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**Impact of the introduction and withdrawal of financial incentives on the delivery of alcohol screening and brief advice in English primary health care: an interrupted time series analysis**

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**Impact of the introduction and withdrawal of financial incentives on the delivery of alcohol screening and brief advice in English primary health care: an interrupted time series analysis**

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## ABSTRACT

### Aim

To evaluate the impact of the introduction and withdrawal of financial incentives on alcohol screening and brief advice delivery in English primary care.

### Design

Interrupted time series using data from The Health Improvement Network (THIN) database. Data were split into three periods: 1) before the introduction of financial incentives (1<sup>st</sup> January 2006 to 31<sup>st</sup> March 2008); 2) during the implementation of financial incentives (1<sup>st</sup> April 2008 to 31<sup>st</sup> March 2015); and 3) after the withdrawal of financial incentives (1<sup>st</sup> April 2015 to 31<sup>st</sup> December 2016). Segmented regression models were fitted, with slope and step change coefficients at both intervention points.

### Setting

England.

### Participants

Newly-registered patients (16+) in 500 primary care practices for 2006-2016 (N=4,278,723).

### Measurements

The outcome measures were percentage of patients each month who: 1) were screened for alcohol use; 2) screened-positive for higher-risk drinking; 3) were reported as having received brief advice on alcohol consumption.

### Findings

There was no significant change in the percentage of newly-registered patients who were screened for alcohol use when financial incentives were introduced. However, the percentage fell ( $p < 0.001$ ) immediately when incentives were withdrawn, and fell by a further 2.96 (95% CI 2.21-3.70) patients per 1,000 each month thereafter. After the introduction of incentives, there was an immediate increase of 9.05 (95% CI 3.87-14.23) per 1,000 patients screening positive for higher-risk drinking, but no significant further change over time. Withdrawal of financial incentives was associated with an immediate fall in

screen-positive rates of 29.96 (95% CI 19.56-40.35) per 1,000 patients, followed by a rise each month thereafter of 2.14 (95% CI 1.51-2.77) per 1,000. Screen-positive patients recorded as receiving alcohol brief advice increased by 20.15 (95% CI 12.30-28.00) per 1,000 following the introduction of financial incentives, and continued to increase by 0.39 (95% CI 0.26-0.53) per 1,000 monthly until withdrawal. At this point, delivery of brief advice fell by 18.33 (95% CI 11.97-24.69) per 1,000 patients and continued to fall by a further 0.70 (95% CI 0.28-1.12) per 1,000 per month.

### **Conclusions**

Removing a financial incentive for alcohol prevention in English primary care was associated with an immediate and sustained reduction in the rate of screening for alcohol use and brief advice provision. This contrasts with no, or limited, increase in screening and brief advice delivery rates following the introduction of the scheme.

### **Keywords**

Alcohol prevention; interrupted time series; financial incentives; primary healthcare; screening; intervention; policy.

## INTRODUCTION

Alcohol is the seventh leading global risk factor for premature death and disability, and causally related to over 60 different medical conditions, including liver cirrhosis, cancer and cardiovascular disease (1-4). In a multi-stranded approach to tackling higher-risk drinking, primary care is ideally placed for the prevention and early detection of alcohol-related problems, due to its high population coverage, accessibility, and the frequency with which higher-risk drinkers present to clinicians (5-8). Brief advice in primary care has been shown to reduce heavy drinking, alcohol-related problems, healthcare utilization and mortality (9-11). Yet despite this evidence, which is endorsed by the World Health Organisation (12) and embedded in clinical guidelines across Europe, Australasia and the USA (13-16), delivery of brief alcohol advice across global health systems remains low (17-19).

Using financial incentives to boost the delivery of evidence-based interventions in routine clinical practice is a common policy strategy in many countries. However, evidence of their impact on the quality and efficiency of healthcare remains inconclusive, particularly where long-term patient outcomes are concerned (20-23). There is also limited understanding of the impact of withdrawing incentives, although data from both the USA and United Kingdom (UK) suggest that performance levels are likely to decline, especially for quality indicators relating to the provision of health advice (24-26).

Introduced in 2004, the Quality and Outcomes Framework (QOF) is the primary system for the performance management and payment of General Practitioners (GPs) in the UK National Health Service (NHS) (27). QOF covers a range of smoking prevention indicators, however whilst practices are required to record the alcohol status of targeted patient groups, such as those with serious mental health conditions, routine implementation of alcohol screening and brief advice is excluded. In England, additional priority areas of practice not covered by the QOF are incentivised by a further set of opt-in payment schemes; the national Directed Enhanced Services (DES) (28). Reflecting their focus on preventative care (29), and in response to disappointing rates of alcohol screening and brief advice delivery achieved in England (30, 31), in 2008 the Enhanced Services were extended to cover higher-risk drinking (32).

Under the alcohol DES, participating practices were paid a small fee of £2.38 (approximately \$3.04 or €2.71) for each newly-registered adult patient they screened to identify higher-risk drinking using a validated self-report questionnaire (33). This compares to £140.00 (\$176.19 or €157.08) paid per patient to practices for delivering health checks to people aged 14+ with learning disabilities (DES also introduced in 2008), and to a maximum of £11,472.64 (\$14,436.29 or €12,872.39) per practice for implementing various smoking identification and treatment services. The alcohol DES was withdrawn in April 2015, replaced by a requirement for practices to identify newly-registered adult patients drinking above recommended levels under the General Medical Services contract (34). Thus whilst GPs are still legally obliged to identify and support higher-risk drinkers in England, they are no longer specifically financially rewarded for carrying out this work.

There are few published data on the impact of the DES on alcohol prevention work in English primary care. One small study conducted in Northern England found that practices receiving financial incentives for alcohol work during 2010-2011 recorded higher rates of alcohol screening and brief advice delivery compared to those not receiving additional payments, although overall, rates remained low (35). However, there has been no nationally representative evaluation of either the impact of financial incentives on the full alcohol prevention pathway from identification (screening) to intervention (advice), or any potential effect of withdrawing the alcohol DES on overall delivery rates.

We sought to assess the impact of the introduction and subsequent withdrawal of financial incentives on recorded rates of: 1) newly-registered patients screened for higher-risk alcohol consumption; 2) patients screening positive; and 3) delivery of brief alcohol advice in English primary care.

## **METHODS**

### **Data source**

We used data from The Health Improvement Network (THIN); a primary care database containing electronic patient records from 500+ general practices, approximately six per cent of UK patients. It is broadly representative of the national population in terms of age, sex, deprivation, and geographical distribution (36). THIN contains details of symptoms,

diagnoses, prescriptions, test results, health indicators and the Townsend deprivation index; a composite measure of social deprivation presented as quintiles (37). Information can be entered by practitioners into the database as free text or codified using alpha-numeric Read Codes. Until replaced by SNOMED CT (Systematized Nomenclature of Medicine - Clinical Terms) on 1<sup>st</sup> April 2018, Read Codes were the standard clinical terminology used to record care in electronic patient records across all UK general practices (38, 39).

