exhibited a steady and declining trend prior to and following the introduction of MUP. No significant change in trend direction or level was found for all alcohol-related crime and disorder, all alcohol-related incidents (public nuisance) or all drug-related crimes.

There were no apparent changes in the trend direction or statistically significant changes in the level of alcohol-related crime and disorder by type (for example serious assault, robbery and assault (with intent to rob), sexual offences, common assault, threatening and abusive behaviour, vandalism, resisting arrest, consumption of alcohol in designated places (for example a public place which has been designated by a local authority byelaw as not permitting alcohol consumption)) in the period eight weeks prior to eight weeks after the introduction of MUP. Outwith the lagged period, there was no evidence of a consistent change point across alcohol-related crime and disorder by type. The study was extended to include public nuisance by type (for example public nuisance, disturbance, noise complaints,

drinking in public, neighbour disputes), and found no discernible change in the trend direction for nuisance, disturbance or drinking in public in the period eight weeks prior to eight weeks after the introduction of MUP. In contrast, and across Scotland, noise complaints were found to exhibit an upward trajectory until three weeks after the introduction of MUP, at which point they commenced a steady decline (though without a significant change point) until the end of the study period.

The study found no changes in the trend direction or statistically significant changes in the level of all alcohol-related crime and disorder in the period eight weeks prior to eight weeks after the introduction of MUP in 27 of the 28 local authorities included in the analysis. The single local authority in which a statistically significant change occurred, East Ayrshire, exhibited an increase in all alcohol-related crime and disorder, counter to the expected direction of change. Further, when modelling specific alcohol-related crime and disorder types at local authority level, the analysis found only vandalism in East Renfrewshire to exhibit a statistically significant decline in the period following the introduction of MUP. That these two findings contrast with all other findings is highly suggestive of them not occurring as a consequence of the introduction of MUP.

The study found no changes in the trend direction or statistically significant changes in the level of all alcohol-related crime and disorder, in the period eight weeks prior to eight weeks after the introduction of MUP, in the 10% most deprived data zones in Scotland. However, the analysis did find a statistically significant decrease in the consumption of alcohol in designated places, six weeks after the introduction of MUP, in the 10% most deprived data zones in Scotland. The study found no statistically significant change in the trend direction or level of the average age, as well as of the male to female ratio of offenders and victims, of all alcohol-related crime and disorder in Greater Glasgow around the introduction of MUP. The analysis found no statistically significant evidence of any spatial or temporal impact of the introduction of MUP on all alcohol-related crime and disorder, controlling for deprivation, in Greater Glasgow. Finally, the analysis found no significant change in all alcohol-related crime and disorder in Greater Glasgow in comparison to a synthetic control site (Greater Manchester).

Despite evidence of a decline in the sale of alcohol following the introduction of MUP, the findings of this study point to this having minimal impact on the trend direction or level of alcohol-related crime, disorder and public nuisance (in total or by type) in Scotland. Nor indeed did the introduction of MUP have an impact on drug-related crimes, identified as a potential unintended outcome in the theory of change developed for this study. Across the multiple analyses comprising the study, only two findings fell in line with those expected in the theory of change. Firstly, and across Scotland, noise complaints were found to exhibit an upward trajectory until three weeks after the introduction of MUP, at which point they commenced a steady decline (though without a significant change point) until the end of the study period. Secondly, and in the 10% most deprived data zones in Scotland, a statistically significant decline in the consumption of alcohol in designated places was found to take place six weeks after the introduction of MUP. Noise complaints across Scotland and the consumption of alcohol in designated places (in the 10% most deprived data zones in Scotland), exhibited statistically significant decline eight weeks or less following the introduction of MUP. That these findings are aligned with those expected in the theory of change merits their further investigation. On the whole, however, that there has been such limited discernible impact of MUP on alcohol-related crime, disorder and public nuisance is suggestive of the reduction in the sale of alcohol being below that required to deliver a crime-related dividend, or that if a crime-related dividend has occurred it has done so at a scale that the study has lacked the sensitivity to identify.

Introduction

To combat a set of health and social harms associated with alcohol consumption, and as part of a public health whole-population approach, the Scottish Parliament passed legislation in 2012 to allow for the implementation of Minimum Unit Pricing (MUP). Secondary legislation set the level of MUP at 50 pence per unit (ppu). The Scottish Government implemented MUP on 1 May 2018. The legislation requires Ministers to report to Parliament on the impact of the act on a number of outcomes, including the five licensing objectives. It is in this context that this study evaluates the impact of MUP on crime and disorder, public safety and public nuisance.

Background

A robust international evidence base consistently finds that as alcohol consumption increases, so too does the prevalence of a multitude of societal harms inclusive of crime and disorder, public safety and nuisance.[1] [2] [3] Indeed, Police Scotland (2017: 23)[4] states that 'alcohol is a prevalent factor in many crimes'. For example, alcohol intoxication is associated with heightened aggression and a feeling of power[5] and, consequently, the risk of being involved in violence increases with drunkenness.[6] Further, a recent Scottish survey found that 30% of respondents stated they had been kept awake at night by drunken noise, 20% had been harassed or bothered by someone who had been drinking on a street or in another public place and 19% had felt unsafe in a public place because of someone else's drinking.[7]

The most recent Scottish Crime and Justice Survey (SCJS) in 2019/20[8] states that, of respondents who report being a victim of crime, and could say something about the offender, around two in five (38%) felt that the offender was under the influence of alcohol. However, this varied by crime type, with over two in five victims of violent crime (44%), assaults (44%) and vandalism (43%) feeling that the offender was under the influence of alcohol. Scottish Government (2019)[9] identified that in 2017/18 'nearly two-thirds (63%) of attempted murder and serious assault crime records made reference to the consumption of alcohol' whereas 'one in ten attempted murders and serious assaults (10%) made reference to drugs'. For

homicides in 2019/20, where the alcohol and drug status of the offender was known, 79% were recorded as being under the influence of alcohol at the time of the offence.[10] [11] In 2019, two in five (40%) prisoners reported being under the influence of alcohol at the time of their offence.[12] Cumulatively, the cost to society of alcohol-related crime and public disorder, (threats to) public safety and public nuisance has been calculated as being vast.[13]

Alcohol consumption is moderated by its affordability, availability and promotion. Over the last thirty years, alcohol in the UK has become more affordable as disposable income has increased. Thus, and in 2019, alcohol sold in the UK was 75% more affordable that it was in 1987.[10] There is an inverse relationship between the price of alcohol and its consumption, as price increases there is a reduction in consumption. Recent systematic reviews and rapid evidence assessments find that price regulation, maintaining a high price per unit of alcohol, holds significant prospect of reducing consumption.[14] [15]

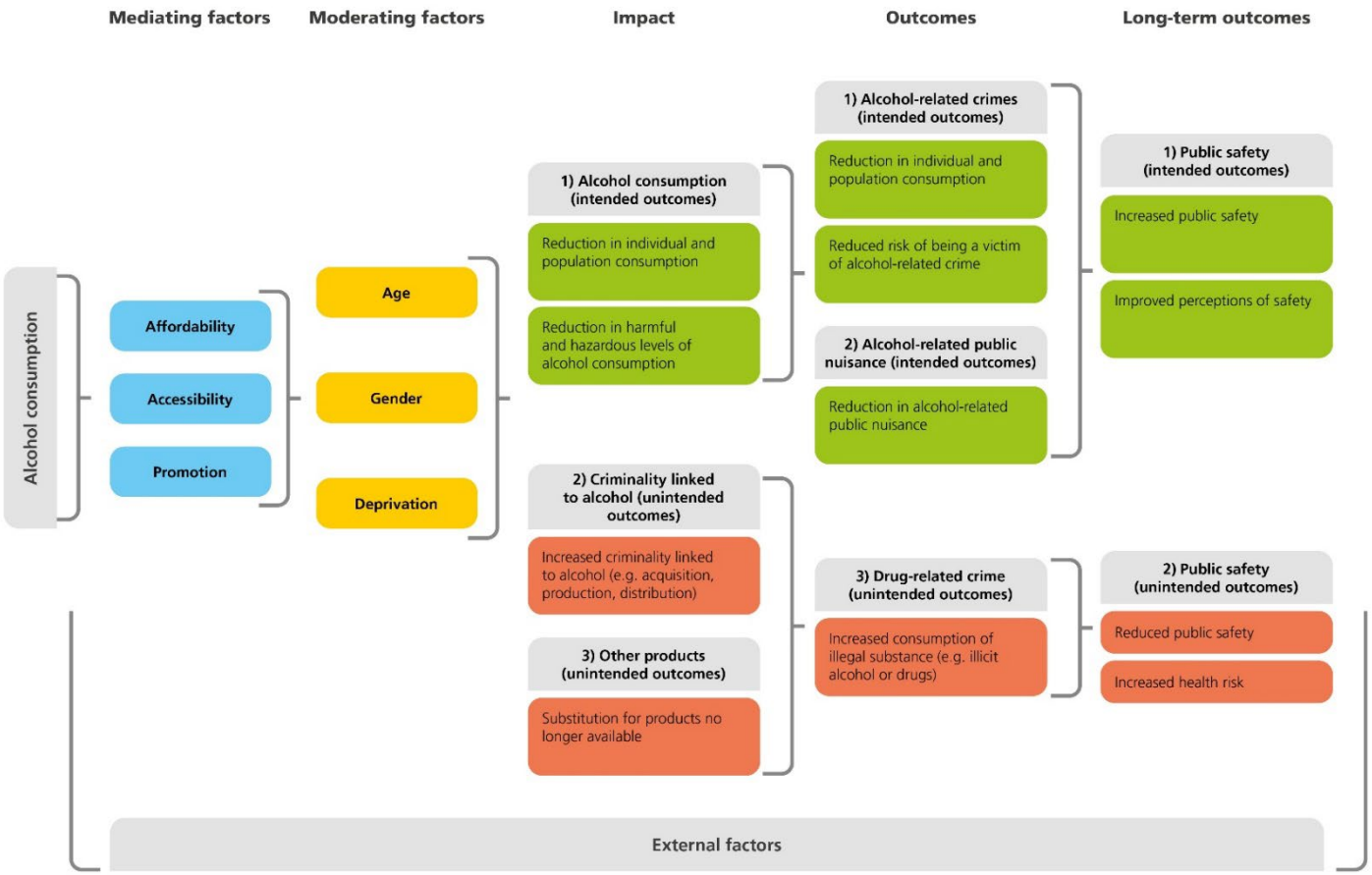
The level of alcohol consumption varies across the population. Scottish Government (2020)[16] identified that 17% of the population aged 16 and over were non-drinkers (no units per week); 59% were moderate drinkers (>0 units and up to 14 units per week); whereas 24% were hazardous/harmful drinkers (more than 14 units per week).

The prevalence of hazardous or harmful drinking levels is twice as high for men (32%) than for women (16%). As household income increases, the proportion of the population drinking above the weekly guidelines also increases. However, the mean weekly consumption by men in the lowest income group is higher (at 40.1 units) than men in higher income groups (between 28.9 and 31.9 units). The heaviest 10% of drinkers consume 48% of all self-reported consumption in Scotland. Finally, it has been estimated that the off-trade sale of pure alcohol per person declined by 3.5% in Scotland[17] in the year following the introduction of MUP, i.e. in the study period.[18] [19]

Theory of change

Founded on the international evidence base, a theory of change for the impact of MUP on crime and disorder, public safety and public nuisance has been developed as part of this study. The theory of change identifies the factors known to moderate and mediate alcohol consumption. It progresses to identify the intended (green) and unintended (red) impacts, outcomes and long-term outcomes of the implementation of MUP. The intended impacts centre on a reduction in alcohol consumption, while the unintended impacts relate to an increase in criminality (for example acquisition, production and distribution) linked to alcohol. The intended outcomes (in this theory of change) are a reduction in alcohol-related crime, disorder and nuisance, while the unintended outcome is a rise in drug-related crime. The long-term intended outcome is an improvement in public safety, while the unintended long-term outcome is a reduction in public safety. The theory of change was reviewed and approved, as part of the inception phase of this study, by subject matter (health and policing) experts. Further, the subject matter experts confirmed the absence of any external factors (of a sufficient scale) likely to confound the influence of the implementation of MUP upon crime and disorder, public safety and public nuisance.

Figure 1. Theory of Change



Research questions

The study set out to address the following research questions:

- RQ1: What impact has MUP had on alcohol-related crime and disorder, public nuisance and public safety?
- RQ2: How have any MUP-related changes in crimes and offences varied by type of crime and offence?
- RQ3: To what extent have any MUP-related impacts on crime and disorder, public safety and public nuisance varied by sex, age group, geographic location and socio-economic position?

Data and methods

The research questions were addressed sequentially and deployed the following outcome measures, study time periods, data and methodological approaches.

Outcome measures

The outcome measures are recorded crime and incident rates per 1,000 population, the average age of victims and offenders, and the male to female ratio of victims and offenders.

Study time periods

Research question 1 (unless otherwise specified due to data limitations) examines the time period January 2015 (week 1) to January 2020 (week 1). The time period prior to the introduction of MUP allows trends to be viewed in their longer-term context. The study period ended, as it did for all research questions, in January 2020 (week 1) to avoid any influence of COVID-19 on the data.

Research question 2 and aspects of research question 3 (unless otherwise specified due to data limitations) examines the time period January 2015 (week 1) to January 2020 (week 1).

Data

Crime data

The study draws on recorded crime data made available under licence by Police Scotland and Greater Manchester Police (utilised to address aspects of research question 3). Research questions 1 and 2 utilise recorded crime data for the whole of Scotland. For research question 1, these data were aggregated in to the following categories: all crimes; all alcohol-related crimes; all non-alcohol-related crimes; all drug-related crimes; and crime group (seven in total). For research question 2, these data were aggregated into specific alcohol-related crime categories. Research question 3 utilises data aggregated into specific alcohol-related categories. Research question 3 aggregates data to differing geographical scales: local authorities in Scotland; data zones in Scotland; and data zones for Greater Glasgow and Lower Super Output Areas (LSOAs) for Greater Manchester. By definition, 'data zones are groups of 2011 Census output areas which have populations of around 500 to 1,000 residents,'[20] while 'LSOAs are built of OAs, typically five, and so contain ~625 households or a mean population of ~1,500, with a minimum population of 1,000'.[3] A detailed explanation of the process adopted to identify 'plausible' alcohol-related crime and disorder (and nuisance) types, their precise specification (by offence/incident code) and the means adopted to match Police Scotland and Greater Manchester Police recorded crime data can be found in Appendix A.

Incident data

The study draws on calls-for-service or incident (opening codes) data made available under licence by Police Scotland. Research questions 1 and 2 utilise these data for the whole of Scotland and do so to examine public nuisance. A detailed account of the incident codes included in the analysis can be found in Appendix A.

Nominal data

The study draws on nominal (victim and offender) data for Greater Glasgow, made available under licence by Police Scotland. These data are used to address research question 3. The data include the date of birth, gender and x-y coordinates of the event in which the victim and offender was involved. These data are further described in Appendix A.

Mid-year population estimates

Mid-year population estimates, from the years 2015 to 2019, were used to convert crime counts into crime rates per 1,000 population. Each mid-year population estimate was treated as starting from week one of any given year. Weekly population estimates were then interpolated linearly from the mid-year estimates. Since year 2020 estimates were not available, 2019 weekly population estimates were used for this time period. Data was obtained from National Records of Scotland[20] and the ONS[21] for Greater Manchester.

Deprivation

The Scottish Index of Multiple Deprivation 2020 was used to classify data zones in Scotland as being in the most deprived decile. Census data from Scotland and England/Wales (2011) were used to qualify the deprivation characteristics (Townsend index)[22] of data zones in Greater Glasgow and Lower Super Output Areas in Greater Manchester.

Statistical methods

Research questions 1 and 2 utilised the change point detection method to identify significant changes in recorded crime, disorder and public nuisance. If a change in trend or level of recorded crime was detected, within +/- eight weeks of the introduction of MUP (a period in which any MUP-related change in behaviour might plausibly be expected to occur), it would be further assessed via the uncontrolled interrupted time series method (regression with ARIMA errors). The potential impact

of MUP was measured at week 18 of year 2018 (May 2018), marking the introduction of MUP, and at the lags identified by the change point analysis.

Research question 3 drew upon multiple methods. Trend change point analysis and interrupted time series analysis were used to assess the impact of the introduction of MUP on alcohol-related crime and disorder across local authorities and data zones in the most deprived decile in Scotland. These techniques were also used to assess changes in the age and gender-ratio of offenders and victims of alcohol-related crime. To assess the existence of both spatial and temporal effects arising as a consequence of the introduction of MUP in Greater Glasgow, while controlling for deprivation, we used Integrated Nested Laplace Approximation (INLA). This Bayesian model incorporated both spatial and temporal autocorrelation alongside the binary MUP introduction variable. The study time period of this analysis spanned quarter one of year 2015 (January) to quarter four of year 2019 (December). To assess the impact of the introduction of MUP on alcohol-related crime in Greater Glasgow in comparison to a control site (Greater Manchester), we used a synthetic control method. The time period for this analysis spanned May 2017 to April 2019.

Detailed information on the methods utilised in this evaluation and the modelling process itself is provided in Appendix B.

Presentation of results

We present the estimated impact of MUP on crime, disorder and nuisance as a percentage change with 95% confidence intervals.

Changes to our published protocol

In respect to Research Questions 1 to 3 the following changes were made to the research protocol:

- We stated that we would investigate criminality linked to alcohol, as well as subgroups of drug-related crime. However, due to the low numbers of such crimes, this proved infeasible.

- We stated that we would evaluate the impact of MUP on (perceptions of) public safety. However, due to the limited quality and quantity of the data available, this proved infeasible.
- The nominals data provided by Police Scotland contained the following characteristics of victims and offenders: date of birth, gender and ethnicity. The limited quality of the data in the ethnicity field prohibited its analysis.
- The synthetic control method that was chosen for the analysis does not permit time-varying covariates. As point of interest data is dynamic (meaning it changes through time), it was not included in the analysis.

Results

This section of the report presents the findings relating to each research question in turn.

Research question 1

Research question 1 explored the impact of the introduction of MUP on all alcohol-related crime, disorder and public nuisance. The analysis explored the presence of changes in trend direction and in the volume of crime (trend change point analysis), paying specific attention to the period eight weeks prior to eight weeks after the introduction of MUP (a period in which any MUP-related change in behaviour might plausibly be expected to occur) in order to identify the existence of possible lagged effects. Thereafter, the percentage changes (where such changes existed) in recorded crime rates per 1,000 population were quantified and tested for significance (uncontrolled interrupted time series analysis). Research question 1 aggregated data for Scotland into the following categories: all crimes; all alcohol-related crimes; all non-alcohol-related crimes; all public nuisance incidents; and all drug-related crimes.

