

What on-line searches tell us about public interest and potential impact on behaviour in response to minimum unit pricing of alcohol in Scotland

David A. Leon^{1,2,3} , Elad Yom-Tov⁴ , Anne M. Johnson⁵ , Mark Petticrew¹ , Elizabeth Williamson¹ , Vasileios Lampos⁶  & Ingemar Cox^{6,7}

London School of Hygiene and Tropical Medicine, London, UK,¹ Department of Community Medicine, UiT, Arctic University of Norway, Tromsø, Norway,² International Laboratory for Population and Health, National Research University Higher School of Economics, Moscow, Russia,³ Microsoft Research, Herzeliya, Israel,⁴ Institute of Global Health, University College London, London, UK,⁵ Department of Computer Science, University College London, London, UK⁶ and Centre for Communication and Computing, University of Copenhagen, Copenhagen, Denmark⁷

ABSTRACT

Aims To investigate whether the introduction of minimum unit pricing (MUP) in Scotland on 1 May 2018 was reflected in changes in the likelihood of alcohol-related queries submitted to an internet search engine, and in particular whether there was any evidence of increased interest in purchasing of alcohol from outside Scotland. **Design** Observational study in which individual queries to the internet Bing search engine for 2018 in Scotland and England were captured and analysed. Fluctuations over time in the likelihood of specific topic searches were examined. The patterns seen in Scotland were contrasted with those in England. **Setting** Scotland and England. **Participants** People who used the Bing search engine during 2018. **Measurements** Numbers of daily queries submitted to Bing in 2018 on eight alcohol-related topics expressed as a proportion of queries on that day on any topic. These daily likelihoods were smoothed using a 14-day moving average for Scotland and England separately. **Findings** There were substantial peaks in queries about MUP itself, cheap sources of alcohol and online alcohol outlets at the time of introduction of MUP in May 2018 in Scotland, but not England. These were relatively short-lived. Queries related to intoxication and alcohol problems did not show a MUP peak, but were appreciably higher in Scotland than in England throughout 2018. **Conclusions** Analysis of internet search engine queries appears to show that a fraction of people in Scotland may have considered circumventing minimum unit pricing in 2018 by looking for on-line alcohol retailers. The overall higher levels of queries related to alcohol problems in Scotland compared with England mirrors the corresponding differences in alcohol consumption and harms between the countries.

Keywords Alcohol, alcohol price, internet searches, minimum unit pricing, policy, Scotland.

Correspondence to: David A. Leon, London School of Hygiene and Tropical Medicine, Keppel Street, London WC1E 7HT, UK. E-mail: david.leon@lshtm.ac.uk
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INTRODUCTION

On 1 May 2018 the Scottish government introduced minimum unit pricing (MUP) of alcohol. This prohibited the retail sale of alcohol where the price of a unit of alcohol (10 ml) was less than 50 p. This was aimed at reducing the considerable burden of alcohol-related ill health and mortality in Scotland [1] that has been apparent for many years [2].

The legislation enacting MUP required that there was a formal evaluation of the scheme. This is under way, and includes specially commissioned studies of heavy drinkers,

analysis of nationally representative survey data that include questions on alcohol consumption and aggregation and analysis of data on alcohol-related mortality, diagnoses and health service contacts [3]. In addition, data are being purchased from market research organizations such as Nielsen, who conduct regular surveys of retail purchases.

Based on marketing survey data, a decline in the *per capita* sales (expressed in terms of volume of pure ethanol) was found in 2018 compared to 2017 [4]. In 2018 there was clear evidence of a sharp decline in the sales of items that prior to MUP had been selling at less than 50 p per unit [4]. A qualitative study of compliance with MUP that

involved interviews with people responsible for enforcement concluded that in general businesses were following the regulations [5]. Most recently an interrupted time-series analysis [6] of households in Scotland and northern England found an immediate reduction in weekly purchases of alcohol per adult per household on the introduction of MUP that was larger than originally projected.

Because MUP was only implemented in Scotland and not in England, there has been a concern that there would be attempts to circumvent MUP price rises through an increase in cross-border shopping [7] and on-line shopping for alcohol where someone in Scotland could order from an on-line store based in England. At the end of 2017 the on-line trade paper *The Spirit Business* predicted that MUP may result in a surge in cross-border shopping or ordering of alcohol on-line [8]. However, the existing evidence on this is limited and the conclusions mixed. In a qualitative study evaluating the implementation of MUP some interviewees said that they were aware of people using on-line purchasing from stores located in England, to which MUP would not apply [5]. However, the first quantitative analysis of the immediate impact of MUP found that there was minimal evidence of an increase in cross-border shopping [4].