To ensure that data of an acceptable standard were included for analysis, individual practices were only eligible if their data were published after the Acceptable Mortality Reporting (AMR) (40) and Acceptable Computer Usage (ACU) dates (41). These are THIN-specific quality measures of the extent to which mortality data are entered on the computer (AMR) and the computer is used for general recording of patient information (ACU). Both markers are applied to the data from each general practice.

Newly-registered patients (defined as within the previous twelve-month period) aged 16 to 99 years, and registered with a practice that had been contributing data to THIN for at least two years prior to the patients' registration date, were eligible for inclusion. Owing to low numbers of new registrations, and a small number of patient records suggesting implausibly high ages, patients with recorded ages of 100+ were excluded from analysis.

Use of THIN for scientific research was approved by the NHS South-East Multi-Centre Research Ethics Committee in 2003. Scientific approval to undertake this study was obtained from IQVIA World Publications Scientific Review Committee (SRC) in January 2017 (SRC Reference Number: 16THIN098).

### **Outcome measures**

The following variables comprised the basis of our outcome indicators:

1. Percentage of eligible patients aged 16+ screened for higher-risk drinking using a validated screening questionnaire (42-45) or questions to ascertain their level of alcohol consumption;
2. Percentage of screened patients identified as higher-risk drinkers based on UK guidelines (13);
3. Percentage of screen positive patients who received brief advice about their drinking.



The design of the alcohol DES meant that practices were only required to record their screening of newly-registered patients to qualify for payment. By including recorded rates of screen positives, and rates of those screen-positives subsequently receiving brief advice, we sought to identify whether appropriate patients received support for higher-risk drinking.

Every recorded consultation was compared against a list of Read Codes corresponding to each of the above indicators. This list comprised both the specific Read Codes that practices were required to use in order to trigger alcohol DES payments (32), alongside unrefined, more inclusive lists of Read codes relating to the identification and treatment of higher-risk drinking identified by previous studies (46, 47) and the clinical codes repository (48). A list of all Read Codes used in our analyses is provided in supplementary [File 1](#).

### **Statistical analysis**

We used interrupted time series analysis (ITS), a quasi-experimental study design (49, 50). We calculated monthly rates (%) and 95% confidence intervals for each outcome indicator for the period 1<sup>st</sup> January 2006 to 31<sup>st</sup> December 2016. Rates were plotted graphically to allow us to visualise trends over time, including an initial assessment of any change occurring pre- and post- the two intervention points of interest: (1) introduction of the alcohol DES on 1<sup>st</sup> April 2008; (2) withdrawal of financial incentives on 31<sup>st</sup> March 2015.

We used segmented regression analysis to quantify the magnitude of the impact of the two interventions on our outcomes of interest. For ease of interpretation of results, we converted outcome measures from proportions to rates per 1,000 patients. Models were specified to allow a linear underlying trend in each outcome, and for each intervention to have both an immediate change in the outcome and to alter the underlying trend (i.e. to change both the intercept and the slope of the fitted trends, see supplementary [File 2](#)). We hypothesised that the introduction of incentives in 2008 would increase activity rates, and that withdrawal in 2015 would reduce their delivery. All models were assessed visually for seasonality, and alternative methods to account for these tested (including either harmonic functions of the month variable or separate month dummies in the model). Final model selection was made on the basis of minimising Bayesian and Akaike Information Criteria (51). A Durbin-Watson test (52) suggested some residual autocorrelation, even after controlling for seasonality, and we therefore report Newey-West standard errors. As data

were aggregated across all THIN practices, there was no need to account for clustering of patients within practices in the analysis.

### **Sensitivity analysis**

Initial inspection of the data showed that few consultations had separate Read Codes for both a positive screening score and the delivery of alcohol brief advice. We therefore conducted a sensitivity analysis where we used the proportion of all patients recorded as being screened who had received advice as an outcome, irrespective of whether the screening result itself was recorded. Next, as guidelines recommend that very heavy drinkers are likely to need support beyond simple brief advice (13), in a further sensitivity analysis, we examined the impact of additionally including Read Codes associated with referring patients to specialist alcohol treatment services in the definition of receiving alcohol brief advice.

### **RESULTS**

Table 1 shows demographic characteristics of: all patients aged 16-99 in the full THIN database (age strata based on age at registration); registered with a new practice between 1<sup>st</sup> January 2006 and 31<sup>st</sup> December 2016; and recorded as experiencing each of the three outcome measures (screening, screening positive, receiving alcohol brief advice). This shows our patient sample was relatively less deprived but the age spread reflected that found in the national population (53).

INSERT TABLE 1 HERE

Rates for each outcome measure (including 95% confidence intervals) are shown in Figure 1. This shows that the screening rate for newly-registered patients remained relatively stable until the withdrawal of financial incentives in 2015. Rates of newly-registered patients screening positive for higher-risk drinking increased steadily until 2012, then fell back slightly before rising sharply at the start of 2016. However, following a time-limited increase in recorded intervention delivery to screen-positive patients between 2009-11, rates have subsequently declined. In the following section, we assess the significance of these trends.

INSERT FIGURE 1 HERE

### **Time trends in alcohol screening**

Table 2 shows the full results for the final ITS models for all three outcome measures; coefficients represent beta values from the specified linear regression models. Screening rates were the only outcome for which a seasonal adjustment was required, with more than ten additional screenings per 1,000 patients in September and October than in any other month. We speculated that this was potentially related to trends in new registrations amongst higher education students at the start of each academic year. Subsequent analysis appears to corroborate this, showing both higher rates of registration and higher rates of screening in 16-24 year olds in these months compared to the rest of the year, an effect not observed in other age groups (see supplementary [File 3](#)).

INSERT TABLE 2 HERE

For Review Only

### **Newly-registered patients screened for heavy drinking**

At the start of the analysis period (1<sup>st</sup> January 2006), 92 out of every 1,000 eligible patients were screened each month, with the screening rate increasing slowly thereafter. There was no significant change at the point when financial incentives were introduced in April 2008. However, there was a significant ( $p < 0.001$ ) shift in this temporal trend on their withdrawal in March 2015, with rates falling by 2.96 (95% CI 2.21-3.70) patients per 1,000 each month thereafter. These trends are illustrated in Figure 2.

INSERT FIGURE 2 HERE

It should be noted that these data (Figure 2) represent the proportion of eligible patients screened each month during the analysis period. The proportion of patients screened within the eligible window (12 months post-registration) was higher, averaging around 65% of all newly-registered patients during the DES period (see supplementary [File 4](#)).

### **Newly-registered patients screening positive for heavy drinking**

At the start of the analysis period, 104 in every 1,000 newly-registered patients who were screened were also recorded as screening positive for higher-risk drinking. As with the screening rate, this increased steadily prior to the introduction of financial incentives. After the introduction of incentives, there was an immediate increase of 9.05 (95% CI 3.87-14.23) per 1,000 in the rate of screen positives; however there was no significant change in the rate at which this increased over time. Withdrawal of financial incentives was associated with a fall in screen positive rates of 29.96 (95% CI 19.56-40.35) per 1,000 patients but a rise in the monthly increase in this rate of 2.14 (95% CI 1.51-2.77) per 1,000. Figure 3 illustrates these trends graphically.