Trend change point analysis

All crimes in Scotland

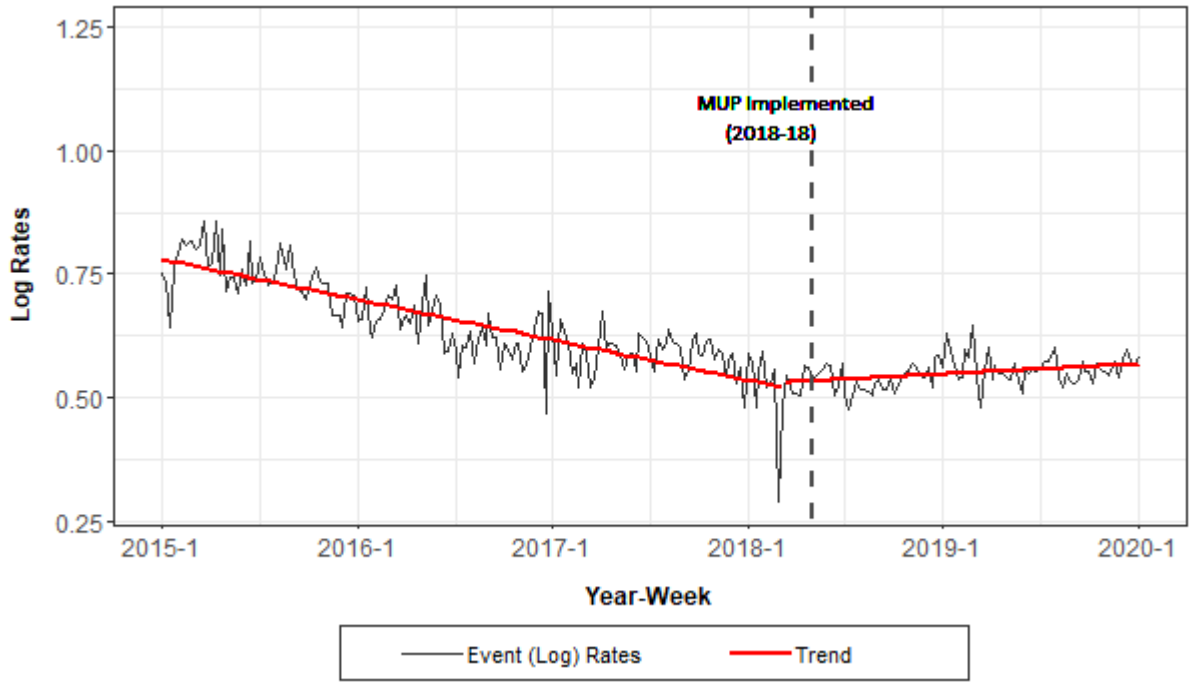


Figure 2. The trend in the weekly (log) rate of all crimes in Scotland, 2015–2020

Figure 2 shows the weekly (log) rate of all crimes in Scotland and how its trend has changed over time, 2015–2020. In overview, there is a steady decline in all crimes for most of the study period. However, there is a noticeable change in trend that occurs eight weeks prior to introduction of MUP, at which point the decline in all crimes begins to level out.

All alcohol-related crimes in Scotland

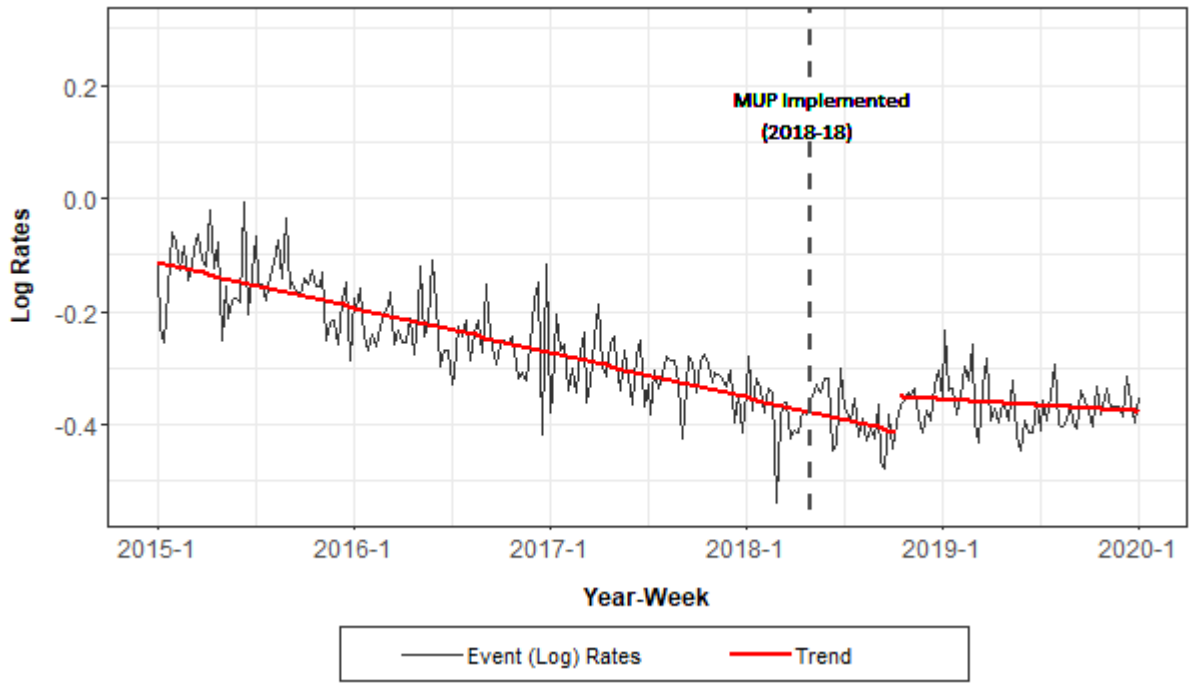


Figure 3. The trend in the weekly (log) rate of all alcohol-related crimes in Scotland, 2015–2020

Figure 3 shows the weekly (log) rate of all alcohol-related crimes in Scotland and how its trend has changed over time, 2015–2020. In overview, alcohol-related crimes in Scotland exhibit long term decline, and no change in trend or level was detected within eight weeks of the introduction of MUP.

All non-alcohol-related crimes in Scotland

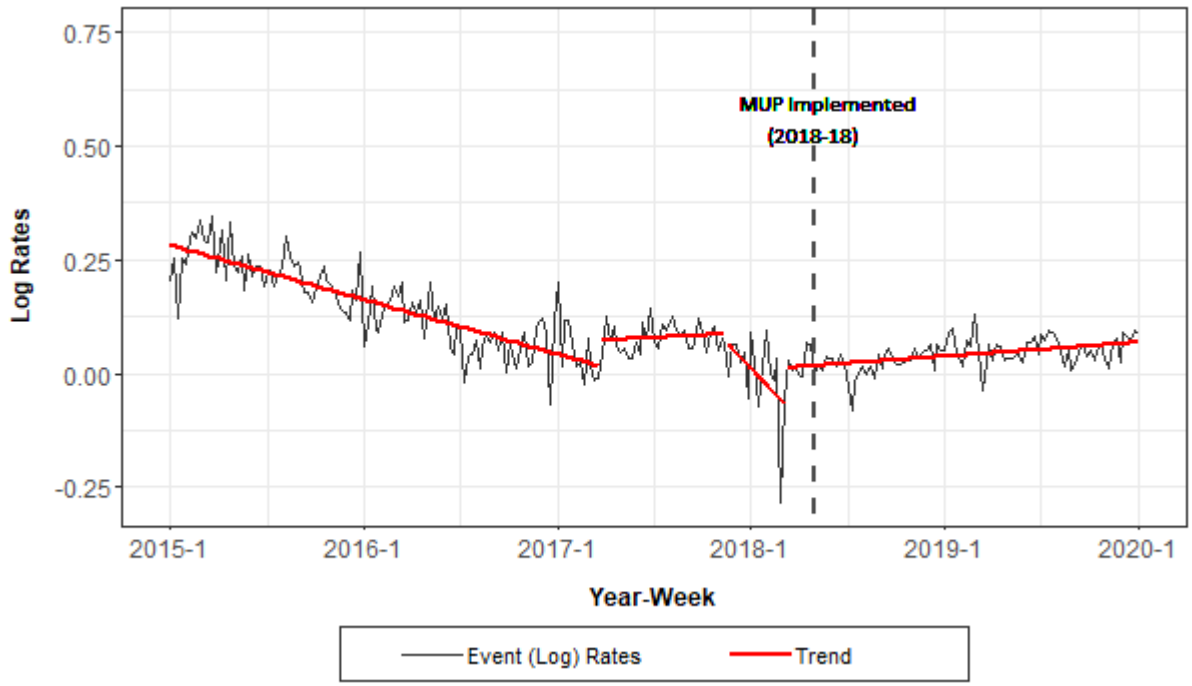


Figure 4. The trend in the weekly (log) rate of all non-alcohol-related crimes in Scotland, 2015–2020

Figure 4 shows the weekly (log) rate of all non-alcohol-related crimes in Scotland and how its trend has changed over time, 2015–2020. In overview, all non-alcohol-related crimes exhibit a similar pattern to ‘all crimes’. There is a noticeable change in trend eight weeks prior to introduction of MUP, at which point the decline in non-alcohol-related crimes levels out and a slowly increasing trend commences.

All public nuisance incidents in Scotland

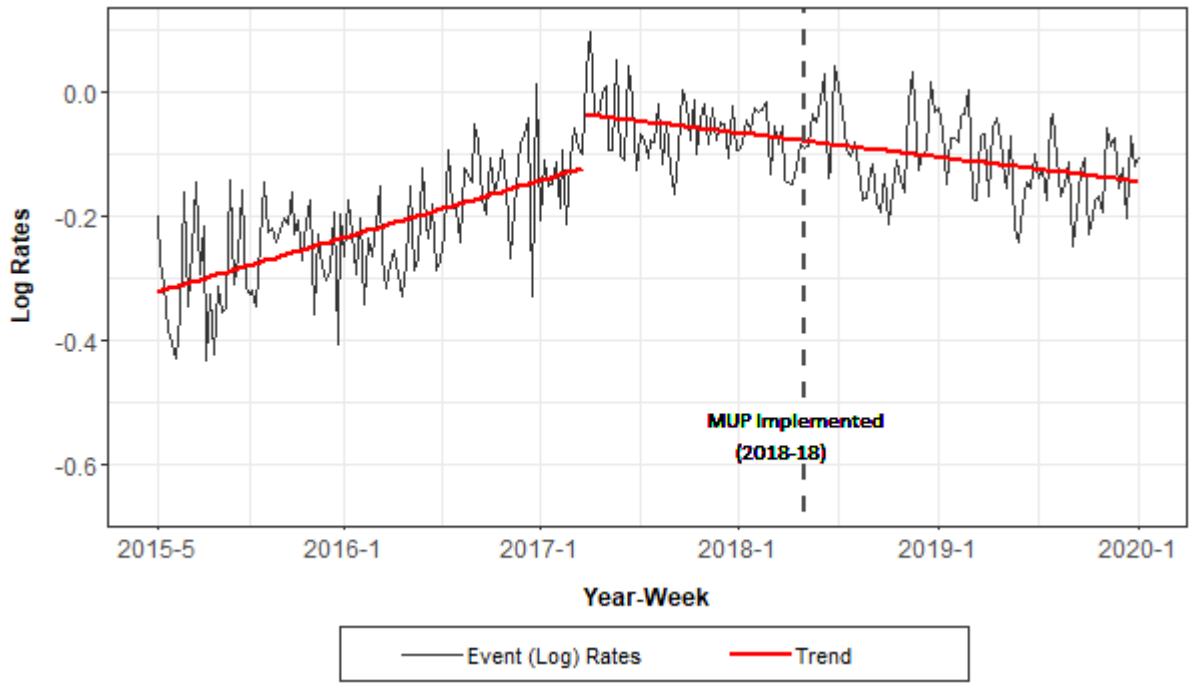


Figure 5. The trend in weekly (log) rate of all public nuisance incidents in Scotland, 2015–2020

Figure 5 shows the weekly (log) rate of all public nuisance incidents in Scotland and how its trend has changed over time, 2015–2020. There is an increase in the rate of incidents from the beginning of the analysis period, followed by a decline from early 2017. No change has been identified around the introduction of MUP.

All drug-related crimes in Scotland

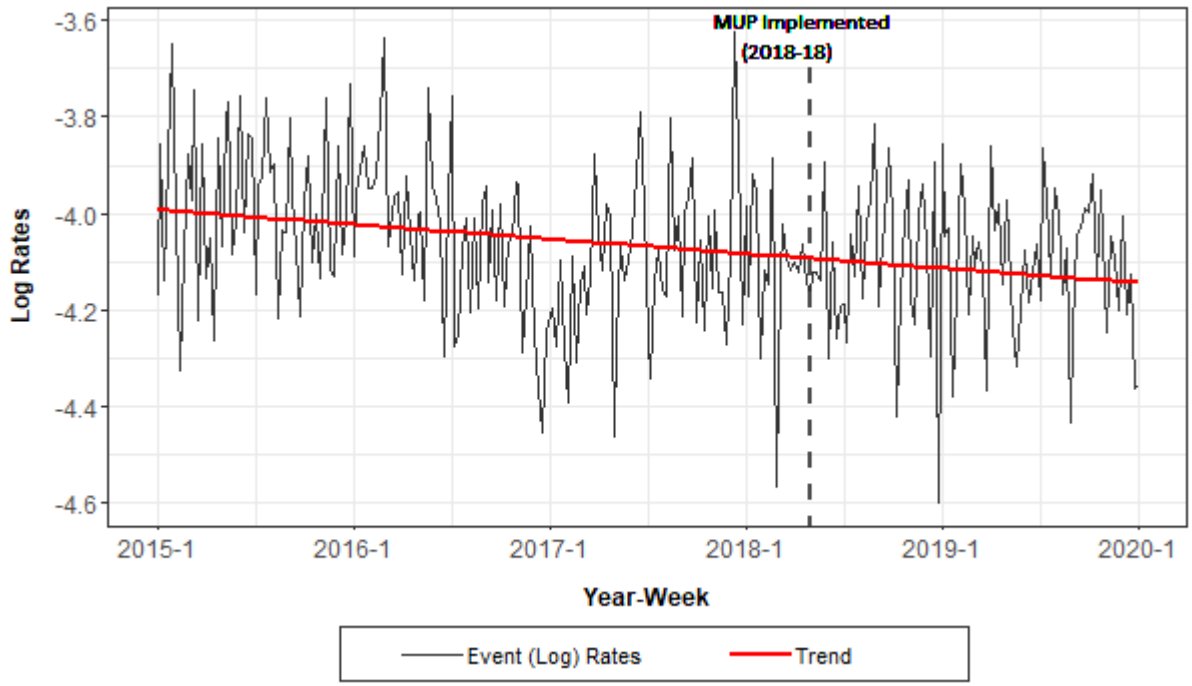


Figure 6. The trend in the weekly (log) rate of all drug-related crimes in Scotland, 2015–2020

Figure 6 shows the weekly (log) rate of all drug-related crimes in Scotland and how its trend has changed over time, 2015–2020. A shift to drug-related crimes was identified as one of the potential unintended consequences identified in the theory of change, but in practice, the trend of all drug-related crimes appears to be relatively stable throughout the study period and unaffected around the introduction of MUP.

Uncontrolled interrupted time series analysis

Table 1 presents the estimated impact of MUP, placing specific attention on the period +/- eight weeks around its introduction, on the rates per 1,000 population of all crimes, all alcohol-related crimes, all non-alcohol-related crime rates, and all drug-related crimes in Scotland. Statistically significant p-values (results) are presented in bold.

Table 1. The estimated impact of MUP on crime (by category)

Data	% Change	CI (Lower)	CI (Upper)	p-value
All crimes in Scotland	-0.16	-17.80	21.17	0.99
All crimes in Scotland (-8 weeks lag)	9.57	1.11	18.77	**0.03**
All alcohol-related crimes in Scotland	6.43	-4.97	19.24	0.28
All non-alcohol-related crimes in Scotland	-1.48	-48.47	88.33	0.96
All non-alcohol-related crimes in Scotland (-8 weeks lag)	17.29	4.39	31.78	**0.01**
Unintended consequences	3.70	-12.10	22.26	0.67
All public nuisance incidents in Scotland	4.25	-7.87	17.94	0.51
Crime Group 1: Crimes of violence etc.	7.90	-2.86	19.84	0.16
Crime Group 2: Sexual offences	3.97	-5.54	14.45	0.43

Data	% Change	CI (Lower)	CI (Upper)	p-value
Crime Group 3: Crimes of dishonesty	0.47	-17.55	22.38	0.96
Crime Group 4: Fire-raising, malicious mischief etc.	-0.50	-9.24	9.09	0.92
Crime Group 5: Other crimes	2.77	-14.44	23.37	0.77
Crime Group 6: Miscellaneous offences	5.17	-8.61	21.05	0.48
Crime Group 7: Offences relating to motor vehicles	-6.55	-26.14	18.18	0.57
All drug-related crimes in Scotland	3.70	-12.10	22.26	0.67

All crimes in Scotland

In the period following the introduction of MUP there was a statistically insignificant 0.16% reduction (95% confidence interval (CI): -17.80% to 21.17%) in the rate of 'all crimes' per 1,000 population in Scotland. On the other hand, and eight weeks prior to the introduction of MUP, there was a statistically significant increase of 9.57% (95% confidence interval (CI): 1.11% to 18.77%) in the rate of 'all crimes' per 1,000 population in Scotland.

All alcohol-related crimes in Scotland

In the period following the introduction of MUP there was a statistically insignificant 6.43% increase (95% confidence interval (CI): -4.97% to 19.24%) in the rate of all alcohol-related crimes per 1,000 population in Scotland.

All non-alcohol-related crimes in Scotland

In the period following the introduction of MUP there was a statistically insignificant 1.48% reduction (95% confidence interval (CI): -17.8% to 21.17%) in the rate of all non-alcohol-related crimes per 1,000 population in Scotland. On the other hand, and eight weeks prior to the introduction of MUP, there was a statistically significant increase of 17.29% (95% confidence interval (CI): 4.39% to 31.78%) in the rate of all non-alcohol-related crimes per 1,000 population in Scotland.

All public nuisance incidents in Scotland

In the period following the introduction of MUP there was a statistically insignificant 4.25% increase (95% confidence interval (CI): -7.87% to 17.94%) in the rate of all public nuisance incidents per 1,000 population in Scotland.

All drug-related crimes in Scotland

In the period following the introduction of MUP there was a statistically insignificant 3.7% increase (95% confidence interval (CI): -12.1% to 22.26%) in the rate of all drug-related crimes per 1,000 population in Scotland.

Research question 2

Research question 2 explored the impact of the introduction of MUP on specific types of alcohol-related crime, disorder and public nuisance. The analysis explored the presence of changes in trend direction and in the volume of crime (trend change point analysis), placing specific attention on the period +/- eight weeks around the introduction of MUP in order to identify the existence of possible lagged effects. Thereafter, the percentage change (where such changes existed) in recorded crime rates per 1,000 population were quantified and tested for significance (uncontrolled interrupted time series analysis). Research question 2 aggregated data, for Scotland, into the following categories: serious assault; robbery and assault (with intent to rob); sexual offences; common assault; threatening and abusive behaviour; vandalism; resisting arrest; ASB; consumption of alcohol in designated places; public nuisance, disturbance; noise; drinking in public; and neighbour disputes.