MUP can be seen as a system-level intervention, with a wide range of anticipated and unanticipated effects [9]. Among these is the possibility that it will influence social norms, attitudes and beliefs concerning alcohol and alcohol harms. On-line activity can potentially shed light on these types of spillover effects. On-line searches and social media activity can provide information about people's behaviours and preferences over time that are either impossible or very difficult to collect using conventional survey techniques. During the past few years a number of studies have used Twitter to examine fluctuations and levels in alcohol consumption in populations [10–12]. Most recently, Twitter has been used to examine public opinion in the 2 weeks following the introduction of MUP [13] although, as with other analyses of Twitter data, the researchers were not able to definitively determine the place of residence of the person tweeting.

In this study we report the results of an analysis of web searches in the months preceding the introduction of MUP and in the following 9 months. The data we used enabled us to reliably separate searches originating from within Scotland from those in England. Our aim was to investigate whether the introduction of MUP in Scotland on 1 May 2018 was reflected in changes in the likelihood of alcohol-related queries submitted to internet search engines that, in turn, could be seen as indicators of public interest in this policy and associated changes in behaviour. In particular, we wished to see if there was any evidence for increased interest in on-line cross-border purchasing of alcohol.

METHODS

We extracted the totality of all queries to the Bing search engine made by people in Scotland and England in 2018. This was performed by one of the authors (E.Y.T.), as a Microsoft research scientist. Each query contained the time and date of the query. In addition, location data for the area of origin of each was sufficiently complete to reliably classify queries as originating either from Scotland or England.

The monthly market share of Bing in the United Kingdom averaged 9% in 2018 [14]. Bing is known to be a representative sample of internet users [15]. The Spearman correlation between the number of people per postal code according to the 2011 census [16] and those on Bing was 0.61 ($P < 10^{-10}$), suggesting that Bing users were relatively well distributed across the United Kingdom proportionally to the population.

At the outset we identified a series of topics ranging from consequences of drinking behaviour to on-line purchase of alcohol that a priori we thought could be affected by the introduction of MUP and might be plausibly reflected in the relative frequency of terms used in on-line searches. Table 1 defines the eight topics, the rationale for their inclusion and their limitations in the current context. The terms or phrases that were used to identify searches relevant to each topic were selected informally by the research group based on their knowledge of the topic, and alcohol drinking behaviour in different parts of the United Kingdom. The mapping of terms to topics is given in the Supporting information, Table S1.

Statistical analysis

The frequency of terms associated with each topic occurring in searches was determined as follows. For each topic we calculated the number of queries made in each day of 2018 that included one or more of the terms that defined each topic. This was then expressed as a proportion of all queries on any subject made on that day. In the subsequent text we refer to this proportion as the likelihood of the queries for each topic.

For some of the topics the absolute number of daily queries was often fewer than 20. This means that there is imprecision in the estimated likelihood due to random error. We quantified this assuming that the absolute number of queries for a topic of interest is generated by a Poisson process. On this basis, we use standard approaches to identify the upper and lower 95% confidence bounds for the true Poisson mean (i.e. the true query likelihood) that are consistent with the daily observed number. As the daily number of total queries on any subject is, in contrast, very large, we ignore the contribution of this denominator to