INSERT FIGURE 3 HERE

### **Delivery of brief alcohol advice to newly-registered screen positive patients**

Fewer than 15 in every 1,000 screen positive patients were recorded as receiving brief advice at the start of the analysis period. This rate increased by 20.15 (95% CI 12.30-28.00) per 1000 patients following the introduction of financial incentives in 2008, and continued to increase by 0.39 (95% CI 0.26-0.53) per 1,000 each month thereafter up to the point at which incentives were withdrawn. At this point, delivery of brief advice fell by 18.33 (95% CI 11.97-24.69) per 1,000

patients and continued to fall by a further 0.70 (95% CI 0.28-1.12) per 1,000 per month. Figure 4 shows these trends.

INSERT FIGURE 4 HERE

Between April 2015 and December 2016, our modelling estimates suggest that 36,223 fewer patients were screened, and 1,646 fewer patients received brief advice in our sample THIN population than if the incentives had not been withdrawn.

### **Sensitivity analyses**

Using data on all screened patients who received alcohol brief advice as our denominator, instead of only those recorded as screening positive, substantially reduced overall delivery rates, but made no substantive difference to our findings. Similarly, including Read Codes relating to specialist treatment referrals alongside those for delivery of alcohol brief advice did not meaningfully alter our results (see supplementary [File 4](#)).

### **Exploratory analysis**

Across all three outcome measures, particularly receipt of alcohol brief advice, visual inspection of the delivery rates over time suggested that there may have been a delay in the effect of one or both of the interventions (introduction and withdrawal of financial incentives). We therefore used R's *change point* package to identify potential turning points in the time series for each outcome (54). This analysis showed some evidence for a lag of around 6 months for the initial effect of the introduction of incentives to affect screen positive and brief advice rates, and a potential lag of 7-10 months for the effect of withdrawing them to be felt (see supplementary [File 5](#)).

## **DISCUSSION**

Our analysis of electronic health records shows that the introduction of financial incentives for alcohol prevention work had limited success in improving rates of newly-registered patients screened for higher-risk drinking in English primary care. However, their withdrawal in March 2015 saw an immediate and significant drop in rates of both alcohol screening and the delivery of brief advice; a downward trend that has continued since. At the end of our analysis period (December 2016), although general practices are now contractually required to deliver alcohol screening and brief advice, fewer than three per cent of patients in our sample identified as drinking above

recommended limits were recorded as receiving appropriate support. Scaling-up our findings to the English population would suggest that up until the end of 2016, 603,719 fewer adult patients were screened for higher-risk drinking, and 27,439 fewer patients received brief advice, as a result of terminating the alcohol DES.

This study represents the first large-scale assessment of the impact of financial incentives on alcohol screening and brief advice in primary care. Two studies in England found that using incentives targeted at patients with mental health and/or cardiovascular conditions led to a significant increase in alcohol screening rates (55, 56). Evidence for the effectiveness of financial incentives for alcohol prevention in general primary care populations is more equivocal. The five-country ODHIN trial reported positive impacts of using incentives to encourage implementation of screening and alcohol brief advice (57, 58). However, increases were not fully sustained at the 12-week follow-up after incentives were withdrawn. Previous research suggests that whilst the introduction of financial incentives can stimulate immediate improvements in healthcare, returns are likely to stagnate over time (59, 60). One case study in Northern England detected slightly higher levels of screening and advice delivery in DES-incentivised compared to non-incentivised practices, but found low levels of alcohol prevention activity irrespective of incentive status (35). Whilst our findings suggest that overall, screening rates for newly-registered patients within the full 12 months post-registration period were relatively high, other studies confirm the low levels of screening carried out in the general patient population (19). Further, and importantly, these results highlight the significant decline in screening rates since incentives were withdrawn.

No other study has assessed the impact of withdrawing financial incentives on alcohol prevention in primary care. There is limited published evidence on what happens when financial incentives are removed for healthcare performance in general, and findings to date have conflicted (24-26). On balance, it appears that the risks of withdrawing incentives may be small when specific clinical practices have already achieved high levels of quality, acceptance and adoption amongst providers (26), but outcomes for other aspects of care may be more negative. Two recent evaluations of the retirement of a series of QOF indicators found that performance in all areas fell after the incentive was removed, but the drop was largest for those indicators generally considered less relevant and acceptable to GPs (61), and those associated with the provision of health advice (25). GPs' resistance to routine implementation of alcohol advice in English primary care is well-documented

(19, 35, 62). As such, the sharp downward trend in delivery rates of alcohol screening and brief advice once incentives were withdrawn reported here should have been anticipated.

The main strength of our study was the use of a large dataset representing over four million newly-registered patients, drawn from a representative sample of several hundred practices. Additionally, whilst the randomized controlled trial remains the research 'gold-standard', interrupted time series analysis provides a strong alternative where an experimental study design is infeasible or unethical (49), such as the evaluation of policy initiatives in healthcare (50). Importantly, our data cover multiple time-points over 11 years of electronic health records. At the same time, whilst our analytic approach was pre-specified, we recognise that alternative methods exist for the analysis of time series data. These include more complex approaches, such as Generalised Additive Mixed Models (GAMM), that can account for higher order autocorrelation and more complex seasonal patterns (63).

Some ecological limitations also exist. In particular, the potential impact of additional or competing policies on our outcomes of interest is acknowledged. Between 2006-2016, relevant policies include the publication of NICE guidelines for preventing the development of hazardous and harmful drinking in June 2010 (13), and the 2012 Alcohol Strategy (64), alongside a change in UK Government, and the subsequent reorganisation of primary care and public health in England. Additionally, duty rates for several alcoholic beverages were reduced immediately prior to the withdrawal of financial incentives in March 2015 (65). However, our change point analysis does not provide strong support for a single consistent effect of any of these potentially confounding policies across all outcomes. Next, we focussed on new registrants only so are unable to draw conclusions with regards to any changes in alcohol screening and advice delivery to existing patients. Previous modelling work demonstrates that screening focussed on new registrations represents a cost-saving and cost-effective approach to encouraging alcohol prevention in primary care, which is less resource-intensive than screening existing patients at their next GP consultation (66). Additionally, whilst the THIN dataset is nationally representative, we lack information on which practices in our dataset opted into the alcohol DES during the analysis period. However, other mandatory schemes would have affected alcohol prevention recording, such as NHS Health Checks for patients aged 40-75, irrespective of incentive status. Moreover, since 1<sup>st</sup> April 2015, all practices are required to screen newly-registered as part of their general contractual obligations (34).