Trend change point analysis

Serious assault

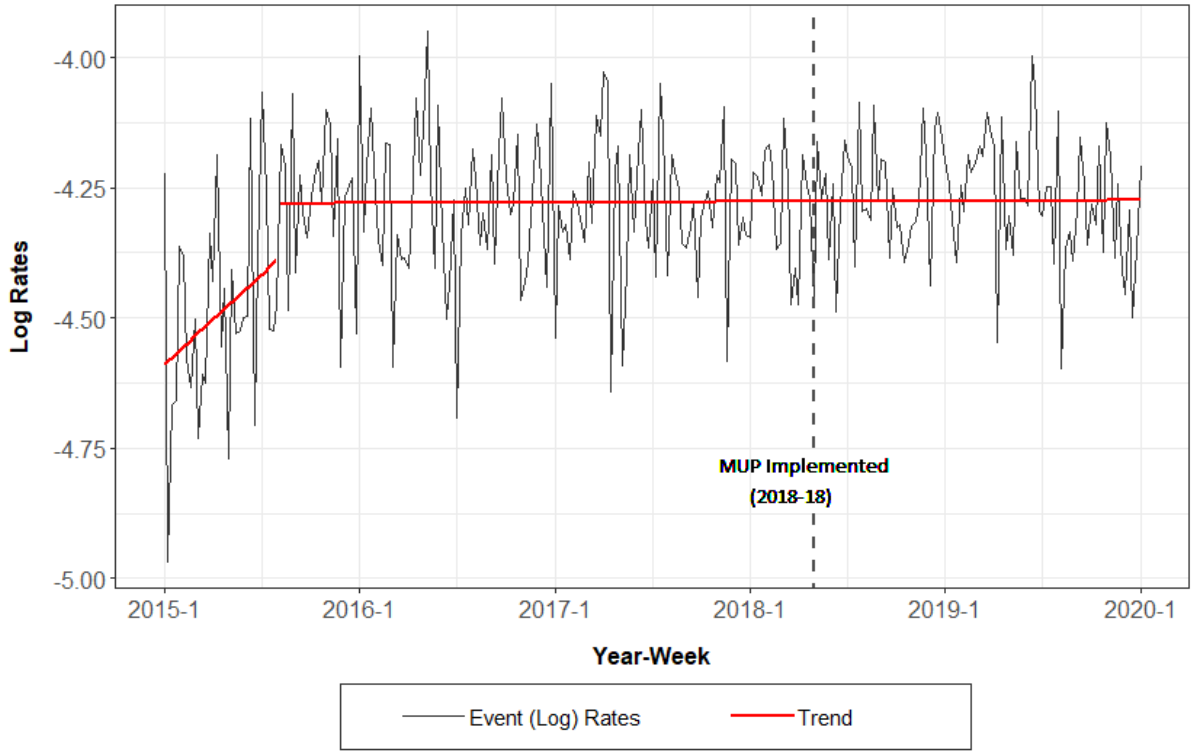


Figure 7. The trend in the weekly (log) rate of serious assault in Scotland, 2015–2020

Figure 7 shows the weekly (log) rate of serious assault in Scotland and how its trend has changed over time, 2015–2020. The trend in serious assault appears to be stable from 2016 onwards.

Robbery and assault (with intent to rob)

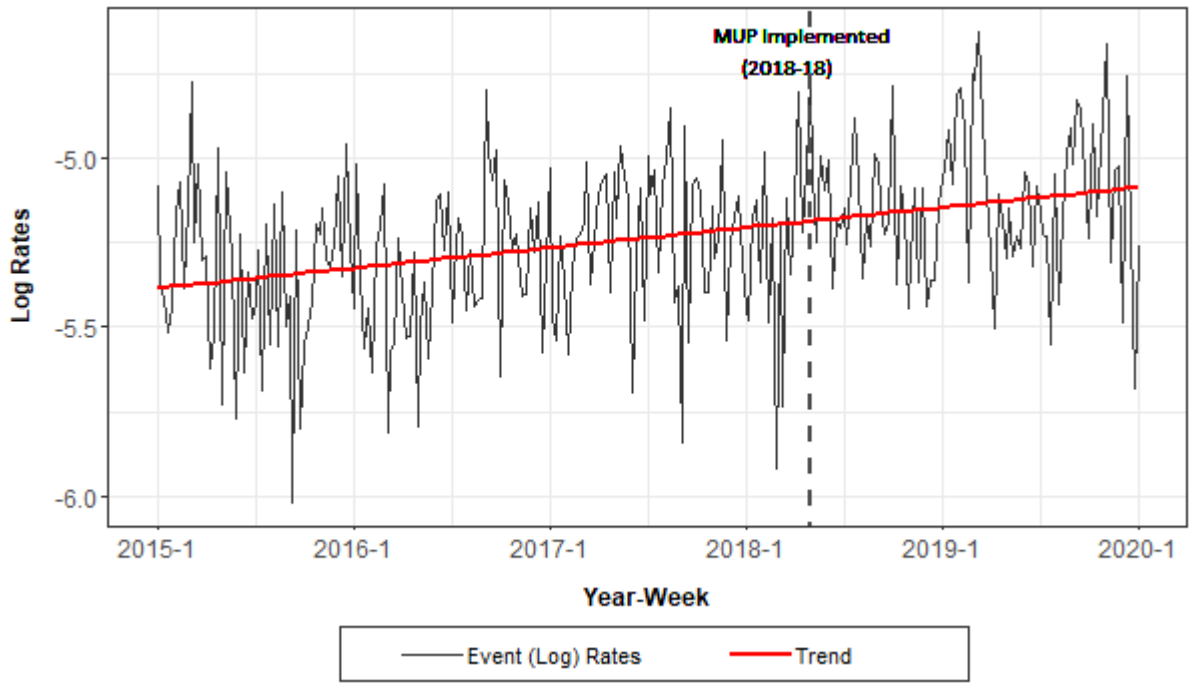


Figure 8. The trend in the weekly (log) rate of robbery and assault (with intent to rob) in Scotland, 2015–2020

Figure 8 shows the weekly rate of robbery and assault (with intent to rob) in Scotland and how its trend has changed over time, 2015–2020. The trend appears to be stable, though rising, throughout the study period.

Sexual offences

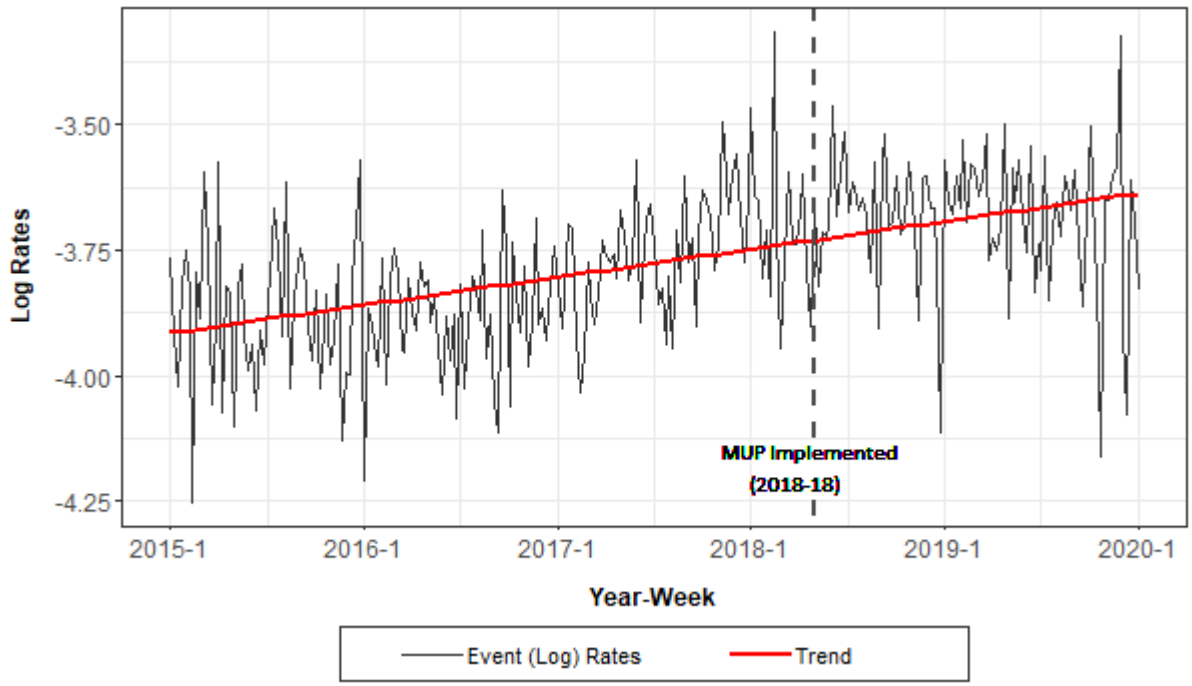


Figure 9. The trend in the weekly (log) rate of sexual offences in Scotland, 2015–2020

Figure 9 shows the weekly rate of sexual offences in Scotland and how its trend has changed over time, 2015–2020. The trend appears to be stable, though rising, throughout the study period.

Common assault

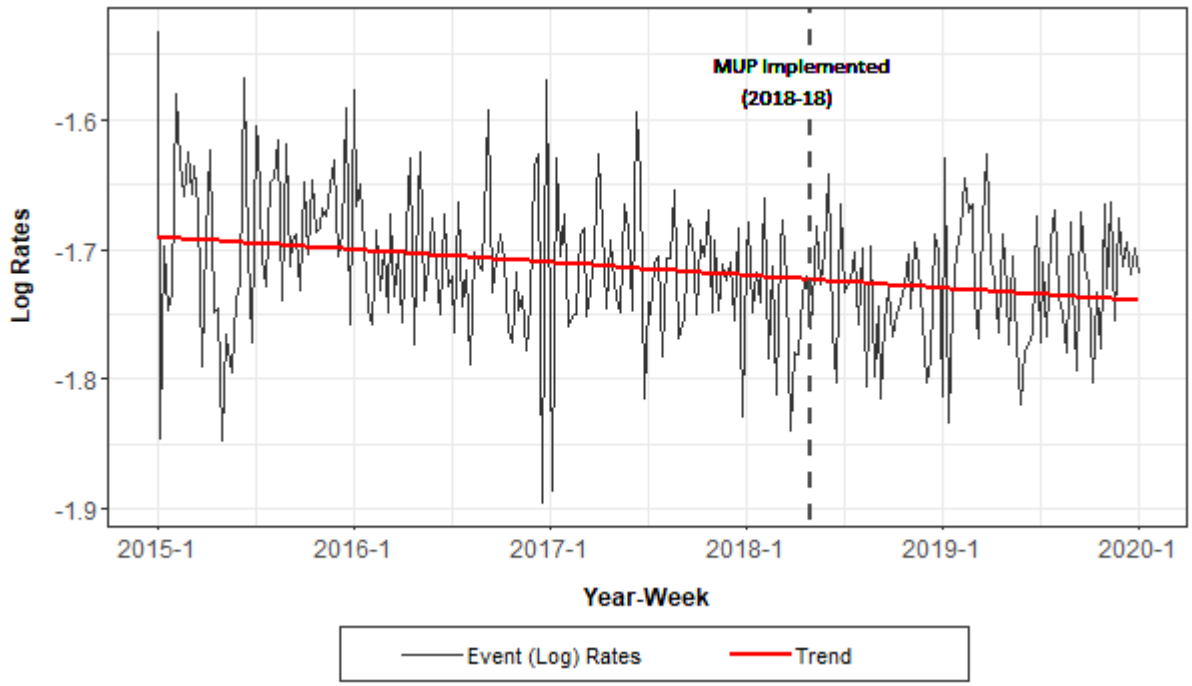


Figure 10. The trend in the weekly (log) rate of common assault in Scotland, 2015–2020

Figure 10 shows the weekly rate of common assault in Scotland and how its trend has changed over time, 2015–2020. The trend appears to be stable, though falling, throughout the study period.

Threatening or abusive behaviour

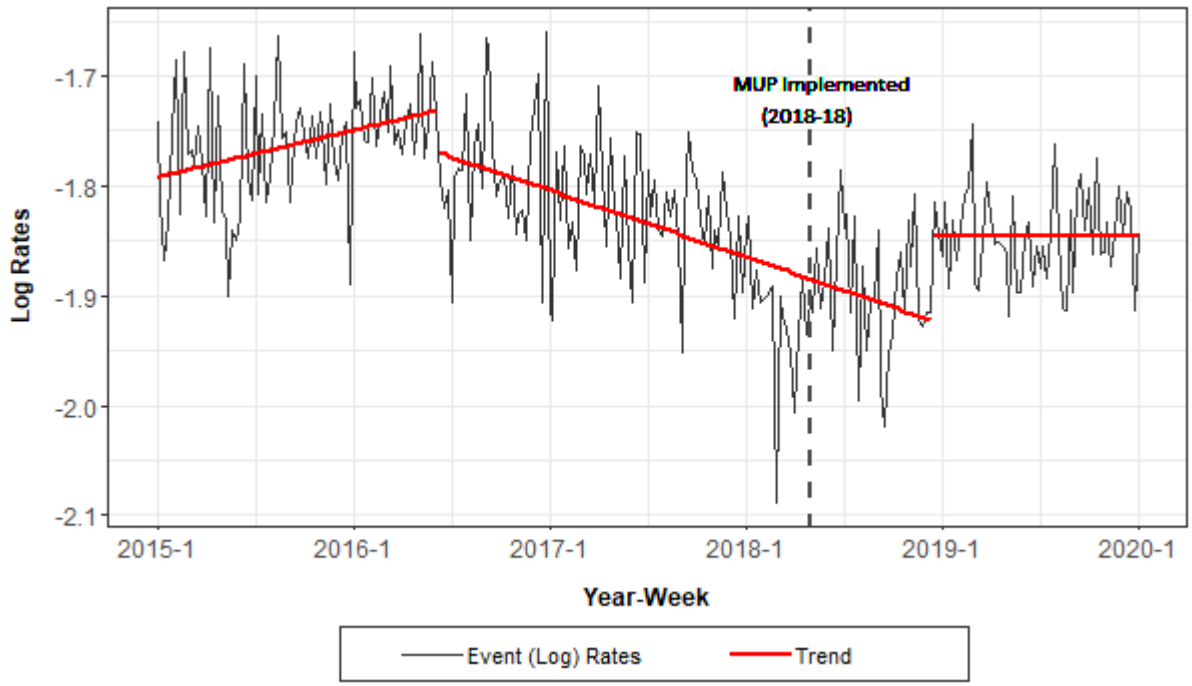


Figure 11. The trend in the weekly (log) rate of threatening or abusive behaviour in Scotland, 2015–2020

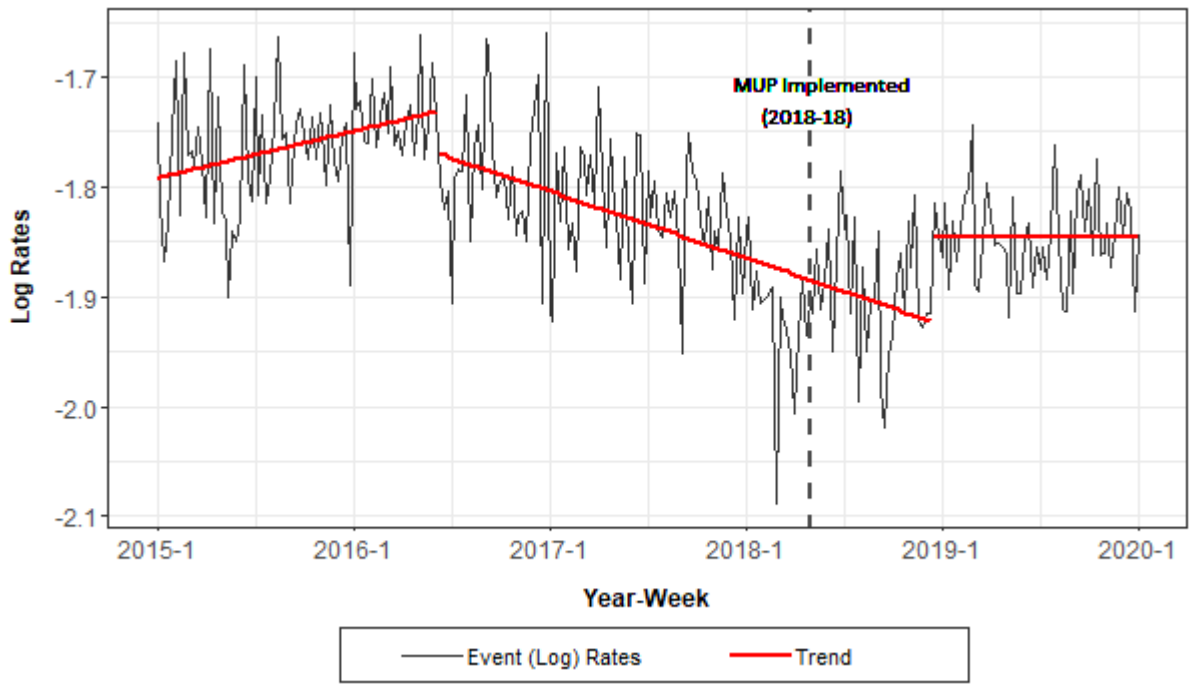


Figure 11 shows the weekly rate of threatening or abusive behaviour in Scotland and how its trend has changed over time, 2015–2020. The trend of threatening and abusive behaviour exhibits instability over the study period, but there are no marked changes detected within eight weeks of the introduction of MUP.

Vandalism

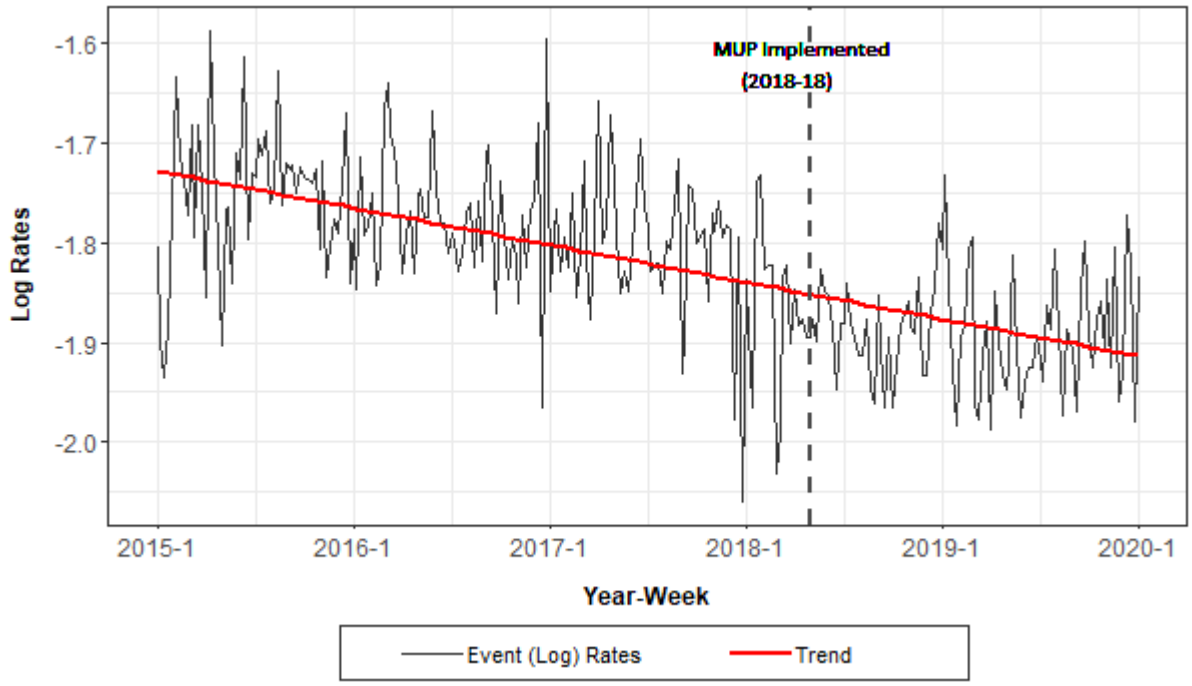


Figure 12. The trend in the weekly (log) rate of vandalism in Scotland, 2015–2020

Figure 12 shows the weekly (log) rate of vandalism in Scotland and how its trend has changed over time, 2015–2020. The trend appears to be stable, though falling, throughout the study period.