Table 1 On-line search topics selected for analysis

Domain	Topic name	Description of terms	Rationale	Limitations/interpretation
Policy interest/awareness	MUP/alcohol price	MUP programme itself and potential/actual changes in price of alcohol in Scotland that would result	General levels of interest in MUP and changes in price could be used to gauge the engagement of internet users with this policy implementation	The introduction of MUP was preceded by several years of public debate and periodic news coverage as the policy was subject to scrutiny by the courts and so on. The general public in Scotland could be expected to be aware of this policy
	Cost of alcohol	Neutral queries concerning cost of alcohol		
Cheap alcohol	Find a bargain	Cheap or bargain sources of alcohol	In response to the introduction of MUP drinkers might initially at least wish to look for cheap or bargain sources of alcohol. This would be understandable, as the whole thrust of the MUP policy was to reduce the availability of cheap alcohol	
	Specific cheap types	Specific types of cheap alcohol which pre-MUP would have been sold at below 50p per unit	This was to capture people who were still searching for these cheap brands in the hope that they would find a source that was not affected by MUP	
MUP circumvention	On-line alcohol	Sources of alcohol that could be purchased on-line	On-line purchasing of alcohol is a growing business. On-line purchases by Scottish residents made from on-line retailers outside of Scotland are not subject to MUP restrictions even if the alcohol is delivered to Scotland.	We were only able to analyses searches for potential sources of on-line purchased alcohol but we could not identify actual on-line purchases <i>per se</i> . Moreover, it was not possible to separate out on-line retailers based in England from those in Scotland
	Cross-border alcohol	Specific geographic locations in England near the Scottish border that are sources of alcohol/cheap alcohol	Cross-border purchase of alcohol from England including on-line has always been seen as a potential issue for the effectiveness of MUP. Few data exist on this	
Harmful consequences of alcohol	Intoxication	Consequences of heavy drinking such as drunkenness/intoxication/hangover	To see if there was any fall in patterns of heavy drinking following the introduction of MUP that might be reflected in reductions in people searching for things to do with heavy drinking episodes	
	Alcohol problems	Alcohol disorder/drinking problems and treatment	The extensive public debate about MUP was conducted in terms of reducing the burden of harmful and hazardous drinking in Scotland. Its introduction could be a trigger for people with an alcohol problem to take some action	

MUP = minimum unit pricing.

the random error of the likelihood. The upper 95% confidence bound for the likelihood was obtained by dividing the upper Poisson limit by the total number of queries on the same day. The lower bound was calculated in an equivalent manner. These daily likelihoods, and their corresponding upper and lower 95% confidence bounds, were each smoothed using a moving average centered on each

day. Having examined the data we found that a 2-week (14-day) smoothing window struck a good balance between removing the noise of day-to-day fluctuations and yet retained sufficient granularity to observe relatively short-term variations.

These analyses were not pre-registered and as such the study and its results should be considered exploratory.

Replication

We attempted to replicate our key results using aggregated data from Google searches. Details of the methods used and results are provided in the Supporting information.

Ethical approval

This study was approved by the Institutional Review Board of the Technion and by the ethics committee of the London School of Hygiene and Tropical Medicine (no. 17989, 14/1/2020). For reasons of privacy, all non-aggregated Bing data were processed by E.Y.T., with the aggregated statistics interpreted by all authors of the paper.

RESULTS

During the period under study approximately 561 000 queries made by approximately 293 000 people matched one or more of the target terms. Of these, 63 000 queries originated in Scotland and 498 000 originated in England. Table 2 shows the frequency of queries by our specific alcohol topics ranked in descending order of number of queries for Scotland and England combined.

The likelihood of searches on each topic group over time for Scotland and England is shown in Fig. 1. It should be noted that the maximum on the vertical axis for the plots varies from a likelihood of 5×10^{-6} for 'cross-border alcohol' to 1.4×10^{-4} for 'intoxication'. As is evident from the width of the 95% confidence bands, the precision of the estimates varies, with the bands being narrowest for those queries with the highest likelihoods, as these are based on the largest absolute numbers of queries.

For five of the eight topics there was a pronounced spike in likelihood, which was largest in Scotland at the time of the introduction of MUP. These peaks were relatively short-lived, and fell to pre-MUP levels by June or July. The topics of 'cross-border alcohol', 'intoxication' and 'alcohol problem' did not show a peak at the time of the

Table 2 Number of Bing search engine queries by topic from 1 January to 31 December 2018 in Scotland and England in total

Topic	Number of queries (in thousands)
Intoxication	427
Alcohol problem	87
Cheap types	30
MUP/alcohol price	6
Cost of alcohol	5
On-line alcohol	4
Find a bargain	2
Cross-border alcohol	0.8

MUP = minimum unit pricing.

introduction of MUP, although there were peaks for these topics at other points in the year.

The search topics 'MUP/alcohol price', 'cost of alcohol', 'find a bargain and 'cheap types' all showed evidence of a very slight increase in England at the time of the introduction of MUP, although these were extremely small compared to those seen in Scotland. In May 2018 'MUP/alcohol price', 'cost of alcohol', 'cheap types' and 'on-line alcohol' showed lower confidence bounds for Scotland that were far higher than the upper confidence bounds for England, indicating that these differences are very unlikely to be explained by chance.