There are also limitations of using routine clinical datasets, such as Read Code data, for research and evaluation purposes (67). Although UK guidelines require that every clinical encounter is recorded on the computer system in primary care (68), there is evidence that the use of pay-for-performance can distort recoding practice, with clinicians tending to prioritise recording of data corresponding to delivery of incentivised areas of care (69). In the case of alcohol screening and brief advice, previous research suggests that concerns around the adverse social and legal consequences of identifying patients with socially stigmatised conditions (70), and the low priority accorded to recording preventative interventions such as alcohol advice (71), has more generally resulted in under-coding of care (35). Changes in the Read Codes available for recording alcohol activity, such as the introduction of new codes in 2008 as part of the DES specification, also affect our ability to evaluate delivery rates accurately (72). However, by employing a comprehensive approach to generate lists of Read Codes to assess performance against our outcome measures, we sought to minimise the impact of such coding artefacts on analysis. Importantly, publicly available data on the delivery of GP Contract Services for the period 2013 to 2018 further corroborates the fall we have identified in alcohol screening rates. NHS Digital data show that 74% of newly-registered patients were recorded as being screened within 12 months of registration in 2014-15, but this fell to 48% in 2015-16 after financial incentives were withdrawn (73).

Several factors may have contributed to the low delivery of alcohol screening and brief advice delivery in English primary care. First, limited take-up could be linked to the design of the alcohol incentive scheme itself. Other studies have reported that the low remuneration levels associated with the alcohol DES meant that screening and advice were given lower priority compared to other more lucrative areas of primary care, such as those covered by the QOF (35, 62). Further, as clinicians were incentivised for screening patients alone, subsequent delivery of alcohol advice may have been under-recorded and less prioritised. The distorting effects of incentivising process as opposed to outcomes in healthcare have been criticised, including by the current UK Government (74). From a public health perspective, there is limited value in rewarding clinicians for identifying heavy drinkers if those patients are not subsequently offered appropriate support.

Second, systematic review findings also suggest that financial incentives are more likely to have a positive and sustained impact when they target practices: where a robust evidence base exists; that align with organisational goals; and have strong provider support (20, 75, 76). In the case of alcohol prevention, although more than 70 RCTs have shown that primary care-based screening



and brief advice is clinically- and cost-effective (9), there is less evidence that clinicians themselves are willing to devote limited consultation time to their provision (77). Moreover, even in areas of practice that have strong support, evidence from behavioral economics highlights the risk that using extrinsic (monetary) incentives to encourage performance may conversely reduce ('crowd-out') a clinician's intrinsic motivation to deliver care, particularly over the longer-term (78-80).

Third and finally, for policymakers considering using short-term incentives to boost clinicians' delivery of preventative healthcare practices, our study further highlights the potential for substantial adverse effects on service provision once payments are withdrawn (81). Adding such practices to clinicians' contractual obligations to ensure their continued delivery is an important first step, but must be closely monitored thereafter, with clear penalties enforced for under-performance. In England, the government introduced another time-limited pay-for-performance scheme for screening and brief advice provision in secondary care via the NHS Commissioning for Quality and Innovation (CQUIN) alcohol indicator (82), despite less clear evidence for effectiveness compared to primary care settings (83). Until March 2020, secondary care providers will receive a payment based on the percentage of eligible adult patients admitted for at least one night and asked about their alcohol use, and subsequently given advice or offered specialist support as appropriate. Given the results reported here, we suggest any future changes to the alcohol CQUIN are implemented with care.

## **CONCLUSION**

Removing a financial incentive for alcohol prevention led to an immediate and sustained reduction in recorded rates of screening and brief advice delivered to newly-registered patients in English primary care. This contrasts with the limited and gradual gains achieved by the original introduction of the scheme. These findings highlight the potential adverse consequences of using short-term financial incentives to boost implementation of alcohol prevention in primary healthcare.

## **Declarations of interest**

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## TABLES AND FIGURES

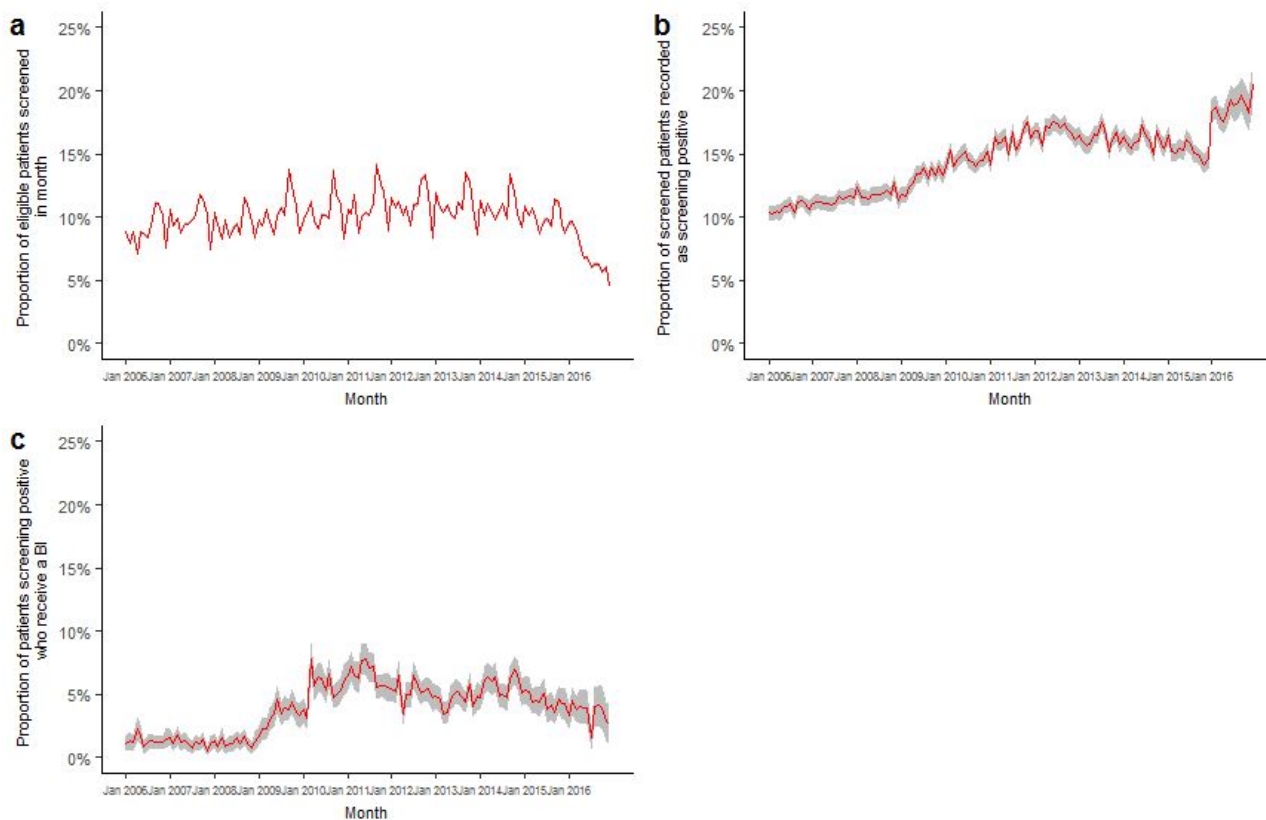
**Table 1 - Demographic characteristics of included patients: n(%)**