Resisting arrest

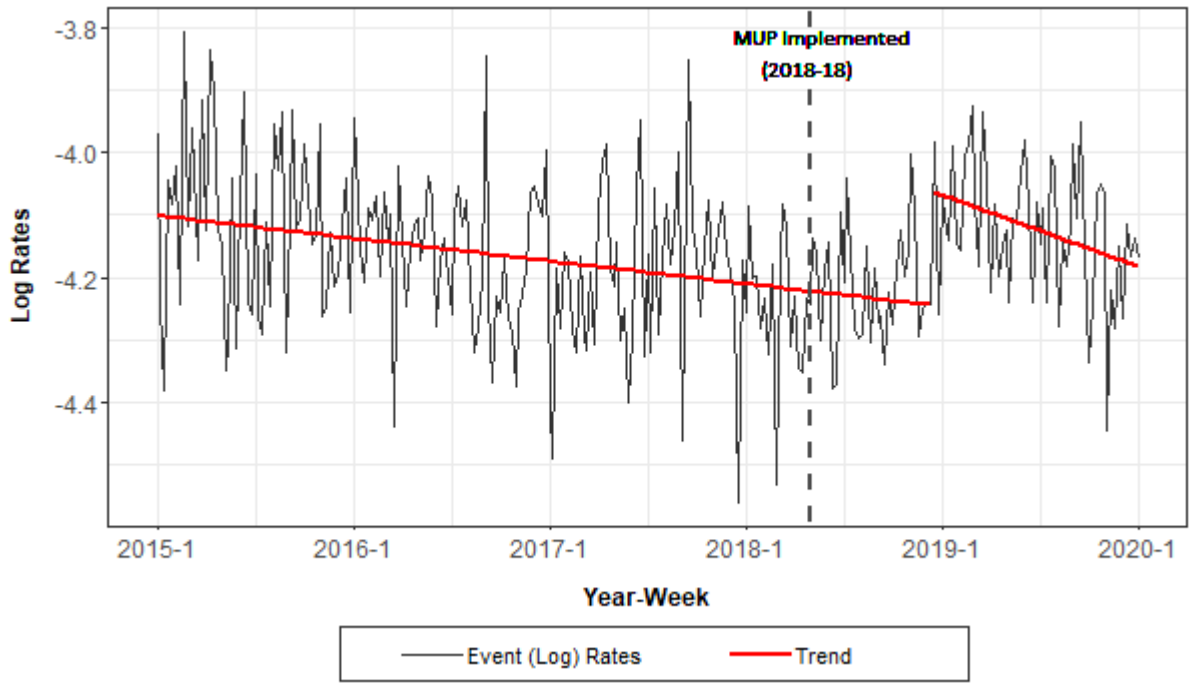


Figure 13. The trend in the weekly (log) rate of resisting arrest in Scotland, 2015–2020

Figure 13 shows the weekly (log) rate of resisting arrest in Scotland and how its trend has changed over time, 2015–2020. In overview, and in the period 2015–2019, the trend appears to be stable and falling. There is a sharp rise in level in 2019, outwith the lagged time period surrounding the introduction of MUP, prior to commencing a stable decline once more.

Antisocial behaviour

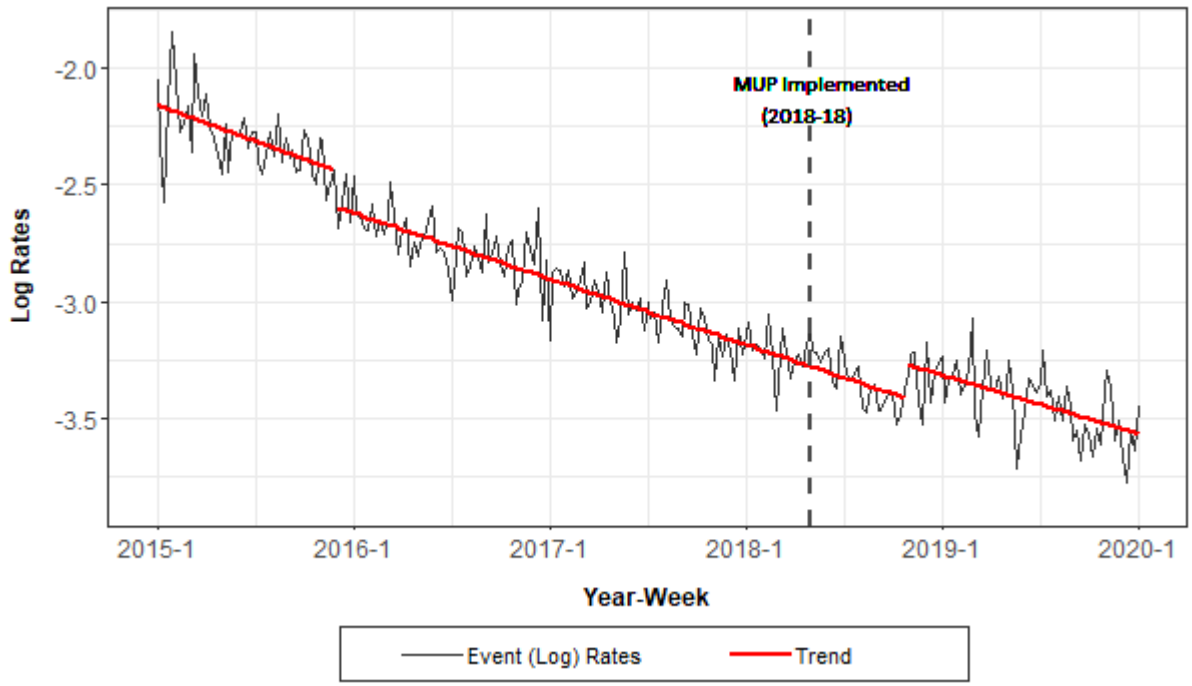


Figure 14. The trend in the weekly (log) rate of ASB in Scotland, 2015–2020

Figure 14 shows the weekly (log) rate of antisocial behaviour offences in Scotland and how its trend has changed over time, 2015–2020. The trend appears to be stable and in decline throughout the study period, excluding a rise in level in 2019.

Consumption of alcohol in designated places

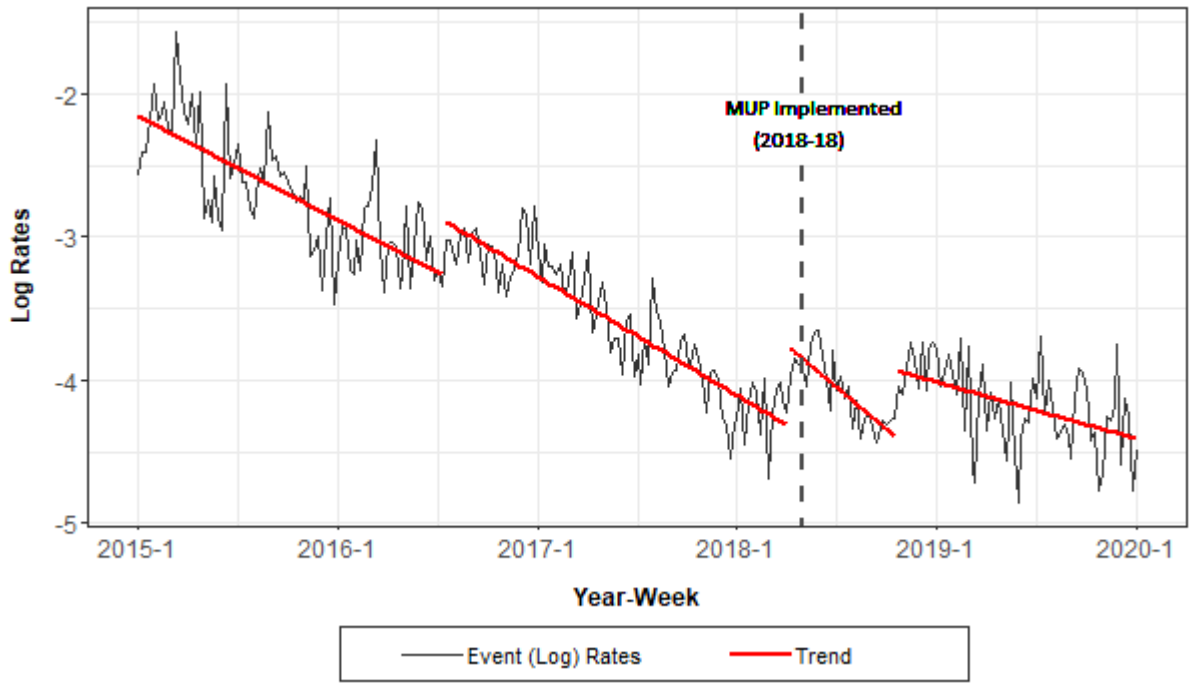


Figure 15. The trend in the weekly (log) rate of the consumption of alcohol in designated places in Scotland, 2015–2020

Figure 15 shows the weekly rate of the consumption of alcohol in designated places in Scotland per 1,000 population and how their trend has changed over time, 2015–2020. In overview, the trend in these offences exhibits decline over the study period. However, there is a noticeable increase in offences four weeks prior to the introduction of MUP.

Public nuisance

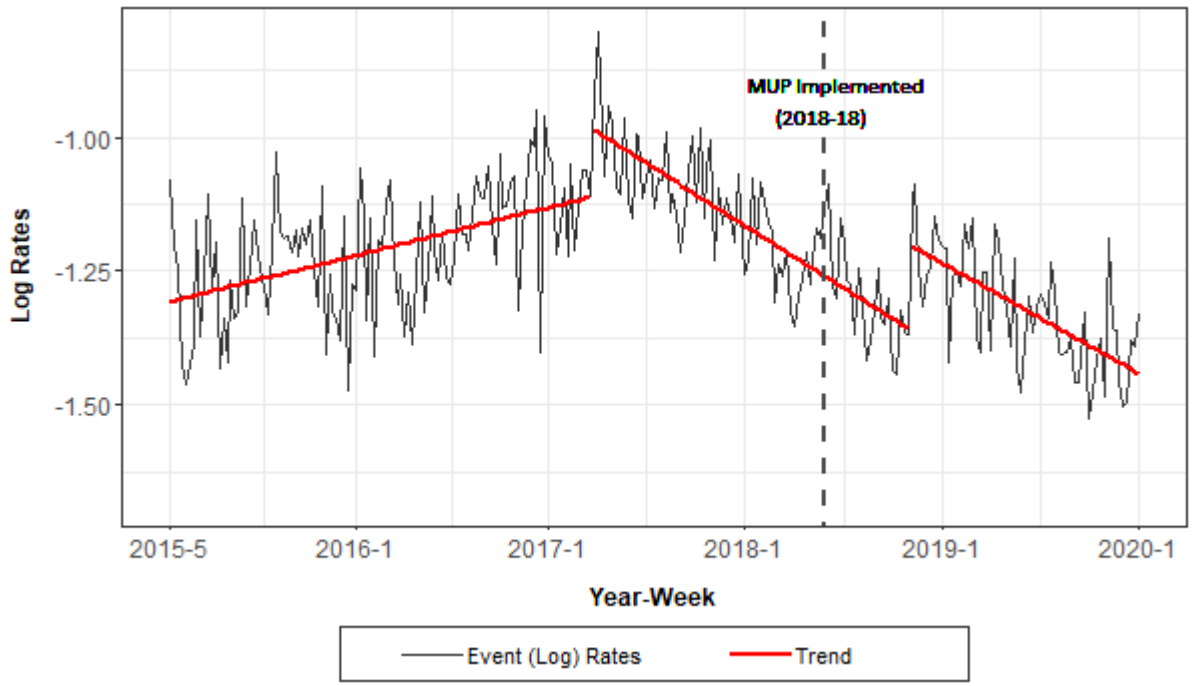


Figure 16. The trend in the weekly (log) rate of public nuisance in Scotland, 2015–2020

Figure 16 shows the weekly rate of all public nuisance incidents in Scotland and how its trend has changed over time, 2015–2020. In overview, the trend in these incidents commenced a stable decline in 2017, which has been maintained to date bar a brief but noticeable rise towards the end of 2018.

Disturbance complaints

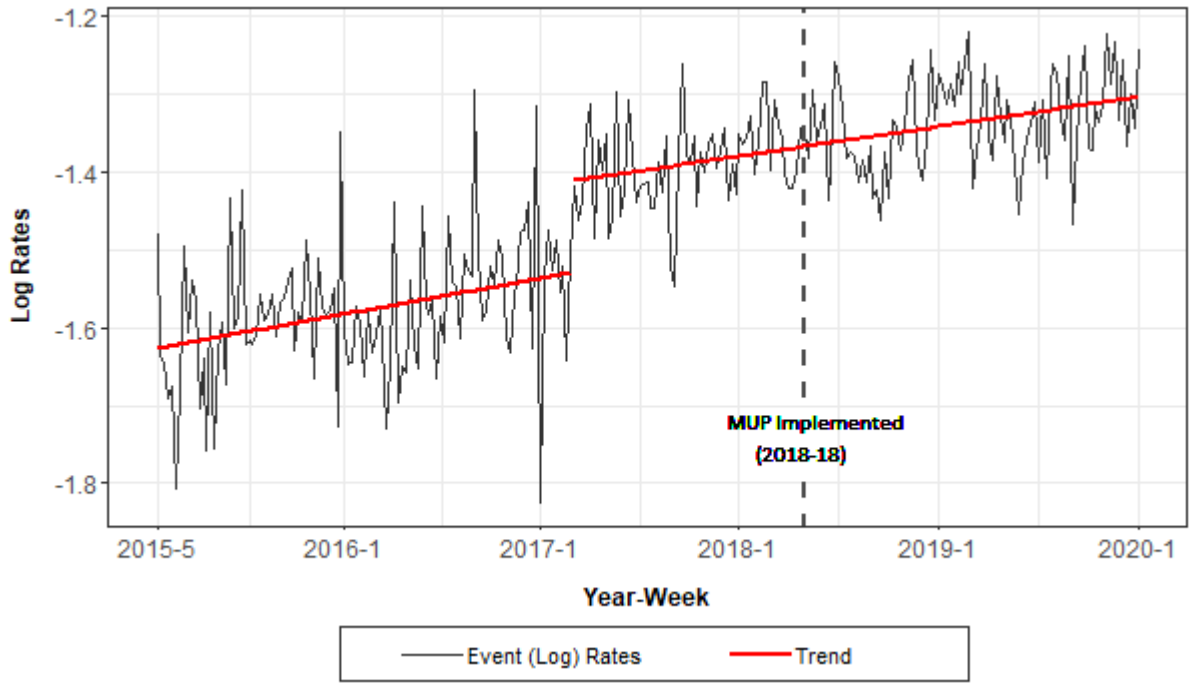


Figure 17. The trend in the weekly (log) rate of disturbance complaints in Scotland, 2015–2020

Figure 17 shows the weekly (log) rate of disturbance complaints in Scotland and how its trend has changed over time, 2015–2020. In overview, the trend in these incidents has been increasing since the commencement of the study period, with a noticeable step change and increase occurring at the beginning of 2017.

Noise complaints

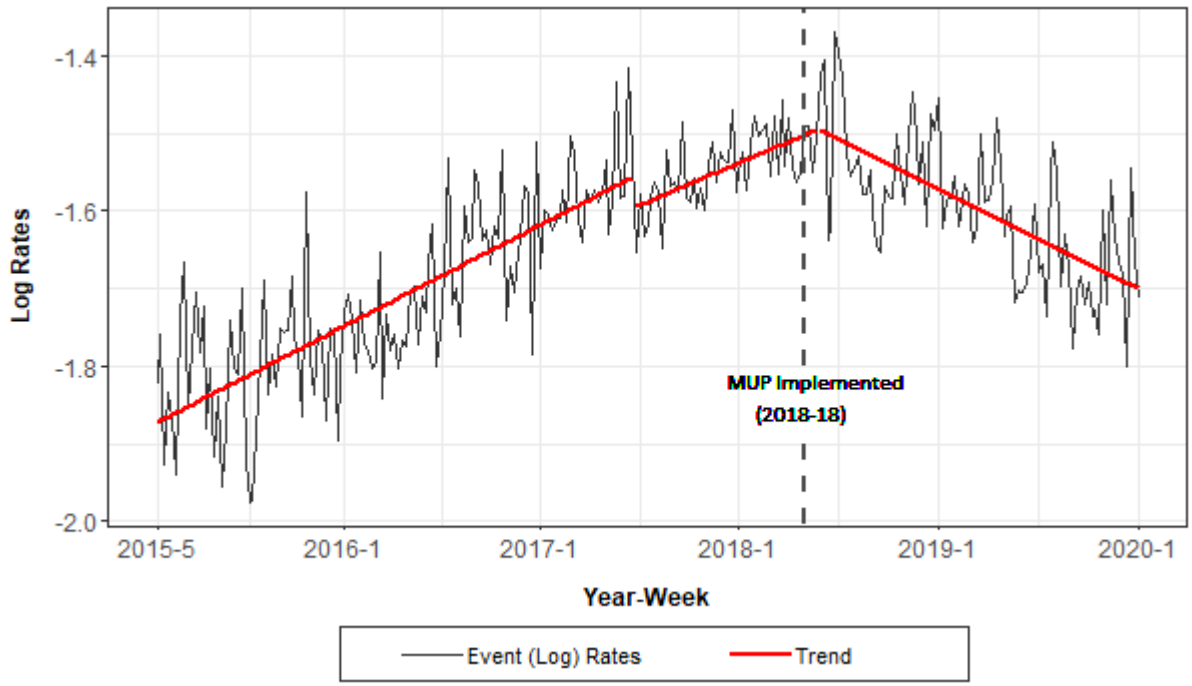


Figure 18. The trend in the weekly (log) rate noise complaints in Scotland, 2015–2020

Figure 18 shows the weekly (log) rate of noise complaints in Scotland and how its trend has changed over time, 2015–2020. The trend in noise complaints increases from the beginning of the evaluation period, prior to commencing a steady decline (though without a significant change point) three weeks after the introduction of MUP until the end of the study period.