Aside from the fluctuations observed, it is striking that the likelihood of five of the topics being searched for was higher in Scotland than in England throughout the year. This was not the case for 'find a bargain', 'on-line alcohol' or 'cross-border'. The level of queries for 'alcohol problems' and 'intoxication' were notably higher in Scotland during the entire period of the study.

We used aggregated data available from Google searches to attempt to replicate some of our findings. The relevant figures are available in the Supporting information. This confirmed that there was a pronounced upswing in searches related to the topic 'MUP/alcohol price' around May 2019. Importantly, the longer time-series available from the Google data allowed us to compare the relative likelihood of a search topic month by month for the aggregate period 2014–17. Not surprisingly, this showed no upswing in May for these earlier years. Searches for 'on-line alcohol' also showed a peak in the Google data around May 2018 that was only seen in Scotland, and was not seen in earlier years.

DISCUSSION

We have found evidence that the introduction of MUP in Scotland was associated with a pronounced but short-lasting peak of search queries for five of the eight topics that we defined a priori as likely to capture different dimensions of awareness and behaviour of alcohol and MUP. There was an unequivocal spike of interest in the policy *per se*, as represented by the topic 'MUP/alcohol price'. This was seen in England as well as Scotland although, not surprisingly, was far more pronounced in Scotland. This finding was confirmed by the supplementary Google results. There was extensive press-coverage in the United Kingdom as a whole of the policy when it was introduced consistent with this peak. This topic could be seen to be overlapping with the 'cost of alcohol' topic, and showed the same features. Overall, this suggests that there was sufficient policy awareness and interest in MUP throughout the United Kingdom to generate a visible signal, particularly in Scotland.