	<b>Newly-registered patients (N=4,278,723)</b>	<b>Patients screened for heavy drinking (N=2,510,055)</b>	<b>Patients screening positive for heavy drinking (N=212,179)</b>	<b>Patients receiving Brief Intervention (N=23,208)</b>
Mean age (SD) *	39.9 (18.8)	37.5 (16.5)	37.9 (14.7)	38.3 (15.7)
16-24	994544 (23.2)%	587707 (23.4)%	44650 (21)%	5023 (21.6)%
25-34	1177382 (27.5)%	789137 (31.4)%	59063 (27.8)%	6527 (28.1)%
35-44	723348 (16.9)%	451124 (18)%	44024 (20.7)%	4374 (18.8)%
45-54	467306 (10.9)%	276422 (11)%	31704 (14.9)%	3335 (14.4)%
55-64	350280 (8.2)%	189885 (7.6)%	20691 (9.8)%	2225 (9.6)%
65-74	250973 (5.9)%	112466 (4.5)%	9066 (4.3)%	1180 (5.1)%
75-99	314890 (7.4)%	103314 (4.1)%	2981 (1.4)%	544 (2.3)%
Female	2322459 (54.3)%	1354510 (54)%	82444 (38.9)%	9855 (42.5)%
Townsend Q1 (least deprived)	709025 (19.4)%	388700 (17.9)%	37388 (20.3)%	2695 (12.7)%
Townsend Q2	715949 (19.6)%	394543 (18.2)%	35551 (19.3)%	3484 (16.5)%
Townsend Q3	827178 (22.7)%	490743 (22.6)%	42017 (22.8)%	4787 (22.6)%
Townsend Q4	802933 (22)%	504983 (23.3)%	39844 (21.6)%	5425 (25.6)%
Townsend Q5 (most deprived)	592206 (16.2)%	389004 (17.9)%	29690 (16.1)%	4786 (22.6)%

\* Age at date of registration



**Figure 1: Rates of eligible patients a) screened; b) screening positive; c) receiving alcohol brief advice 1<sup>st</sup> January 2006 – 31<sup>st</sup> December 2016.**

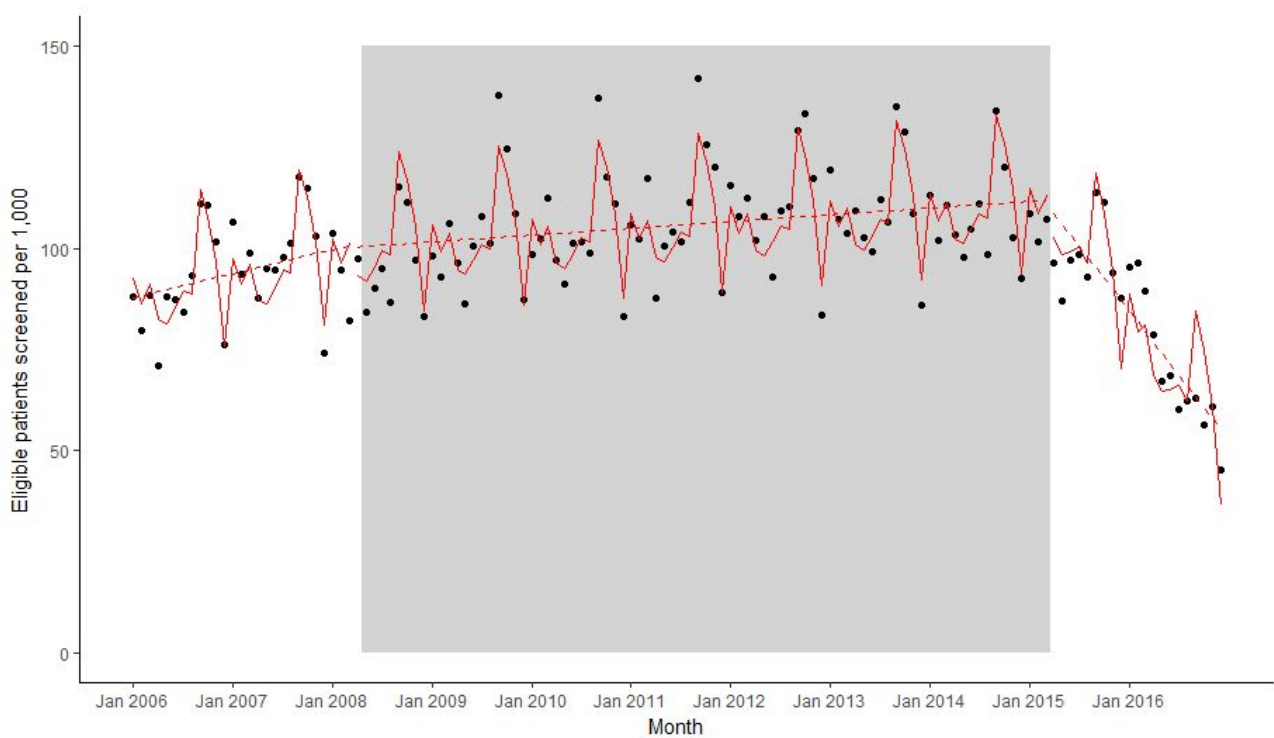


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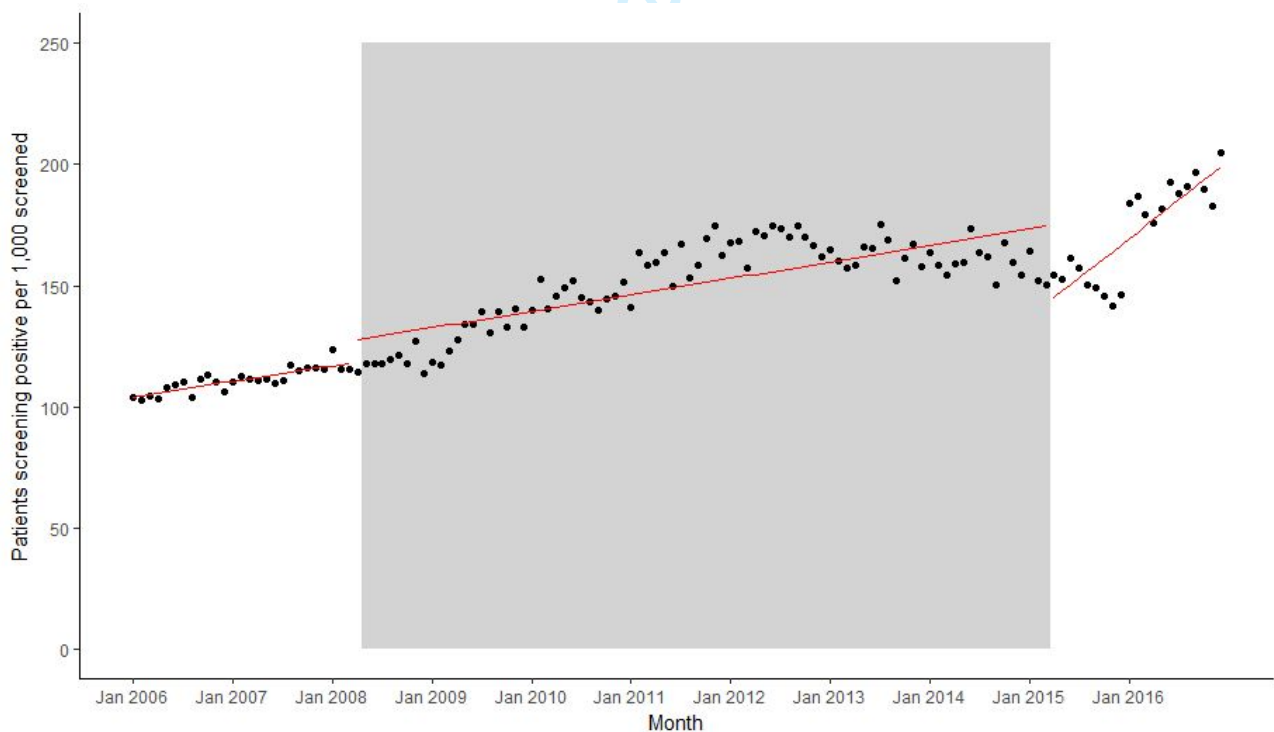