Drinking in public

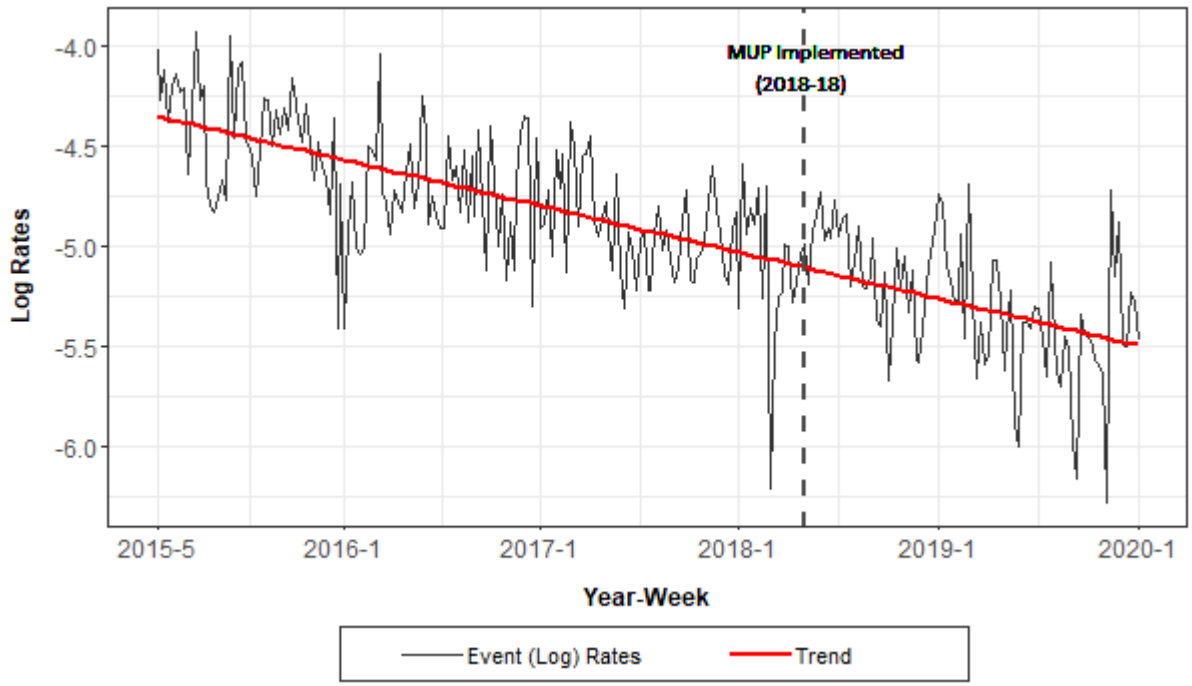


Figure 19. The trend in the weekly (log) rate of incidents of public drinking in Scotland, 2015–2020

Figure 19 shows the weekly (log) rate of incidents of public drinking in Scotland and how its trend has changed over time, 2015–2020. The trend in incidents of public drinking has been in steady decline since the beginning of the study period.

Neighbour disputes

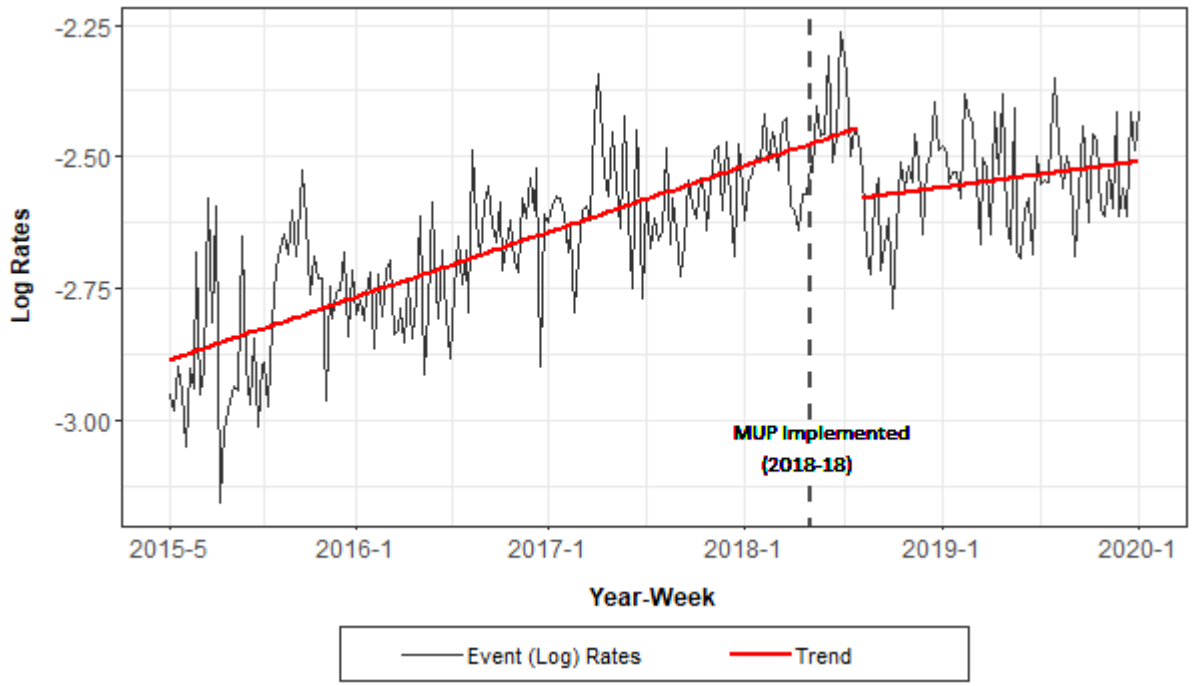


Figure 20. The trend in the weekly (log) rate of neighbour disputes in Scotland, 2015–2020

Figure 20 shows the weekly (log) rate of neighbour disputes in Scotland and how its trend has changed over time, 2015–2020. The trend has been rising since the beginning of the study period. While there appears to be no step change immediately following the introduction of MUP, there is a noticeable step change (reduction) 13 weeks later.

Uncontrolled interrupted time series analysis

Table 2 presents the estimated impact of the introduction of MUP on specific alcohol-related crime, disorder and nuisance types in Scotland. Statistically significant p-values (results) are presented in bold.

Table 2. The estimated impact of the introduction on MUP on crime, disorder and nuisance types.

Data	% Change	CI (Lower)	CI (Upper)	p-value
ASB	5.74	-5.82	18.77	0.35
Common assault	1.63	-1.19	4.50	0.25
Consumption of alcohol in designated places	24.63	-19.43	92.90	0.32
Consumption of alcohol in designated places (-4 weeks lag)	36.98	-3.82	95.03	0.08
Disturbance	2.82	-13.32	21.90	0.75
Drinking in public	18.07	-11.49	57.46	0.26
Neighbour disputes	12.78	-1.98	29.82	0.09
Neighbour disputes (+13 weeks lag)	-20.48	-30.44	-9.06	**0.01**
Noise	7.23	-7.04	23.74	0.34
Noise (+3 weeks lag)	6.65	-0.30	14.11	0.06

Data	% Change	CI (Lower)	CI (Upper)	p-value
Public nuisance	3.95	-13.24	24.48	0.67
Resisting arrest	4.66	-8.52	19.72	0.51
Robbery and assault with intent to rob	13.26	-28.89	80.40	0.60
Serious assault	-6.12	-28.25	22.75	0.65
Sexual offences	2.84	-25.17	41.34	0.86
Threatening or abusive behaviour	5.46	-2.57	14.11	0.19
Vandalism	-1.98	-10.15	6.93	0.65

Serious assault

The introduction of MUP was associated with a statistically insignificant 6.12% fall (95% confidence interval (CI): -28.25% to 22.75%) in serious assault offences per 1000 population in Scotland.

Robbery and assault with intent to rob

The introduction of MUP was associated with a statistically insignificant 13.26% rise (95% confidence interval (CI): -28.89% to 80.4%) in robbery and assault with intent to rob offences per 1,000 population in Scotland.

Sexual offences

The introduction of MUP was associated with a statistically insignificant 2.84% rise (95% confidence interval (CI): -25.17% to 41.34%) in sexual offences per 1,000 population in Scotland.

Common assault

The introduction of MUP was associated with a statistically insignificant 1.63% rise (95% confidence interval (CI): -1.19% to 4.5%) in common assault offences per 1,000 population in Scotland.

Threatening or abusive behaviour

The introduction of MUP was associated with a statistically insignificant 5.46% rise (95% confidence interval (CI): -2.57% to 14.11%) in threatening or abusive behaviour offences per 1,000 population in Scotland.

Vandalism

The introduction of MUP was associated with a statistically insignificant 1.98% fall (95% confidence interval (CI): -10.15% to 6.93%) in vandalism offences per 1,000 population in Scotland.

Resisting arrest

The introduction of MUP was associated with a statistically insignificant 4.66% rise (95% confidence interval (CI): -8.52% to 19.72%) in resisting arrest offences per 1,000 population in Scotland.

Antisocial behaviour

The introduction of MUP was associated with a statistically insignificant 5.74% rise (95% confidence interval (CI): -5.82% to 18.77%) in antisocial behaviour offences per 1,000 population in Scotland.

Consumption of alcohol in designated places

The introduction of MUP was associated with a statistically insignificant 24.63% rise (95% confidence interval (CI): -19.43% to 92.9%) in consumption of alcohol in designated places offences per 1,000 population in Scotland. A 36.98% rise (95% confidence interval (CI): -3.82% to 95.03%) in consumption of alcohol in designated places offences, which took place four weeks before introduction of MUP, was also statistically insignificant.

Public nuisance

The introduction of MUP was associated with a statistically insignificant 3.95% rise (95% confidence interval (CI): -13.24% to 24.48%) in public nuisance incidents per 1,000 population in Scotland.

Disturbance complaints

The introduction of MUP was associated with a statistically insignificant 2.82% rise (95% confidence interval (CI): -13.32% to 21.9%) in disturbance complaints per 1,000 population in Scotland.

Noise complaints

The introduction of MUP was associated with a statistically insignificant 7.23% rise (95% confidence interval (CI): -7.04% to 23.74%) in noise complaints per 1,000 population in Scotland. At lag +3 weeks, after the introduction of MUP, there was further statistically insignificant rise of 6.65% (95% confidence interval (CI): -0.3% to 14.11%).

Drinking in public

The introduction of MUP was associated with a statistically insignificant a18.07% rise (95% confidence interval (CI): -11.49% to 57.46%) in incidents of public drinking per 1,000 population in Scotland.

Neighbour disputes

The introduction of MUP was associated with a statistically insignificant 12.78% rise (95% confidence interval (CI): -1.98% to 29.82%) in neighbour disputes per 1,000 population in Scotland. On the other hand, 13 weeks after the introduction of MUP, there was a step change in rates per 1,000 population of neighbour disputes incidents, which was associated with a statistically significant 20.48% decline (95% confidence interval (CI): -30.44% to -9.06%) in these incidents.

Research question 3

Research question 3 explored the extent to which any MUP-related impacts on crime and disorder vary by sex, age group, geographic location and socio-economic position. Using data for Scotland, the analysis commenced with an assessment of MUP-related impacts at local authority level and then according to area deprivation. Using data for Greater Glasgow, the analysis progressed to explore the existence of MUP-related impacts upon the sex and age groups of both offenders and victims. Finally, using data for Greater Glasgow, the analysis considered the existence of spatial and temporal MUP-related impacts controlling for deprivation and the existence of MUP-related impacts in Greater Glasgow when compared to a control setting.

Local authorities

The analysis explored the existence of changes in both the trend direction and level of alcohol-related (and drug-related) crime and disorder across 28 local authorities in Scotland (trend change point analysis). The crime and disorder categories were those utilised in research question 2. We considered a period of eight weeks before to eight weeks after the introduction of MUP to identify possible lagged effects. If any lag was identified, it was further assessed via uncontrolled interrupted time series analysis and the results reported.

Table 3 and Table 4 present the estimated impact of the introduction of MUP on all alcohol-related crime at the local authority level and by specific crime categories respectively.

Table 3. The estimated impact of the introduction of MUP on all alcohol-related crime at local authority level.

Local authority	% Change	CI (Lower)	CI (Upper)	p-value
Aberdeen City	2.11	-18.78	28.40	0.86
Aberdeenshire	-8.42	-25.17	12.08	0.39
Angus	-1.92	-29.74	36.89	0.91
Argyll and Bute	4.02	-9.70	19.72	0.58
City of Edinburgh	3.20	-16.05	26.87	0.77
Clackmannanshire	2.16	-41.02	76.83	0.94
Dumfries and Galloway	1.70	-12.01	17.59	0.82
Dundee City	3.18	-9.43	17.59	0.64
East Ayrshire	14.96	0.20	31.78	**0.05**
East Dunbartonshire	32.54	-43.67	211.74	0.52
East Lothian	6.85	-4.02	18.89	0.22
East Renfrewshire	-12.67	-29.67	8.44	0.22

Local authority	% Change	CI (Lower)	CI (Upper)	p-value
Falkirk	9.98	-11.22	36.34	0.39
Fife	3.93	-7.41	16.65	0.51
Glasgow City	5.59	-21.18	41.48	0.72
Inverclyde	9.58	-25.40	61.12	0.64
Midlothian	3.32	-13.41	23.24	0.72
Moray	21.56	-1.88	50.53	0.07
North Ayrshire	8.63	-9.24	30.08	0.37
North Lanarkshire	4.72	-4.69	15.03	0.34
Perth and Kinross	-13.28	-42.42	30.60	0.50
Renfrewshire	27.56	-21.26	106.68	0.32
Scottish Borders	8.18	-37.19	86.26	0.78
South Ayrshire	4.49	-6.29	16.53	0.43
South Lanarkshire	-1.69	-28.54	35.26	0.92
Stirling	-3.20	-15.30	10.63	0.63
West Dunbartonshire	5.17	-7.78	19.96	0.45

Local authority	% Change	CI (Lower)	CI (Upper)	p-value
West Lothian	0.43	-6.57	8.00	0.91

Of all the local authorities included in the analysis, only East Ayrshire experienced a statistically significant change in all alcohol-related crimes following the introduction of MUP, with an increase of 14.96% being found (95% confidence interval (CI): 0.2% to 31.78%). Across the remaining local authorities both falls and rises in alcohol-related crimes were observed, ranging from a fall of 13.28% (95% confidence interval (CI): -42.42% to 30.6%) in Perth and Kinross to an increase of 32.54% (95% confidence interval (CI): -43.67% to 211.74% in East Dunbartonshire. However, none of these changes were statistically significant.

Table 4. The estimated impact of the introduction of MUP on specific crime types at local authority level.

Local authority: Crime category	% Change	CI (Lower)	CI (Upper)	p-value
Dundee City: Threatening or abusive behaviour	9.10	-9.34	31.00	0.36
Dundee City: Threatening or abusive behaviour (+6 weeks lag)	9.61	-4.69	25.99	0.20
East Renfrewshire: Vandalism	-31.39	-48.11	-9.34	**0.01**
East Renfrewshire: Vandalism (+4 weeks lag)	-39.53	-52.38	-23.20	**0.01**
Glasgow City: Consumption of alcohol in designated places	63.33	2.22	160.91	**0.04**
Moray: Threatening or abusive behaviour	86.38	0.60	245.22	**0.05**
Moray: Threatening or abusive behaviour (-4 weeks lag)	59.54	18.18	115.55	**0.01**

When modelling specific alcohol-related crime categories at local authority level, both statistically significant increases and decreases were discerned. For example, a statistically significant 63.33% increase (95% confidence interval (CI): 2.22% to 160.91%) in the consumption of alcohol in designated place was found in Glasgow City, and a statistically significant 86.38% increase (95% confidence interval (CI): 0.6% to 245.22%) in threatening or abusive behaviour was found in Moray. Both results are counter to the expected direction of change stipulated in the theory of

change. In contrast, a statistically significant 31.39% decrease (95% confidence interval (CI): -48.11% to -9.34 in vandalism was found in East Renfrewshire.

Deprivation

The analysis explored changes in both the trend direction and level of all alcohol-related crimes, as well as of specific alcohol-related crime categories, in the 10% most deprived data zones in Scotland. We considered a period of eight weeks before to eight weeks after the introduction of MUP to identify possible lagged effects. If any lag effect was identified, it was further assessed via uncontrolled interrupted time series analysis and the results reported.

Table 5 presents the estimated impact of the introduction of MUP on all alcohol-related crime, and upon specific alcohol-related crime categories, in the 10% most deprived data zones of Scotland.

Table 5. The estimated impact of MUP on all, and on specific categories of, alcohol-related crime in the 10% most deprived data zones in Scotland.

Data	% Change	CI (Lower)	CI (Upper)	p-value
Alcohol crimes in the most deprived decile (MDD)	1.04	-5.92	8.55	0.78
ASB in the MDD	20.49	-0.10	45.21	**0.05**
Common assault in the MDD	-0.05	-4.78	4.92	0.99
Consumption of alcohol in designated places in the MDD	18.76	-34.82	116.41	0.58
Consumption of alcohol in designated places in the MDD after (+6 weeks lag)	-34.02	-52.53	-8.33	**0.01**
Consumption of alcohol in designated places in the MDD (-7 weeks lag)	71.74	23.49	138.93	**0.01**
Drug offences in the MDD	12.79	-52.72	169.12	0.79
Resisting arrest in the MDD	-3.51	-22.20	19.60	0.75
Robbery and assault with intent to rob in the MDD	17.00	-44.95	148.68	0.68
Serious assault in the MDD	-2.26	-54.07	107.92	0.95
Sexual offences in the MDD	5.37	-69.52	264.01	0.93

Data	% Change	CI (Lower)	CI (Upper)	p-value
Threatening or abusive behaviour in the MDD	2.23	-8.42	14.11	0.70
Threatening or abusive behaviour in the MDD (-10 weeks lag)	-10.31	-18.29	-1.59	**0.02**
Vandalism in the MDD	-1.64	-7.13	4.19	0.57

The introduction of MUP was associated with a statistically insignificant 1.04% increase in all alcohol-related crimes (95% confidence interval (CI): -5.92% to 8.55%) across data zones in the most deprived decile. When modelling specific alcohol-related crime categories, both increases and decreases specific categories of alcohol-related crime were discerned. A statistically significant 20.49% increase (95% confidence interval (CI): -0.10% to 45.21%) in antisocial behaviour was found. And, a statistically significant 71.74% increase (95% confidence interval (CI): 23.49% to 138.93%) in threatening or abusive behaviour was found (seven weeks prior to introduction of MUP). Both these results are counter to the expected direction of change stipulated in the theory of change. In contrast, and in line with the expected direction of change identified in the theory of change, a statistically significant 34.02% decrease (95% confidence interval (CI): -52.53% to -8.33%) in the consumption of alcohol in designated places and a statistically significant 10.31% decrease (95% confidence interval (CI): -18.29% to -1.59%) in threatening or abusive behaviour were found. However, the latter increase was identified to occur 10 weeks prior to the introduction of MUP.