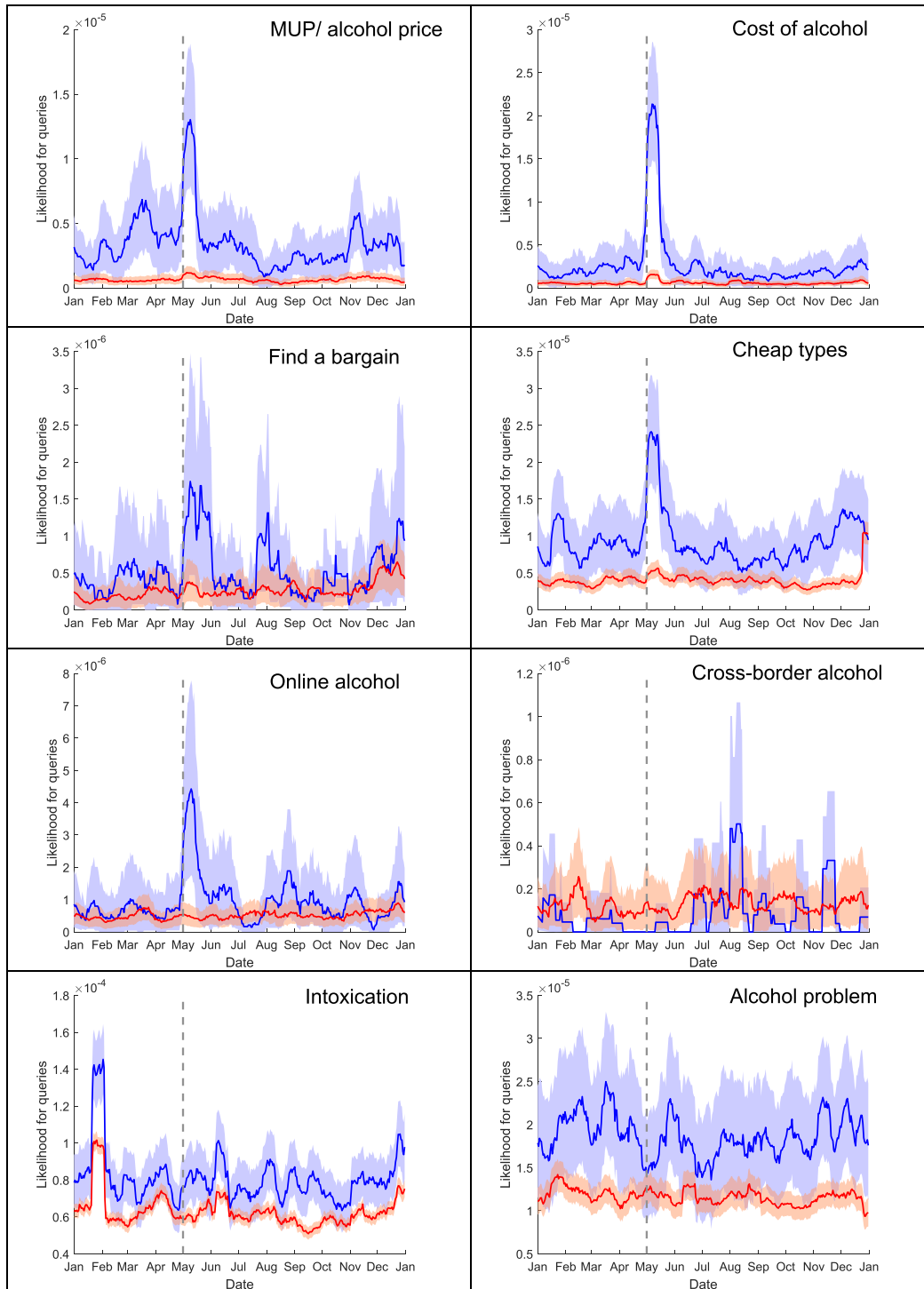


Figure 1 Variation in daily likelihood over 2018 by topic for Scotland (blue line) and England (red line) with 95% confidence bounds. Date of minimum unit pricing (MUP) implementation (1 May 2018) shown by vertical black dashed line. Likelihood of queries for a topic is the frequency of searches for that topic on a day divided by the total number of queries on any subject. The plotted values are 14-day moving averages centred on each day. [Colour figure can be viewed at wileyonlinelibrary.com]

Two of the topics related to searches for cheap sources of alcohol: 'find a bargain' and 'cheap types'. The first was made up of terms that were explicitly about cheap alcohol, while the second was made up of specific brands/types of cheap alcohol to which the MUP policy was specifically targeted, as they had a unit price below 50 p. These topics were in contrast to the 'MUP/alcohol price' topic that focused upon pricing in general. Topics concerning cheap sources of alcohol showed significant peaks that were only notable in Scotland around the time of the introduction of MUP.

Finally, there are two topics of particular interest with respect to searches that could be aimed at circumventing MUP. These are 'cross-border alcohol' and 'on-line alcohol'. There were very few queries for 'cross-border alcohol', and there was no indication of a peak around the time of the introduction of MUP. However, while it is clear that cross-border alcohol queries could represent an attempt to avoid MUP by travelling south of the border to buy cheap alcohol in England, it is less clear that an interest in on-line alcohol would similarly represent circumvention. This is because only alcohol purchased on-line from companies based outside Scotland and delivered to Scotland at prices below the MUP may represent an attempt to circumvent MUP. There is nothing in the MUP legislation that prohibits buying alcohol outside Scotland from retailers not constrained by MUP. However, some of the on-line alcohol searches may, in fact, represent interest in on-line delivery of alcohol from supermarkets or retailers based in Scotland, where the price of alcohol would have to conform with MUP. Nevertheless, there was a clear Scottish-specific signal for 'on-line alcohol' that occurred at the time of the introduction of MUP. This is replicated in the Google analyses, which also show that the peak in May was specific to 2018 and was not seen in earlier years. These results, to our knowledge, provide the first evidence that a fraction of the Scottish population may have considered this approach to circumventing MUP. However, it should be emphasized that we have been unable to investigate how far these searches were translated into actual on-line purchases and whether the items purchased were below MUP. Nevertheless, our findings are a step towards reducing the paucity of evidence that exists more widely about the impact of on-line-sourced alcohol on alcohol harms [17].

A recent report commissioned by NHS Scotland examined the economic impact of MUP on Scottish retailers and alcohol producers and conducted some small-scale investigations of cross-border purchasing behaviour [18]. In telephone interviews with five Scottish and five English retailers within 15 km of the border, some evidence emerged of an increased volume of sales in the two largest of the retailers located in England following the introduction of MUP. This was attributed by the interview respondents to an increase in purchases made by people

living in Scotland. However, this study found no evidence of organized shopping trips by groups of people from Scotland arriving in mini-buses South of the border to avail themselves of the cheaper alcohol. In comparison with this small-scale semi-quantitative survey, the evidence we have found of potential cross-border purchase through on-line retailers is worthy of note, as it is based on a national picture.