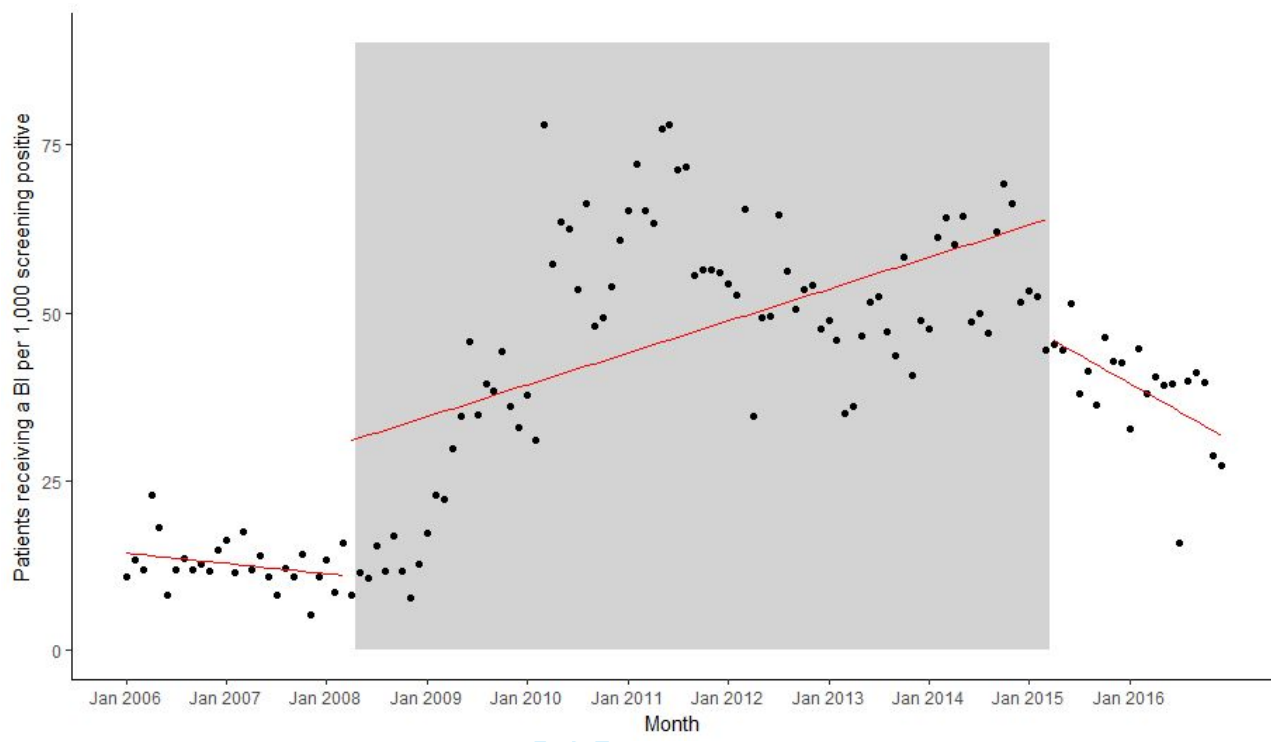
**Figure 2: Eligible patients screened between 1<sup>st</sup> January 2006 and 31<sup>st</sup> December 2016: Observed (black dots) and modelled screening rates with (dashed red line) and without (solid red line) seasonal adjustment**



**Figure 3: Eligible screen positive patients between 1<sup>st</sup> January 2006 and 31<sup>st</sup> December 2016: Observed (black dots) and modelled (red line)**



**Figure 4: Brief advice delivery to eligible patients between 1<sup>st</sup> January 2006 and 31<sup>st</sup> December 2016: Observed (black dots) and modelled (red line) trends**



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**Supplementary file (1) List of Read Codes used in Analyses****Table 1: All Alcohol Screening Read Codes**

Read Code	Description	Value <sup>1</sup>		
		Male	Female	Upper
<b><i>Incentivised (DES) Alcohol Screening Read Codes<sup>2</sup></i></b>				
388u.00	Fast alcohol screening test	3	3	16
9k15.00	Alcohol screen - AUDIT completed	8	8	40
9k16.00	Alcohol screen - fast alcohol screening test completed	3	3	16
9k17.00	Alcohol screen - AUDIT C completed	5	5	12
<b><i>Non-incentivised Alcohol Screening Read Codes<sup>3</sup></i></b>				
38D2.00	Single alcohol screening questionnaire	1	1	1
38D3.00	Alcohol use disorders identification test	8	8	40
38D4.00	Alcohol use disorder identificatn test consumptn questionre	5	5	12
38D5.00	Alcoh use disor id test Piccinelli consumption questionnaire	5	5	20
38Df.00	Five-shot questionnaire on heavy drinking	2.5	2.5	5
8IH4.00	Alcohol Use Disorders Identification Test declined			
9k1..00	Alcohol misuse - enhanced services administration			
9k12.00	Alcohol misuse - enhanced service completed			
9k13.00	Alcohol questionnaire completed			
9k18.00	Alcohol screen - AUDIT PC completed			
9k19.00	Alcohol assessment declined - enhanced services admin			
9k19.11	Alcohol assessment declined			
ZR1E.00	Alcohol dependence scale	9	9	25
ZR1E.11	ADS - Alcohol dependence scale	9	9	25
ZR1F.00	Alcohol use disorders identification test	8	8	40
ZR1F.11	AUDIT - Alcohol use disorders identification test	8	8	40
ZR1G.00	Alcohol use inventory			
ZR3f.00	Comprehensive drinker profile			
ZR3f.11	CDP - Comprehensive drinker profile			
ZRa1.00	Michigan alcoholism screening test	4	4	50
ZRa1.11	MAST - Michigan alcoholism screening test	4	4	50
ZRa1100	Brief Michigan alcoholism screening test	6	6	

<sup>1</sup> Values representing positive screening score provided where relevant, including for men/women as appropriate.