Nominal characteristics

This aspect of the analysis sought to identify any changes in the trend direction or level of the average age, as well as of the male to female ratio, of offenders and victims of all alcohol-related crime and disorder around the introduction of MUP in Greater Glasgow. We considered a period of eight weeks before to eight weeks after the introduction of MUP to identify possible lagged effects.

Figure 21 shows the average weekly age of victims and offenders of all alcohol-related crime in Greater Glasgow and how their trends changed over time, 2015–2020. Both the average age of victims and offenders can be seen to be falling over the study period, but no significant change to these trends can be observed around the introduction of MUP.

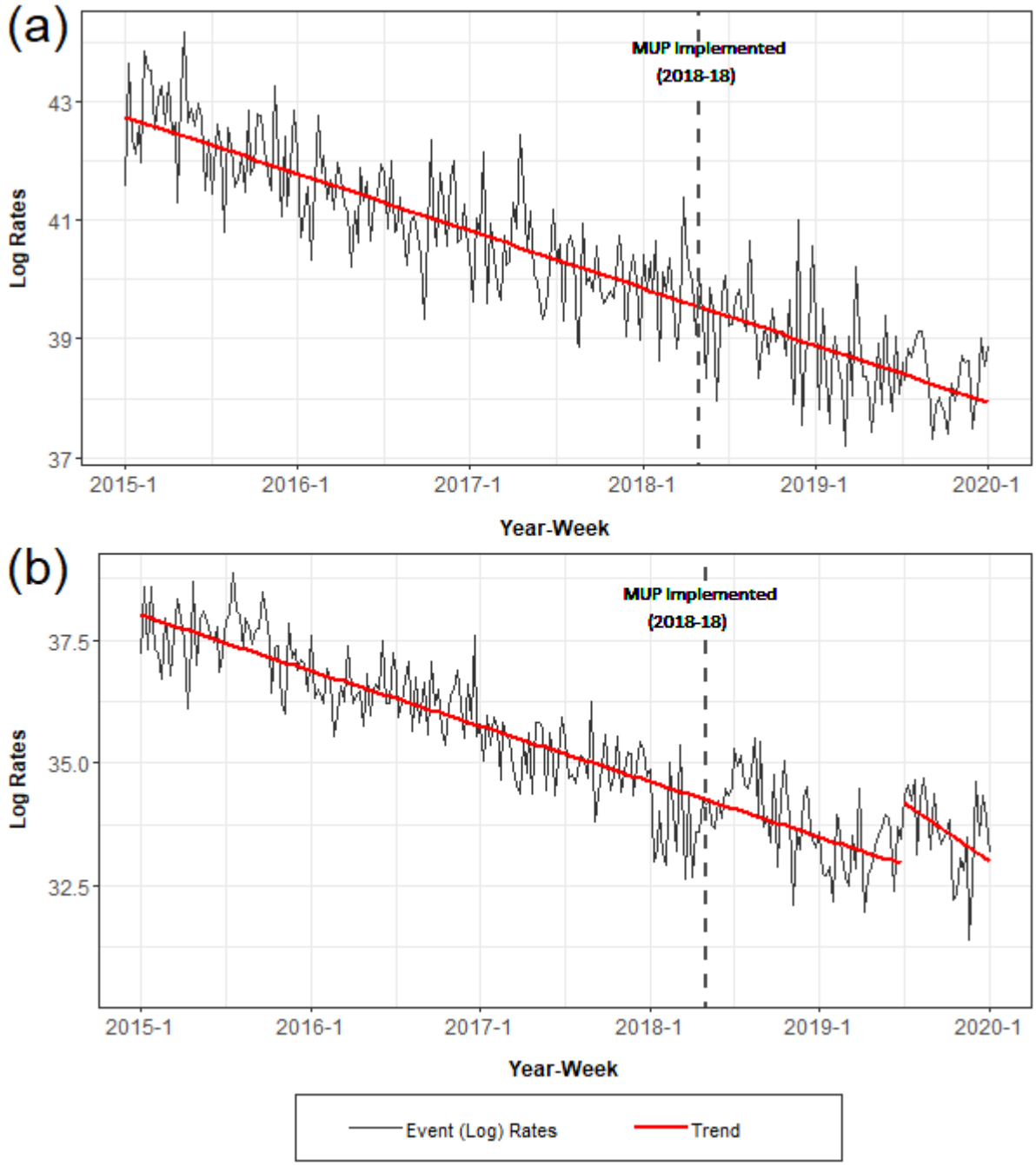


Figure 21. The trend in the average age of a) victims and b) offenders of all alcohol-related crimes in Greater Glasgow, 2015–2020

Figure 22 shows the weekly gender ratios of victims and offenders in Greater Glasgow and how these have changed over time, 2015–2020. In overview, the gender ratios remained stable over the study period and no significant changes can be observed around the introduction of MUP.

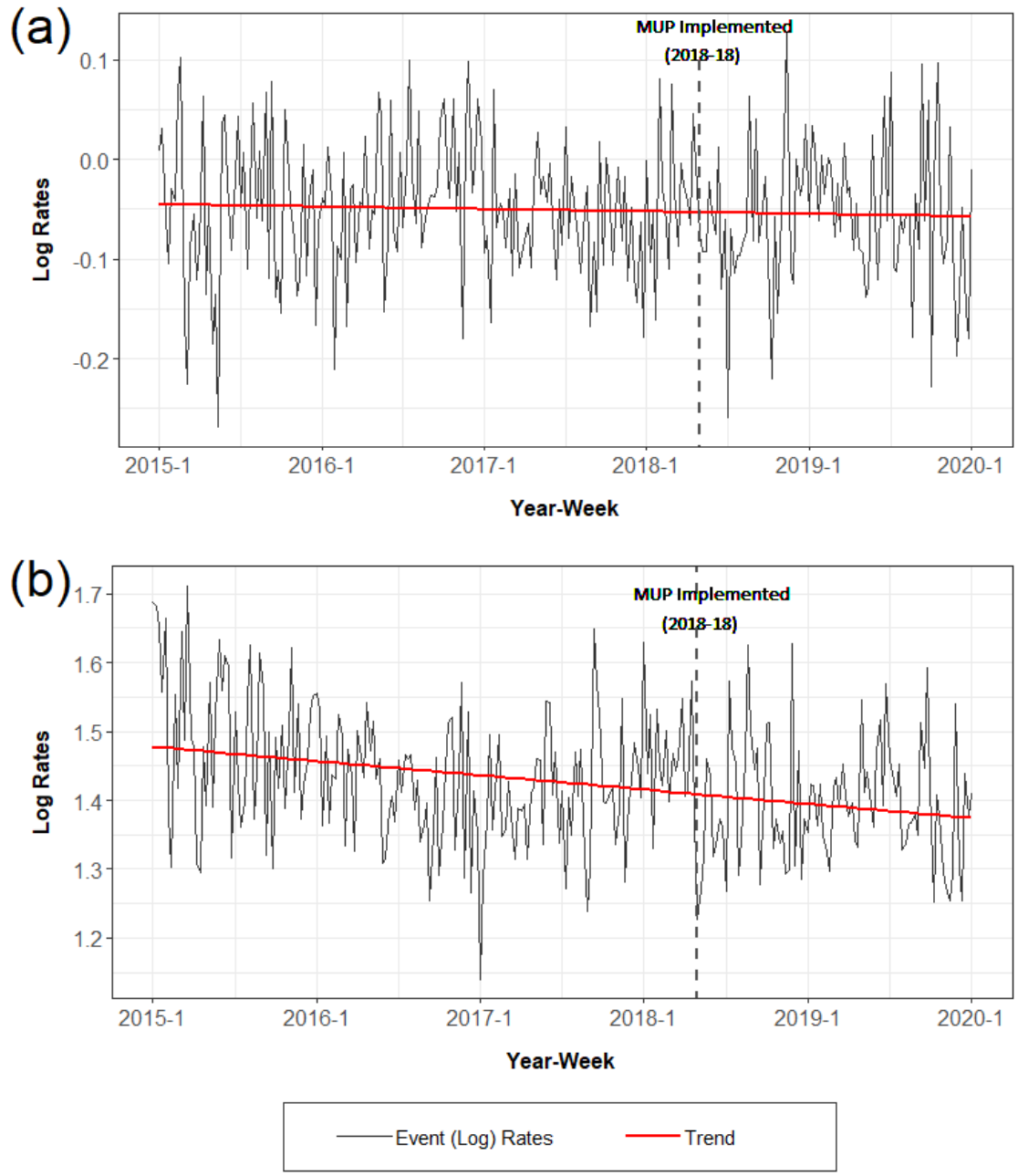


Figure 22. The trend in the gender ratio of a) victims and b) offenders of all alcohol-related crimes in Greater Glasgow, 2015–2020

Table 6 presents the estimated impact of the introduction of MUP on all nominal characteristics. The introduction of MUP was associated with a statistically insignificant reduction of 0.57 years in the average age of victims (95% confidence interval (CI): -1.25 to 0.1) and a statistically insignificant increase of 0.29 years in the average age of offenders (95% confidence interval (CI): -3.22 to 3.79) of all alcohol-related crimes. The introduction of MUP was associated with a statistically insignificant 0.07 reduction in the victim gender ratio (95% confidence interval (CI): -0.27 to 0.12) and a statistically insignificant 0.34 increase in the offender gender ratio (95% confidence interval (CI): -0.73 to 0.05) increase in offender in relation to all alcohol-related crimes.

Table 6. The estimated impact of the introduction of MUP on all nominal characteristics

Data	% Change	CI (Lower)	CI (Upper)	p-value
Offender Average Age (Years)	0.29	-3.22	3.79	0.87
Offender Gender Ratio	-0.34	-0.73	0.05	0.09
Victim Average Age (Years)	-0.57	-1.25	0.10	0.10
Victim Gender Ratio	-0.07	-0.27	0.12	0.47

Spatial and temporal impacts of MUP controlling for deprivation

The study used Integrated Nested Laplace Approximation (INLA) to explore the presence of both spatial and temporal impacts arising from the introduction of MUP, controlling for deprivation. The INLA modelling approach takes account of spatial and temporal information about crime levels and assumes that levels of crime are associated with levels of crime in surrounding neighbourhoods and time periods.

Table 7. Testing the spatial and temporal impacts of MUP controlling for deprivation

Variable	Mean % change	Low CI	High CI
Deprivation (Informative prior*)	19.12	17.59	20.56
Deprivation (Weakly informative prior)	19.12	17.59	20.56
MUP introduction (Informative prior)	9.53	-31.06	74.02
MUP introduction (Weakly informative prior)	11.18	-28.54	72.98

In Table 7, the results confirm the lack of spatial and temporal effects arising from the introduction of MUP, controlling for deprivation. Here, separate models are built parameterised with an informative prior and a weakly informative prior to

* 'Informative prior' describes the inclusion of full distribution parameters concerning an experimental variable (such as deprivation) in a Bayesian model, while 'Weakly informative prior' describes the partial inclusion of such distribution parameters.

demonstrate the robustness in the choice of prior probabilities. The analysis finds a statistically insignificant rise of 11.18% in all alcohol-related crimes in Greater Glasgow, with 95% credible intervals* ranging from -28.54% to 72.98%. Further sensitivity analysis finds a statistically insignificant increase of 9.53% in all alcohol-related crimes in Greater Glasgow, with 95% credible intervals ranging from -31.06% to 74.02%.

Comparing area with MUP to control area

The study undertook a time series assessment (a before-and-after the introduction of MUP comparison) of a treated area (Greater Glasgow) in comparison to an untreated area. To ensure the comparability of the treated and untreated areas, it established a synthetic control group, built at a micro-geographical level, to be reflective of the area-based characteristics (demographics and deprivation) of Greater Glasgow. To advance the analysis, longitudinal data on all alcohol-related crime was collected for both the treated area (Greater Glasgow) and the untreated area (control), with the untreated area data being weighted to mirror that of the treated area. More detailed information on these steps can be found in Appendix B.

Figure 23 shows the comparison between the control and treatment areas, in terms of the raw data, the results of synthetic control, and lastly the outcome of placebo effect analysis. Specifically, panel (a) shows the monthly trends in the count of all alcohol-related crimes in Greater Glasgow (red) and in the untreated area (black), panel (b) presents the weighted sum of all alcohol-related crime rates per 1,000 population in both areas and (c) the difference between the treatment and control sites with simulated placebo effect analysis. A number of insights can be drawn from this figure. Firstly, it is apparent that though of a different volume, the crime count trends were similar in Greater Glasgow and in the untreated area prior to the

* Credible interval – is an interval within which an unobserved parameter value falls with a particular probability. Credible intervals are analogous to confidence intervals in frequentist statistics.

introduction of MUP (depicted in panel a). Secondly, the application of the synthetic control (weights) allowed for the crime rate trends to be closely matched in Greater Glasgow and in the untreated area (depicted in panel b). Thirdly, there is no discernible distinction between the all alcohol-related crime rate trends in the treated and untreated areas in the period following the introduction of MUP (depicted in panel b). Finally, the placebo effect (sensitivity) analysis further confirms that the introduction of MUP held no significant impact on the rate of all alcohol-related crimes in Greater Glasgow. This is depicted in panel c wherein the trajectory of the rate of all alcohol-related crimes in the treatment area (red line) appears to match the simulated trajectories of placebo effects (grey lines) in the control area. The introduction of MUP was followed by a statistically insignificant 0.6% rise in all alcohol-related crimes in Greater Glasgow, with 95% CI ranging from -1.4% to 2.7%.

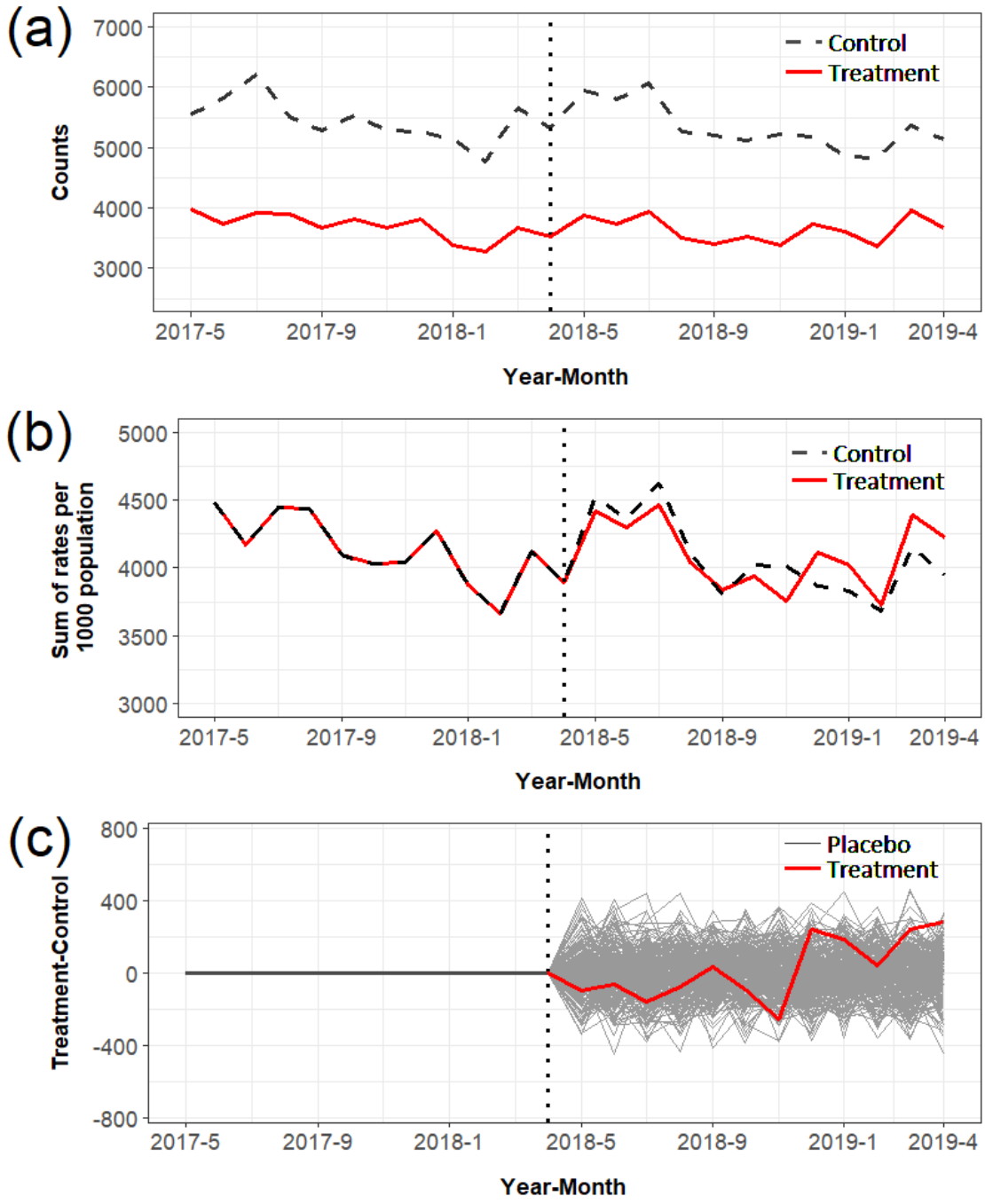


Figure 23. Comparison of crime rates in synthetic controls areas and areas with MUP in place (a) the monthly count of alcohol-related crimes in Greater Glasgow (red) and in the untreated area (black), (b) the difference between the weighted sum of rates per 1,000 population in Greater Glasgow (red) and in the untreated area (black), and (c) the trajectory of the rate of all alcohol-related crimes in the treatment area (red) and the simulated trajectories of placebo effects (grey) in the control area.

Discussion

This report presents an analysis of the impact of Minimum Unit Pricing on crime and disorder, public safety and public nuisance. In this section, we summarise and then interpret the main findings by research question.

Main findings

RQ1: What impact has MUP had on alcohol-related crime and disorder, public safety and public nuisance?

The data available to the study enabled an assessment of the impact of MUP on alcohol-related crime, disorder and public nuisance. It was not possible to assess the impact of MUP on public safety. The study found that the long-term decline in all recorded crime and disorder in Scotland had ceased prior to the introduction of MUP. The trend in all recorded crime and disorder was shaped by the volume of all non-alcohol-related crime, which underwent a statistically significant increase prior to the introduction of MUP. In contrast, all alcohol-related crime and disorder exhibited a steady and declining trend prior to and following the introduction of MUP. No statistically significant change in trend direction or level was found for all alcohol-related crime and disorder, all alcohol-related incidents (nuisance) or all drug-related crimes following the introduction of MUP.

RQ2: How have any MUP-related changes in crimes and offences varied by type of crime and offence?