There was no evidence from the relative frequency of search topics over time that MUP had an impact on adverse consequences of drinking behaviour ('alcohol problems' and 'intoxication'). These topics showed appreciable variation throughout 2018. 'Intoxication' shows an increased likelihood around Christmas, as might be expected when the consequences of drinking more than normal would be expected to show peaks [19,20]. This could be related to Burns Night (25 January), a celebration of the Scottish poet Robert Burns.

Finally, consistent with what is known about both drinking behaviour and alcohol-related mortality, the majority of the alcohol topics we examined had a significantly higher likelihood of being the subject of internet searches in Scotland compared to England throughout the year. Further work is warranted to assess whether any degree of convergence in levels of selected alcohol queries between Scotland and other parts of the United Kingdom might indicate convergence in drinking behaviour and harms. It is particularly striking that queries for 'alcohol problems' are so much higher in Scotland than in England in 2018, despite the fact that this topic did not produce a notable signal at the time of MUP. This is consistent with Scotland having higher levels of alcohol consumption and alcohol-related harms than England [1,2,21].

Strengths and limitations

By definition, the population we have studied is restricted to those people who have access to and are able to use search engines. In the period January–March 2018, 89% of Scottish adults had used the internet in the previous 3 months compared to 90% for the United Kingdom as a whole [22]. Levels of internet use increase as age declines. From this survey, 97% of adults aged 45–54 years and 99% aged 16–44 years had used the internet during the past 3 months. It is well established that consumption levels [23] and the prevalence of harmful drinking are highest among those of working age [24], and to this extent not having access to the internet is very unlikely to have biased our results.

Our main analyses were based on searches conducted using the Bing search engine. The downside of this is that in 2018 it had only a small market share in the United Kingdom of approximately 9% [14], compared to approximately 87% for Google. However, prior work has not found

a difference in the representativeness of the two search engines [25,26], although there has not been a specific comparison between Scotland and England. Using Bing had the advantage of allowing us to look at the absolute frequencies of search terms, as we analysed a data set comprised of records for each search. The equivalent Google data that to which we had access did not include absolute frequencies. The Bing data allowed us to estimate uncertainty intervals around the relative frequencies for each search topic which requires knowledge of absolute frequencies.

Finally, as we have acknowledged in earlier parts of the paper, our study can only tell us about what people looked for on the internet. Whether the results of any searches they conducted influenced their behaviour is unknown. Nevertheless, we believe that our finding of peaks in interest around the time of MUP for topics such as 'cost of alcohol' and 'on-line alcohol' are consistent with a motivation to act, and thus may indicate a potential impact of MUP on behaviour.

CONCLUSIONS

In conclusion, this study has illustrated that analysis of internet search engine queries is able to capture signals from a public health intervention. In particular, it provides the first population-wide evidence that a fraction of people in Scotland may have considered circumventing MUP in particular by looking for on-line sources of alcohol, some of which may not have been subject to unit price floors of MUP because they were outside Scotland. Beyond this, it has shown that the overall levels of alcohol queries in the two countries appear to mirror the higher burden of alcohol consumption and problems in Scotland than in England. Analysis of internet search engine activity should be further explored as a means of assessing the population reaction to changes in national policies in health and elsewhere.

Declaration of interests

D.A.L. and M.P. are members of the Evaluation Advisory Group for MUP (the MESAS study) established by the Scottish Government. None of the other co-authors declared any conflicts of interest.

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Author contributions

David Leon: Conceptualization; formal analysis; methodology. **Elad Yom-Tov:** Conceptualization; data curation; formal analysis; methodology; visualization. **Anne Johnson:** Conceptualization; methodology. **Mark Petticrew:** Conceptualization; methodology. **Elizabeth Williamson:** Methodology. **Vasileios Lampos:** Conceptualization; formal analysis; investigation; methodology; resources; visualization. **Ingemar Cox:** Conceptualization; methodology.

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Supporting Information

Additional supporting information may be found online in the Supporting Information section at the end of the article.

Table S1. Query terms by topic.

Figure S1. Google query likelihood over time for “MUP/alcohol price” in 2018 (blue) and mean level 2014–2017 (black dashed line) for Scotland, compared to England (red).

Figure S2. Google query likelihood over time for “Online alcohol” in 2018 (blue) and mean level 2014–2017 (black dashed line) for Scotland, compared to England (red).