<sup>2</sup> No specific codes were available to indicate a positive FAST or AUDIT-C test so GPs were asked to add a value to a field associated with the code.

<sup>3</sup> In addition to standard screening tests, this includes Read Codes representing lower versus higher risk alcohol consumption assessments.

ZRa1111	BMAST - Brief Michigan alcoholism screening test	6	6	
ZRa1200	Short Michigan alcoholism screening test	3	3	13
ZRa1211	SMAST - Short Michigan alcoholism screening test	3	3	13
6892.00	Alcohol consumption screen			
68S..00	Alcohol consumption screen			
8IA7.00	Alcohol consumption screening test declined			
<b><i>Non-incentivised Alcohol Consumption Read Codes</i></b>				
1361.00	Teetotaller			
1361.11	Non-drinker alcohol			
1361.12	Non-drinker alcohol			
1362.00	Trivial drinker - <1u/day			
1362.11	Drinks rarely			
1362.12	Drinks occasionally			
1363.00	Light drinker - 1-2u/day			
1364.00	Moderate drinker - 3-6u/day			
1365.00	Heavy drinker - 7-9u/day			
1366.00	Very heavy drinker - >9u/day			
1367.00	Stopped drinking alcohol			
1368.00	Alcohol consumption unknown			
1369.00	Suspect alcohol abuse - denied			
136A.00	Ex-trivial drinker (<1u/day)			
136a.00	Increasing risk drinking			
136B.00	Ex-light drinker - (1-2u/day)			
136b.00	Feels should cut down drinking			
136C.00	Ex-moderate drinker - (3-6u/d)			
136c.00	Higher risk drinking			
136D.00	Ex-heavy drinker - (7-9u/day)			
136d.00	Lower risk drinking			
136e.00	Declines to state current alcohol consumption			
136E.00	Ex-very heavy drinker-(>9u/d)			
136F.00	Spirit drinker			
136G.00	Beer drinker			
136H.00	Drinks beer and spirits			
136I.00	Drinks wine			
136J.00	Social drinker			
136K.00	Alcohol intake above recommended sensible limits			
136L.00	Alcohol intake within recommended sensible limits			
136M.00	Current non drinker			
136N.00	Light drinker			
136O.00	Moderate drinker			
136P.00	Heavy drinker			
136Q.00	Very heavy drinker			

136R.00	Binge drinker			
136S.00	Hazardous alcohol use			
136T.00	Harmful alcohol use			
136V.00	Alcohol units per week	14	14	99
136W.00	Alcohol misuse			
136X.00	Alcohol units consumed on heaviest drinking day			
136Z.00	Alcohol consumption NOS			
E23..12	Alcohol problem drinking			
E250.00	Nondependent alcohol abuse			
E250.12	Hangover (alcohol)			
E250.14	Intoxication - alcohol			
E250000	Nondependent alcohol abuse, unspecified			
E250100	Nondependent alcohol abuse, continuous			
E250200	Nondependent alcohol abuse, episodic			
E250300	Nondependent alcohol abuse in remission			
E250z00	Nondependent alcohol abuse NOS			
ZV11300	[V]Personal history of alcoholism			
ZV4KC00	[V] Alcohol use			

**Table 2: All Alcohol Advice Read Codes**

Read Code	Description
<b><i>Incentivised (DES) Alcohol Advice Read Codes</i></b>	
8CAM.00	Patient advised about alcohol
9k1A.00	Brief intervention for excessive alcohol consump <sup>tn</sup> completed
9k1B.00	Extended intervention for excessive alcohol consump <sup>tn</sup> complt
<b><i>Non-incentivised Alcohol Advice Read Codes</i></b>	
6792	Health ed. - alcohol
67A5.00	Pregnancy alcohol advice
67H0.00	Lifestyle advice regarding alcohol
8BA8.00	Alcohol detoxification
8BA <sup>s</sup> .00	Alcohol relapse prevention
8BA <sup>u</sup> .00	Alcohol harm reduction programme
8BA <sup>w</sup> .00	Alcohol twelve step programme
8CAM000	Advised to abstain from alcohol consumption
8CA <sup>v</sup> .00	Advised to contact primary care alcohol worker
8CdK.00	Specialist alcohol treatment service signposted
8CE1.00	Alcohol leaflet given
8Cx0200	Family wellbeing discussion about alcohol
8G32.00	Aversion therapy - alcoholism
8H35.00	Admitted to alcohol detoxification centre
8H7 <sup>p</sup> .00	Referral to community alcohol team
8HHe.00	Referral to community drug and alcohol team
8HkG.00	Referral to specialist alcohol treatment service
8HKJ.00	Referral to alcohol brief intervention service

8Hq..00	Admission to substance misuse detoxification centre
8IA7.00	Alcohol consumption screening test declined
8IAF.00	Brief intervention for excessive alcohol consump <sup>tn</sup> declined
8IAJ.00	Declined referral to specialist alcohol treatment service
8IAt.00	Extended interven for excessive alcohol consumption declined
8IEA.00	Referral to community alcohol team declined
8W2..00	Refer to MH services deferred until alcohol misuse resolved
9k11.00	Alcohol consumption counselling
9k14.00	Alcohol counselling by other agencies
9NJz.00	In-house alcohol detoxification
9NN2.00	Under care of community alcohol team
Z191.00	Alcohol detoxification
Z191100	Alcohol withdrawal regime
Z191200	Planned reduction of alcohol consumption
Z191211	Alcohol reduction programme
Z191300	Controlled drinking regime
Z191400	Self-monitoring of alcohol intake
Z4B1.00	Alcoholism counselling
ZC22100	Advice to change drink intake
ZC22200	Advice to change alcoholic drink intake
ZC2H.00	Advice to change alcohol intake
ZG23100	Advice on alcohol consumption
ZV6D600	[V]Alcohol abuse counselling and surveillance

**Supplementary file (2) Time series model specification***Table 1: Model specification for time series analysis of all outcomes*

<b>Month</b>	<b>1</b>	<b>2</b>	<b>...</b>	<b>27</b>	<b>28</b>	<b>29</b>	<b>30</b>	<b>...</b>	<b>111</b>	<b>112</b>	<b>113</b>	<b>114</b>	<b>...</b>
<b>Intervention 1 intercept</b>	0	0		0	1	1	1		1	1	1	1	
<b>Intervention 1 slope</b>	0	0		0	1	2	3		84	85	86	87	
<b>Intervention 2 intercept</b>	0	0		0	0	0	0		0	1	1	1	
<b>Intervention 2 slope</b>	0	0		0	0	0	0		0	1	2	3	

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**Supplementary file (3) Time trends in new registrations**

Figure 4 shows the total number of registrations in THIN across the full analysis period (2006-2016) by month and age of patient at the point of registration. This clearly shows that registration levels are highest in September and October and that this is driven by increased levels of registration in the 16-19 and 20-24 year-old age groups.