There were no changes in the trend direction or statistically significant changes in the level of alcohol-related crime and disorder by type (such as serious assault, robbery and assault (with intent to rob), sexual offences, common assault, threatening and abusive behaviour, vandalism, resisting arrest, drug-related offences, consumption of alcohol in designated places) in the period eight weeks prior to eight weeks after the introduction of MUP. Outwith the lagged period, there was no evidence of a consistent change point across alcohol-related crime and disorder by type. The analysis was extended to include nuisance by type (for

example public nuisance, disturbance complaints, noise complaints, drinking in public, neighbour disputes), finding no discernible change in the trend direction for public nuisance, disturbance complaints or incidents of drinking in public in the period eight weeks prior to eight weeks after the introduction of MUP. In contrast, noise complaints were found to exhibit an upward trajectory until three weeks after the introduction of MUP, at which point they commenced a steady decline (without a significant change point) until the end of the study period.

RQ3: To what extent have any MUP-related impacts on crime and disorder varied by sex, age group, geographic location and socio-economic position?

The analysis found no apparent changes in the trend direction or statistically significant changes in the level of all alcohol-related crime and disorder in the period eight weeks prior to eight weeks after the introduction of MUP in 27 of the 28 local authorities included in the study. The single local authority in which a statistically significant change occurred, East Ayrshire, exhibited an increase in all alcohol-related crime and disorder. When modelling specific alcohol-related crime and disorder types at local authority level, the analysis found only vandalism in East Renfrewshire to exhibit a statistically significant decline.

The analysis found no apparent changes in the trend direction or statistically significant changes in the level of all alcohol-related crime and disorder, in the period eight weeks prior to eight weeks after the introduction of MUP, in the 10% most deprived data zones in Scotland. However, the analysis did find a statistically significant decrease in the consumption of alcohol in designated places, six weeks after the introduction of MUP, in the 10% most deprived data zones in Scotland.

The analysis found no apparent changes in the trend direction or statistically significant changes in the level of the average age, as well as of the male to female ratio of offenders and victims, of all alcohol-related crime and disorder around the introduction of MUP in Greater Glasgow. Likewise, there was no evidence of any statistically significant spatial or temporal impact of MUP on all alcohol-related crime and disorder, controlling for deprivation, in Greater Glasgow. Finally, the study found

no significant change in all alcohol-related crime and disorder in Greater Glasgow in comparison to a synthetic control site (Greater Manchester).

Strengths and limitations of this study

There are a number of key features of the research design that help strengthen our interpretation of its findings. Firstly, the evaluation utilised fine grained recorded crime and incident data. This enabled the assessment of changes to specific alcohol-related crime, disorder and public nuisance types to be sensitive to multiple geographical and temporal scales. Secondly, the evaluation deployed multiple methods to assess the existence of spatial and temporal changes in the trend and level of multiple crime, disorder and public nuisance types. The consistency of the findings, emergent from the application of these diverse methodologies, serves to heighten confidence in their reliability.

There are a number of limitations to the research. Firstly, the research was unable to access data of sufficient quality and/or quantity to assess the impact of MUP on criminality linked to alcohol, subgroups of drug-related crime and (perceptions of) public safety. Secondly, the study required to foreshorten its post-MUP implementation assessment period, as a consequence of COVID-19. Nevertheless, this represents a sizeable period of time post-MUP implementation, and is unlikely to have affected the results of the analyses. Thirdly, the research undertook limited assessment of potential changes to the age and gender of offenders and victims arising as a consequence of the introduction of MUP. Finally, it should be noted that while the study identified ‘plausible’ categories of alcohol-related crime, based on the assessment of the international literature, the application of alcohol markers in recorded crime data and interviews with experts, it is not possible to claim that all crimes perpetrated in these crime categories were associated with the consumption of alcohol. In these terms, it remains possible that a crime-related dividend has occurred as a consequence of MUP, but it has done so at a scale (geography, socio-economic status, social group) that the evaluation has lacked the sensitivity to identify.

Conclusion

The theory of change identified that the intended impact of the implementation of MUP was a reduction in alcohol consumption. In this theory of change, the intended outcomes of reduced alcohol consumption were a reduction in crime, disorder and nuisance, while the unintended outcome was a rise in drug-related crime. Despite evidence of a small decline in the sale of alcohol following the introduction of MUP, the findings of this study point to this having minimal impact on the trend direction or level of alcohol-related crime, disorder and public nuisance (in total or by type) in Scotland. Nor indeed did the introduction of MUP have an impact on drug-related crime. Across the multiple analyses comprising the research, only two findings fell in line with those expected in the theory of change. Firstly, and across Scotland, noise complaints were found to exhibit an upward trajectory until three weeks after the introduction of MUP, at which point they commenced a steady decline (though without a significant change point) until the end of the study period. Secondly, and in the 10% most deprived data zones in Scotland, a statistically significant decline in the consumption of alcohol in designated places was found to take place six weeks after the introduction of MUP. That these findings are aligned with those expected in the theory of change merits their further investigation. On the whole, however, the limited discernible impact of MUP on alcohol-related crime, disorder and public nuisance suggests that the reduction in the sale of alcohol was below that required to deliver a crime-related dividend or that if a crime-related dividend has occurred, the dividend was so small that this study was not sensitive enough to identify it.

Appendix A: Data

This appendix presents an account of the data utilised in the research. Firstly, the crime, disorder, public nuisance and public safety data available to the study are described. Secondly, the process whereby types of crime, disorder and public nuisance were identified as alcohol-related is outlined. Thirdly, procedural and legislative changes that have impacted police crime recording practices in the study period are presented. Fourthly, the means whereby aspects of the Scottish and English/Welsh crime and disorder data were matched is explained. Finally, a series of tables are presented to identify the variables deployed in the address of each research question, inclusive of where data for individual offences have been grouped in to broader offence categories.

1. The data used in the evaluation

To undertake this evaluation, it was necessary to deploy proprietary datasets held by Police Scotland and Greater Manchester Police.

Police Scotland granted access, under licence and in accord with strict security protocol, to a range of data. These data can be described as follows:

Crime data

Recorded crime (crime event) data for Scotland were provided, spanning the period January 2015 until June 2020. These data were processed into weekly, monthly and quarterly intervals based on the ‘date reported’ field. Specific categories and types of crimes and offences were identified through the ‘offence code’ field. A local authority lookup code was provided with these data, while the data zone in which a crime event took place was identified via its x-y coordinates. In overview, these data enabled identification and quantification of different types of crime and disorder.

It should be noted that while police recorded crime records are the main source of information on crime levels and trends in small areas, they remain an imperfect measure of crime as they are estimated from the number of notifiable crimes

reported to, and subsequently recorded by, the police. A potential source of bias in police recorded crime records, therefore, is their under-counting of offences[23]

Incident data

Incident (calls-for-service) opening code data for Scotland were provided, spanning the period April 2015 until June 2020. These data, collected via the System for Tasking and Operational Resource Management (STORM), were processed into weekly intervals based on the 'date reported' field. The data zone in which an incident took place was identified via its x-y coordinates. The 'incident code' and 'disposal code' fields were used to categorise the data, enabling both the identification and quantification of different types of public nuisance incidents that do not result as a crime or an offence.

Incident (calls-for-service) data are considered to be free from some of the bias inherent in police recorded crime data, introduced during the process of recording a crime incident.[24] Incidents are reported to the police by the public in a number of ways, for example, through 999 calls for assistance, at a police station or to a police officer on patrol.[24] [25]

Nominals data

The characteristics of known victims (complainant dataset) and offenders (accused dataset) in Greater Glasgow area were provided, spanning the period January 2015 until June 2020. These data were processed into weekly intervals based on the 'date raised' field. The average age of known victims and offenders was calculated based on the 'date of birth' field, and the 'gender' field was used to calculate the gender ratios of offenders and victims. The data identified the x-y coordinates of the known victim or offender postcode centroid and the offence type with which they were associated.

Crime markers

The recorded crime event data for Greater Glasgow includes a series of markers, including a ghost marker identifying if alcohol was present or considered an aggravating factor. Markers, in general, are used for statistical purposes. However, Police Scotland reported that it is non-mandatory to record markers, leading to data quality issues. Consequently, alcohol markers do not provide a reliable quantitative measure. Nevertheless, they can be used to qualify likely alcohol-related crimes (see section 2, below).

Greater Manchester Police data

Greater Manchester Police granted access, under licence and in accord with strict security protocol, to a range of data. Recorded crime (crime event) data for Greater Manchester were provided, spanning the period January 2015 until August 2020. The Greater Manchester area consists of the following ten local authorities: Bolton, Bury, Manchester, Oldham, Rochdale, Salford, Stockport, Tameside, Trafford and Wigan. These data were processed into weekly, monthly and quarterly intervals based on the 'date reported' field. Comparable categories and types of crimes and offences (to the Police Scotland data) were identified through the individual Home Office 'offence code' field (see table RQ3: Synthetic control – matched alcohol-related crimes). The Lower Super Output Area (LSOA) in which a crime event took place was identified using its x-y coordinates. In overview, these data enabled identification and quantification of different types of crime and disorder.

2. The identification of alcohol-related crime, disorder and public nuisance

Three related steps were undertaken to identify specific types of crime, disorder and public nuisance likely to be alcohol related. Firstly, a review of the international evidence base was used to establish the categories of crime, disorder and public nuisance (for example violence, sexual assault, vandalism, noise) in which alcohol has been identified as a contributing factor in offending behaviour. Secondly, the Police Scotland crime event data was probed to identify the presence of alcohol

markers by specific crime and offence codes. Police Scotland identified that the application of alcohol markers to crime events to be a non-mandatory exercise. Thus, these data do not provide a reliable measure of alcohol-related crime by volume. These data can be used, however, to identify crime and offence types in which alcohol is a likely contributing factor in a significant proportion of cases.

Thirdly, interviews were held with subject area specialists (policing) to confirm the selection of specific types of crime, disorder and public nuisance, derived from the literature review and data analysis, as plausibly alcohol related. For the purposes of the evaluation, all other crime events were identified as plausibly non-alcohol related. Specific crime event codes were used to identify drug-related and other alcohol-related crimes identified as potential unintended consequences of MUP in the theory of change, and following the literature review and discussion with subject area specialists. In the evaluation analyses, alcohol-related crimes were analysed individually or by category. The decision as to which route to follow was determined by the volume of crimes/offences by offence code, to ensure that a high-volume crime would not dominate a cumulative trend and/or to enable statistical analysis through combining lower volume crimes.

3. Changes to police crime recording

There have been a number of procedural and legislative changes, specifically between 2016 and 2020, which have impacted police crime recording in Scotland. While these changes do not impact the findings of this study, they may hold some influence on the trend and volume of specific crimes and offences over the study period. Firstly, there has been a procedural change, from April 2017 onwards, to the recording of ‘handling offensive weapons’ crimes, resulting in additional crimes being recorded.[26] Secondly, the Abusive Behaviour and Sexual Harm (Scotland) Act 2016 resulted in additional sexual crimes being recorded from July 2017. Thirdly, the recent increase in drug possession crimes may in part be due to the UK Government’s 2017 amendment to the Misuse of Drugs Act 1971, which made it illegal to possess etizolam (a ‘designer’ benzodiazepine) through classification as a

Class C drug.[27] [28] Finally, the implementation of the Domestic Abuse (Scotland) Act 2018 resulted in additional crimes being recorded from April 2019.[27]

4. Data matching

In order to facilitate the application of the synthetic control method in the address of research question 3, an exercise was undertaken to map the Home Office Counting Rules and Crime Tree structure to the Scottish crime and offence structures. These mappings are illustrated in table RQ3: Synthetic control – matched alcohol-related crimes represent a 'best fit' in some cases, due to subtle differences between the Scottish and England & Wales crime counting rules.

5. Data categories

This section of the appendix reports the outputs, via a series of tables, of the various steps undertaken in preparing the recorded crime, incident and nominal data for the evaluation analyses. The tables identify both the individual and grouped variables deployed in the address of each research question.

Table A1. RQ1: Alcohol-related crimes (offence codes and title)

Offence	Title
100100	Murder
100200	Attempted murder
100301	Culpable homicide (common law)
100302	Causing death by dangerous driving
100303	Death by careless driving when under influence of drink/drugs
100304	Causing death by careless driving

Offence	Title
100400	Serious assault
100600	Robbery and assault with intent to rob
201400	Rape (offences prior to 1 December 2010)
201401	Rape of male (16+)
201402	Rape of female (16+)
201404	Rape of older female child (13–15 years)
201406	Rape of young female child (Under 13)
201500	Attempted rape (offences prior to 1 December 2010)
201501	Attempted rape male (16+)
201502	Attempted rape female (16+)
201503	Attempted rape older male child (13–15)
201504	Attempted rape older female child (13–15)
201601	Sexual assault by penetration of male (16+)
201602	Sexual assault by penetration of female (16+)
201604	Sexual assault by penetration of female (13–15 years)
201605	Sexual assault of male (16+)

Offence	Title
201606	Sexual assault of female (16+)
201607	Sexual assault of older male child (13–15 years)
201608	Sexual assault of older female child (13–15 years)
201610	Sexual coercion of female (16+)
201616	Assault by penetration of young female child (under 13)
201618	Sexual assault of young female child (under 13)
201702	Public indecency
201703	Sexual exposure
201822	Lewd and libidinous practices
403312	Vandalism
503804	Falsely accusing (named) person of crime
503807	Resisting arrest
604701	Common assault
604702	Breach of the peace
604703	Urinating etc.
604704	Racially aggravated harassment

Offence	Title
604705	Racially aggravated conduct
604706	Common assault of an emergency worker
604707	Antisocial behaviour offences
604708	Threatening or abusive behaviour
606001	Drunk and incapable
606003	Drunk in charge of a child
606004	Drunk and attempting to enter licensed premises
606006	Disorderly on licensed premises
606007	Drunk in or attempting to enter designated sports ground
606008	Refusing to quit licensed premises
606101	Sale of drink to person under 18
606103	Licensed person, employee or agent drunk in licensed premises
606104	Permitting riotous behaviour in licensed premises
606206	Person under 18 buying excisable liquor or consuming in bar
606212	Alcohol offences, travelling to and from sporting event
606213	Sports grounds offences (possessing alcohol etc.)

Offence	Title
606214	Confiscation of alcohol from person under 18
606299	Liquor licensing laws, other offences
607204	Licensing offences, etc.
607208	Consumption of alcohol in designated places
607803	Drunk when riding a bicycle
608534	Anti-social behaviour, private landlord offences
730001	Dangerous driving offences
730002	Driving carelessly
730101	Driving motor vehicle while unfit through drink or drugs
730102	In charge of motor vehicle while unfit through drink/drugs
730103	Driving mv with blood alcohol content above prescribed limit
730104	In charge of mv while blood alcohol content above limit
730105	Failure to provide breath specimen at the roadside
730106	Failure to provide breath, blood or urine specimen at police station

Table A2. RQ1: Alcohol-related incidents (incident codes and title)

Code	Description
AB-24	Public nuisance
AB-28	Disturbance
AB-53	Noise
AB-55	Drinking in public
AB-56	Neighbour dispute

Table A3. RQ1: Unintended consequences (Drug-related offence codes and title)

Offence	Title
101105	Drugging
504401	Illegal importation of drugs
504402	Production, manufacture or cultivation of drugs
504403	Supply, possession with intent to supply etc. of drugs
504405	Drugs, money laundering related offences
504406	Bringing drugs into prison
504407	Psychoactive substances: Production, import/export, supply, possession in custody
504408	Psychoactive substances: Other offences
504499	Drugs, other offences
607316	Methylated Spirits (Sale by Retail) (S) Act 1937

Table A4. RQ1: Crime groups (Scottish crime and offence structure)

Group	Title
Group 1	Crimes of violence etc.
Group 2	Sexual offences
Group 3	Crimes of dishonesty
Group 4	Fire-raising, malicious mischief etc.
Group 5	Other crimes
Group 6	Miscellaneous offences
Group 7	Offences relating to motor vehicles

Table A5. RQ2: Alcohol-related crime and disorder categories

Crime category	Title
1	Serious assault
2	Robbery and assault with intent to rob
3	Sexual offences
4	Vandalism
5	Resisting arrest
6	Drug offences
7	Common assault
8	ASB
9	Threatening or abusive behaviour
10	Consumption of alcohol in designated places

Table A6. Offences included in alcohol-related crime and disorder categories

Crime category	Offence	Title
1	100400	Serious assault
2	100600	Robbery and assault with intent to rob
3	201400	Rape (offences prior to 1 December 2010)
3	201401	Rape of male (16+)
3	201402	Rape of female (16+)
3	201404	Rape of older female child (13–15 years)
3	201406	Rape of young female child (under 13)
3	201500	Attempted rape (offences prior to 1 December 2010)
3	201501	Attempted rape male (16+)
3	201502	Attempted rape female (16+)
3	201503	Attempted rape older male child (13–15)
3	201504	Attempted rape older female child (13–15)
3	201601	Sexual assault by penetration of male (16+)
3	201602	Sexual assault by penetration of female (16+)

Crime category	Offence	Title
3	201604	Sexual assault by penetration of female (13–15 years)
3	201605	Sexual assault of male (16+)
3	201606	Sexual assault of female (16+)
3	201607	Sexual assault of older male child (13–15 years)
3	201608	Sexual assault of older female child (13–15 years)
3	201610	Sexual coercion of female (16+)
3	201616	Assault by penetration of young female child (under 13)
3	201618	Sexual assault of young female child (under 13)
3	201702	Public indecency
3	201703	Sexual exposure
3	201822	Lewd and libidinous practices
4	403312	Vandalism
5	503807	Resisting arrest
6	604701	Common assault
7	604702	Breach of the peace

Crime category	Offence	Title
7	604703	Urinating etc.
7	604707	Antisocial behaviour offences
7	606001	Drunk and incapable
7	606003	Drunk in charge of a child
7	606004	Drunk and attempting to enter licensed premises
7	606006	Disorderly on licensed premises
7	606007	Drunk in or attempting to enter designated sports ground
7	606008	Refusing to quit licensed premises
7	606101	Sale of drink to person under 18
7	606103	Licensed person, employee or agent drunk in licensed premises
7	606104	Permitting riotous behaviour in licensed premises
7	606206	Person under 18 buying excisable liquor or consuming in bar
7	606212	Alcohol offences, travelling to and from sporting event
7	606213	Sports grounds offences (possessing alcohol etc.)

Crime category	Offence	Title
7	606214	Confiscation of alcohol from person under 18
7	606299	Liquor licensing laws, other offences
8	604708	Threatening or abusive behaviour
9	607208	Consumption of alcohol in designated places

Table A7. RQ3: Changes in nominal characteristics, alcohol-related crimes matching

Code	Offence
100100	Murder
100200	Attempted murder
100301	Culpable homicide – common law
100400	Serious assault
100600	Robbery
101105	Drugging
201400	Rape (offences prior to 1 December 2010)
201401	Rape of male (16+)
201402	Rape of female (16+)
201404	Rape of older female child (13–15 years)
201406	Rape of young female child (under 13)
201500	Assault with intent to rape (offences prior to 1 December 2010)
201501	Assault with intent to rape male (16+)
201502	Assault with intent to rape female (16+)

Code	Offence
201503	Assault with intent to rape older male child (13–15)
201504	Assault with intent to rape older female child (13–15)
201601	Sexual assault by penetration of male (16+)
201602	Sexual assault by penetration of female (16+)
201604	Sexual assault by penetration of female (13–15 years)
201605	Sexual assault of male (16+)
201606	Sexual assault of female (16+)
201607	Sexual assault of older male child (13–15 years)
201608	Sexual assault of older female child (13–15 years)
201610	Sexual coercion of female (16+)
201616	Assault by penetration of young female child (under 13)
201618	Sexual assault of young female child (under 13)
201702	Public indecency
201703	Sexual exposure
201822	Lewd and libidinous practices
403312	Vandalism

Code	Offence
503804	Falsely accusing named person of crime
503807	Resisting arrest
504401	Illegal importation of drugs
504402	Production, manufacture or cultivation of drugs
504403	Supply of drugs including possess with intent
504405	Drugs, money laundering offences
504406	Bringing drugs into prison
504499	Other drugs offences
604701	Minor assault
604702	Breach of the peace
604703	Urinating etc.
604704	Racially aggravated harassment
604705	Racially aggravated conduct
604706	Minor assault of an emergency worker
604707	Antisocial behaviour offences
604708	Threatening and abusive behaviour (CJ&LSA s38)

Code	Offence
606001	Drunk and incapable
606003	Drunk in charge of a child
606004	Drunk and attempting to enter licensed premises
606006	Disorderly on licensed premises (and refusing to quit pre 2009/10)
606007	Drunk in or attempting to enter designated sports ground
606008	Refusing to quit a licensed premise (previously 606006 pre 2009/10)
606101	Sale of drink to person under 18
606103	Licensed person, employee or agent drunk in licensed premise
606104	Permitting riotous behaviour in licensed premises
606206	Person under 18 buying excisable liquor or consuming in bar
606212	Alcohol offences, travelling to and from sporting event
606213	Sports grounds offences possessing alcohol etc.
606299	Liquor licensing laws, other offences
607204	Licensing offences Civic Government Scotland Act 1982
607208	Consumption of alcohol in designated places
607316	Methylated spirits – Sale by Retail – Scotland Act 1937

Code	Offence
607803	Drunk when riding a bicycle
608534	Anti-social behaviour, private landlord offences
730001	Dangerous driving offences
730002	Careless driving
730101	Driving motor vehicle while unfit through drink or drugs
730102	In charge of motor vehicle while unfit through drink or drugs
730103	Driving motor vehicle with blood alcohol content above prescribed limit
730104	In charge of motor vehicle with blood alcohol content above prescribed limit
730105	Failure to provide breath specimen at the roadside
730106	Failure to provide breath, blood or urine specimen at police station

Table A8. RQ3: Synthetic control – matched alcohol-related crimes

Scotland offence code	Scotland crime and offence title	Home Office code	England & Wales offence category	England & Wales offence title
100100	Murder	1/1	1 Murder	Murder of persons aged 1 year or over
100200	Attempted murder	2	2 Attempted murder	Attempted murder
100302	Causing death by dangerous driving	4/8	4/8 Causing death by careless or inconsiderate driving	Causing death by careless or inconsiderate driving
100303	Death by careless driving when under influence of drink/drugs	4/6	4/6 Causing death by careless driving under influence of drink or drugs	Causing death by careless driving when under the influence of drink or drugs
201401	Rape of male (16+)	19/10	19F Rape of a male aged 16 and over	Rape of a male aged 16 or over
201402	Rape of female (16+)	19/8	19C Rape of a female aged 16 and over	Rape of a female aged 16 or over

Scotland offence code	Scotland crime and offence title	Home Office code	England & Wales offence category	England & Wales offence title
201404	Rape of older female child (13–15 years)	19/7	19D Rape of a female child under 16	Rape of a female aged under 16
201501	Attempted rape male (16+)	19/14	19F Rape of a male aged 16 and over	Attempted rape of a male aged 16 or over
201502	Attempted rape female (16+)	19/12	19C Rape of a female aged 16 and over	Attempted rape of a female aged 16 or over
201503	Attempted rape older male child (13–15)	19/13	19G Rape of a male child under 16	Attempted rape of a male aged under 16
201504	Attempted rape older female child (13–15)	19/11	19D Rape of a female child under 16	Attempted rape of a female aged under 16
201601	Sexual assault by penetration of male (16+)	17/13	17A Sexual assault on a male aged 13 and over	Assault on a male by penetration

Scotland offence code	Scotland crime and offence title	Home Office code	England & Wales offence category	England & Wales offence title
201602	Sexual assault by penetration of female (16+)	20/3	20A Sexual assault on a female aged 13 or over	Assault on a female by penetration
201605	Sexual assault of male (16+)	17/15	17A Sexual assault on a male aged 13 and over	Sexual assault on a male
201606	Sexual assault of female (16+)	20/5	20A Sexual assault on a female aged 13 or over	Sexual assault on a female
201616	Assault by penetration of young female child (under 13)	20/4	20B Sexual assault on a female child under 13	Assault of a female child under 13 by penetration
201618	Sexual assault of young female child (under 13)	20/6	20B Sexual assault on a female child under 13	Sexual assault of a female child under 13
201703	Sexual exposure	88/9	88E Exposure and voyeurism	Exposure

Scotland offence code	Scotland crime and offence title	Home Office code	England & Wales offence category	England & Wales offence title
503807	Resisting arrest	5/1	8S Assault with injury on a constable	Wounding with intent to resist/prevent arrest
604701	Common assault	105/1	105A Assault without Injury	Common assault and battery
604705	Racially aggravated conduct	125/82	9B Racially or religiously aggravated public fear, alarm or distress	Racially or religiously aggravated harassment or alarm or distress – words or writing
604706	Common assault of an emergency worker	5/1	8T Assault with Injury on an emergency worker (other than a constable)	Wounding with intent to resist/prevent arrest
604707	Antisocial behaviour offences	8/32	66 Other offences against the State or public order	Breach of Antisocial Behaviour Order

Scotland offence code	Scotland crime and offence title	Home Office code	England & Wales offence category	England & Wales offence title
604708	Threatening or abusive behaviour	125/11	99 Other notifiable offences	Threaten or claim to contaminate or interfere with goods with intention of causing public alarm, anxiety, economic loss, etc.
730001	Dangerous driving offences	802	802 Dangerous driving	Aiding, abetting, causing or permitting dangerous driving

Appendix B: Detailed description of statistical methods

This appendix provides a description of the methods deployed in the evaluation.

1. Trend change point analysis

Preparing the data

Data was aggregated to weekly frequency. Most years comprise 52 weeks, though some comprise 53 weeks. This can have an impact on seasonality assessment and modelling. Since 2015 comprised 53 weeks, the first week of 2016 was estimated as an average between the last week of year 2015 (week 53) and the first week of year 2016 (week 1).

Both variance of crime and incident rates were stabilised using the natural logarithm transformation. This step enables the standardisation of measures across different event types to ensure that the dataset assumes a normal distribution. This is a necessary requirement for the subsequent analysis. The normality was checked using Kernel Density plots. Where data was sparse (zero counts in a given week), the count was replaced with a count of 1, enabling application of the natural logarithm. The 'Median Absolute Deviation (MAD)' was deployed on the raw datasets in order to identify outliers. Assuming that the underlying distribution to be normal, the outlier cut-off was set at 2 on the expectation that approximately 95% of events taken from a normal distribution fall within 2 standard deviations from the mean (and median). Following this process, no outliers were found in the datasets.

Procedure for analysing changes in long-term trend

In order to analyse changes in long-term trend, seasonality was removed through additive decomposition of the time series. In other words, the seasonality is first removed from the time series to prevent the false detection of a change point due to seasonal change in the time series. Subsequently, a piecewise linear trend is fitted over time. Then, changes in trend are identified through analysing changes in

regression. The changes are identified using the Pruned Exact Linear Time (PELT) method, which detects change points through finding a minimum cost function and optimal number of change points and their location.

Software

Analysis was performed using the following statistical software:

- R 4.0.3 using the EnvCpt package.

Sensitivity analysis using truncated time series

In order to assess the robustness of the change point analysis, each analysis is repeated using a truncated version of the time series data. This ensures accurate estimation of seasonality and its subsequent removal. To this end, two-years data are removed from each time series, resulting in the change point analysis being undertaken using dataset covering the time period January 2017 (week 1) to January 2020 (week 1).

The results of the change point analysis using the original time series and the truncated time series were then compared. In overview, the results were found to be unchanged within the period +/- eight weeks of the introduction of MUP. Due to the shortened time series, and the consequent estimation of seasonality in the truncated data, changes were observed in the number of change points detected in a few of the results. However, none of these changes were observed within the period +/- six weeks of the introduction of MUP. Figure B1 and Figure B2 provide two examples of these results (all alcohol-related crimes in Scotland and the consumption of alcohol in designated places).

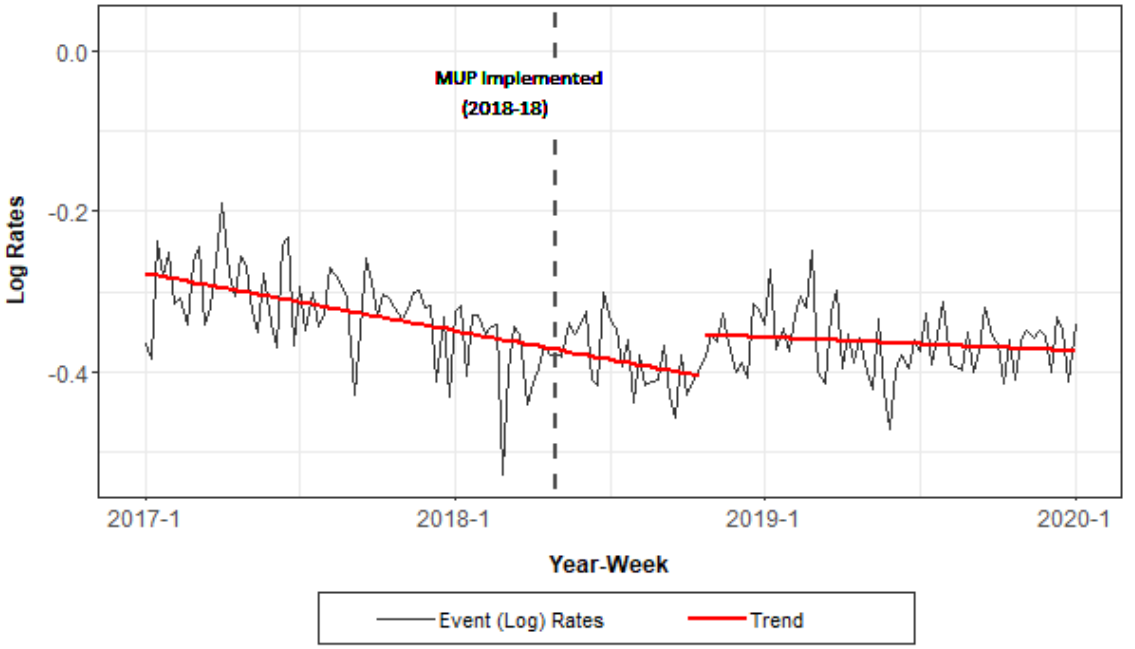


Figure B1. Truncated time series showing the trend in the weekly (log) rate of all alcohol-related crimes in Scotland, 2017–2020

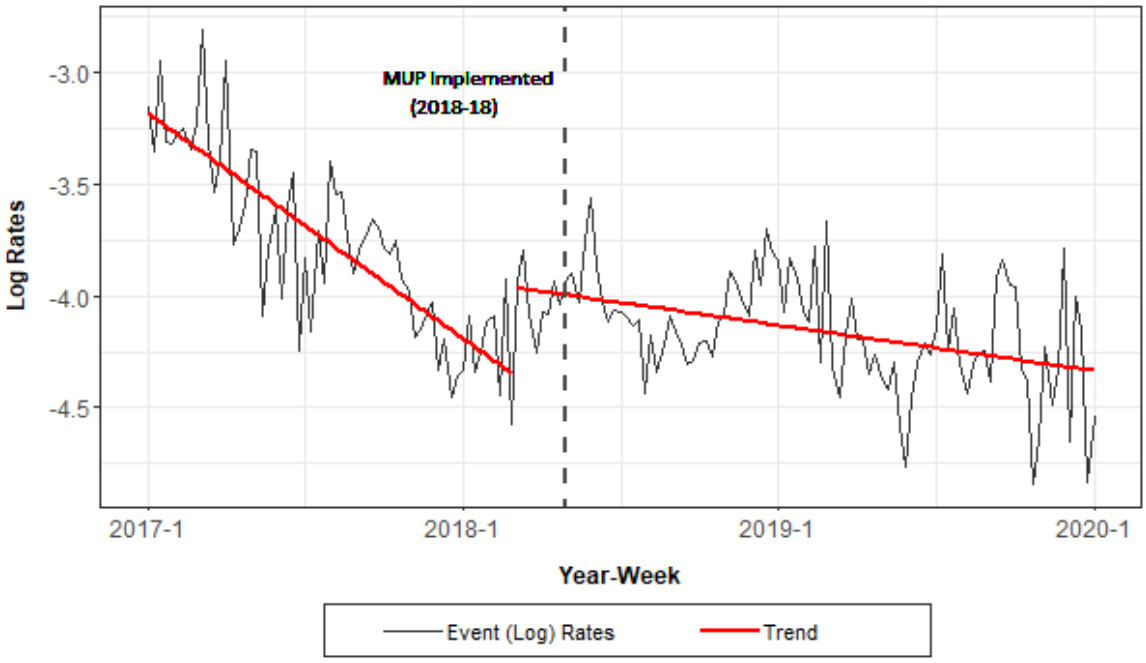


Figure B2. Truncated time series showing the trend in the weekly (log) rate of consumption of alcohol in designated places, 2017–2020.

In Figure B1, the number of change points detected (for example 1), as well as its location, were the same as those in the original time series data (see Figure 3). In Figure B2 only one change point was detected compared to four change points in the original time series (see Figure 15). However, the location of the one change corresponds in both truncated and full time series data. In summary, the analysis based on the truncated time series finds the change point detection technique to be robust in detecting trend level change in the datasets.

2. Regression with ARIMA errors

Diagnosing autocorrelation and non-stationarity

The datasets prepared for the change point analysis are deployed. Seasonality and trend cause non-stationarity of data. Autocorrelation (ACF) and partial autocorrelation (PACF) plots were used to assess trend and seasonal differencing. They were also used to identify the number of autoregressive (AR) and moving average (MA) terms for the candidate models.

Selecting the baseline model

The baseline ARIMA model was selected from the candidate models. Selection was based on Akaike Information Criterion, significance of all AR and MA terms, as well as residuals diagnostics.

Constructing the variable to test the effect of the intervention

The first step is to create a temporal region that spans eight weeks prior to eight weeks after the implementation of MUP, in order to accommodate possible lagged effects. For any identified change point within this region, a significance test is undertaken. A binary exploratory variable is set to 0 for the period before any identified change points within the temporal region, or before week 18 of year 2018 if no change point is identified within the region. The remaining periods following this point are set to 1.

Software and analysis

Using the event (log) rates and the constructed binary variable, the 'arima' function of the 'statsmodels' package in Python 3.7 was used to perform the analysis.

Residuals assessment

Residuals of all models were assessed to ensure normal distribution and lack of autocorrelation. Kernel Density plots were analysed to check the normal distribution of the data. ACF plot and Ljung-Box tests were used to assess lack of autocorrelation within the residuals.

3. Integrated Nested Laplace Approximation (INLA)

Model specification

Alcohol-related crimes for data zone i, at time point t, are modelled as counts using a Poisson distribution. This is then offset by the expected alcohol-related crime rates per 1,000 of the given data zone population. Estimates of data zone population were obtained from the UK Data Service.[29]

The model is structured as follows:

$$O_{it} \sim Poisson(\mu_{it})$$

$$log(\mu_{it}) = log(E_{it}) + \alpha + \beta X_{it} + s_i + u_i + \varphi_t + \gamma_t + \varsigma_{it} + \epsilon$$

O_{it} is the count of crimes at the data zone level (i) and quarter (t)

μ_{it} is the mean of a Poisson distribution

E_{it} is an offset as a rate per 1000 population

α is an intercept

β is a vector of coefficients for covariates (X_{it})

s_i is a structured spatial component (CAR)

$u_i$is an unstructured spatial component

φ_t is a structured temporal component (RW1)

γ_t is an unstructured temporal component

ς_{it} is a spatiotemporal component (IID)

ϵ is an interaction term

The inclusion of interaction terms is to account for possible over-dispersion in the datasets. We chose weakly informative priors (such as values for 'shape' and 'rate' parameters) to build the models. To ensure that the choice of prior does not affect the results, these were then compared with more informative priors, which showed no significant difference.

Testing the effect of the intervention

To test for the significance of the MUP intervention, a binary exploratory variable was introduced. The variable was set to 0 before quarter 2 of year 2018 (May 2018) and set to 1 starting from quarter 2 of year 2018 onwards.

Control variable

Deprivation score (Townsend index).[30 31]

Model assessment

The deviance information criterion (DIC), which is similar to the AIC, was used to choose the best model. It is defined as: $DIC = \overline{D} + p_D$, where $\overline{D}$ stands for posterior mean of deviance, and p_D is the effective number of parameters. Lower DIC values tend to indicate better model fit.

The significance of the MUP intervention (and the control variable) is assessed against 95% credible intervals. The variables are said to be significant if the mean effect and the intervals do not cross 0. The effect of the MUP intervention is calculated and presented as a % change.

Count data can be overdispersed, which means that the variance of the data is larger than its mean. Random effects are included in the model to represent variation that cannot be explained through the fixed effects (covariates). Overdispersion is accounted for in the model by including the spatiotemporal random effect, which is i.i.d. Gaussian.

Software

Analysis was performed using the following statistical software:

- R 4.0.3 using the INLA package.

4. Synthetic control

Where randomised controlled trials are not possible, a synthetic control is one of the quasi-experimental methods frequently used in evaluating the impact of an intervention. This approach is more robust than interrupted time series analysis, which often does not allow for comparison with an area outside the intervention area. Originally, a synthetic control is deployed in one large treated area and several untreated control areas.[32]

Our analysis uses a version of a synthetic control applied to high-dimensional, micro-level data.[33] Weights are calculated for control areas to achieve a common trend before the intervention, as well as to match the control areas to the treatment areas as closely as possible. Divergence of the treatment trend from the control trend indicates the impact of the intervention.

In order to achieve more robust estimates of significance, we apply placebo effect analysis. This involves computing hundreds of permutations (250 in our case), where control areas are assigned randomly as treatment areas.

Data preparation

The treatment sites were all the data zones within Greater Glasgow, while control sites were all the LSOAs within Greater Manchester. Alcohol crimes in Scotland were matched as closely as possible with similar crimes in England and Wales. In order to overcome problems with differing population sizes, all data was represented as rates per 1,000 population. Population estimates for data zones and LSOAs were obtained from the UK Data Service. [29]

Covariates

Deprivation deciles were calculated for each data zone within Greater Glasgow and for each LSOA within Greater Manchester using the Townsend index. [31] The density of the data zones in Greater Glasgow and the LSOAs in Greater Manchester were obtained from the UK Data Service. [29]

Software

Analysis was performed using the following statistical software:

- R 4.0.3 using the MicroSynth package.

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