**Figure 1: Total number of registrations in THIN across the full analysis period (2006-2016) by month and age of patient at the point of registration.**

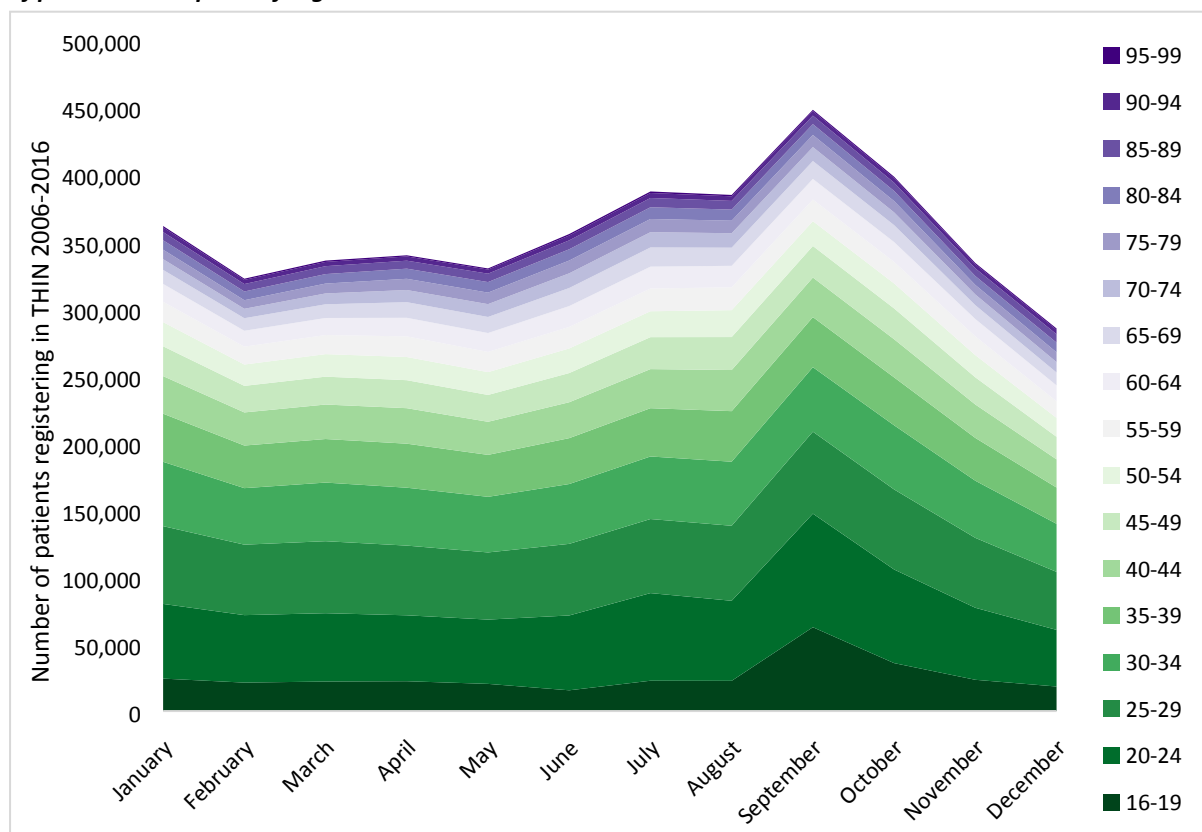
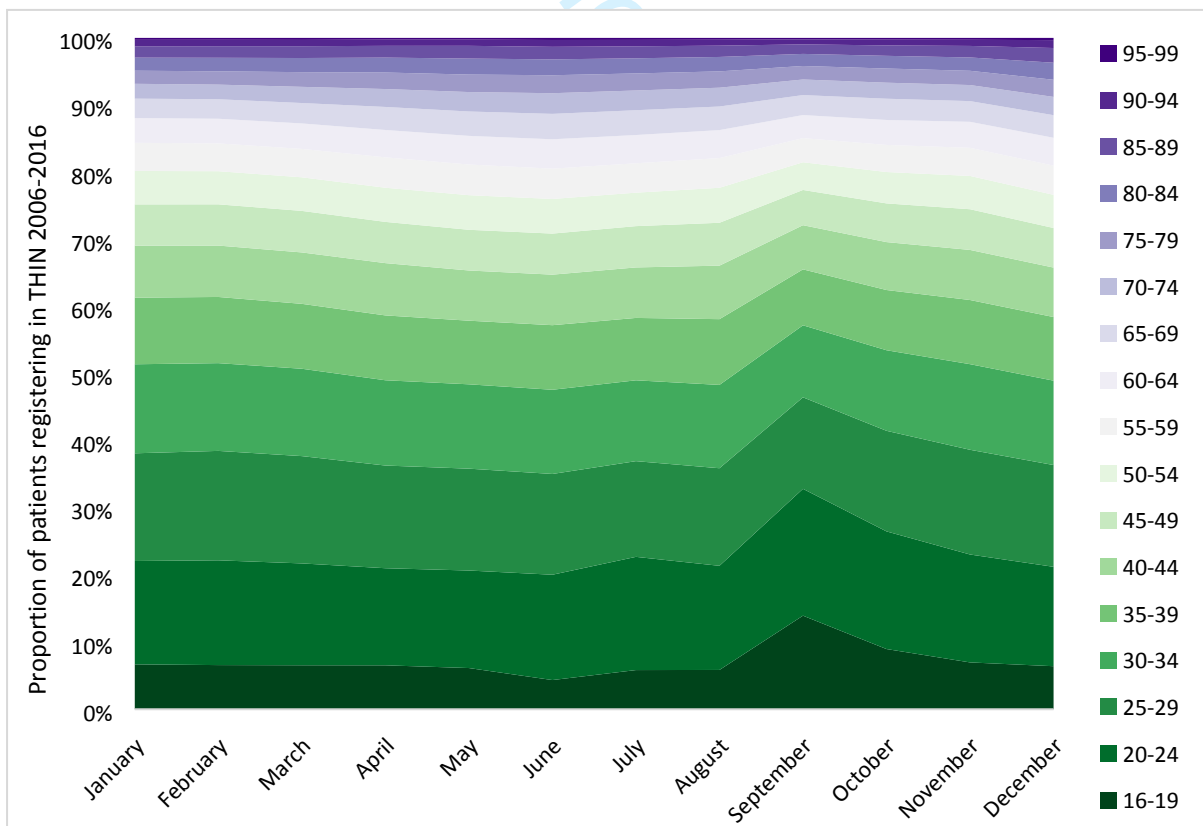


Table 6 shows 16-24 year old registrants as a proportion of all newly registering patients, and Figure 5 presents this graphically, further reinforcing that this group are a much greater proportion of newly registering patients in September and October than in other months.

**Table 1: 16-24 year old registrants as a proportion of all newly registering patients**

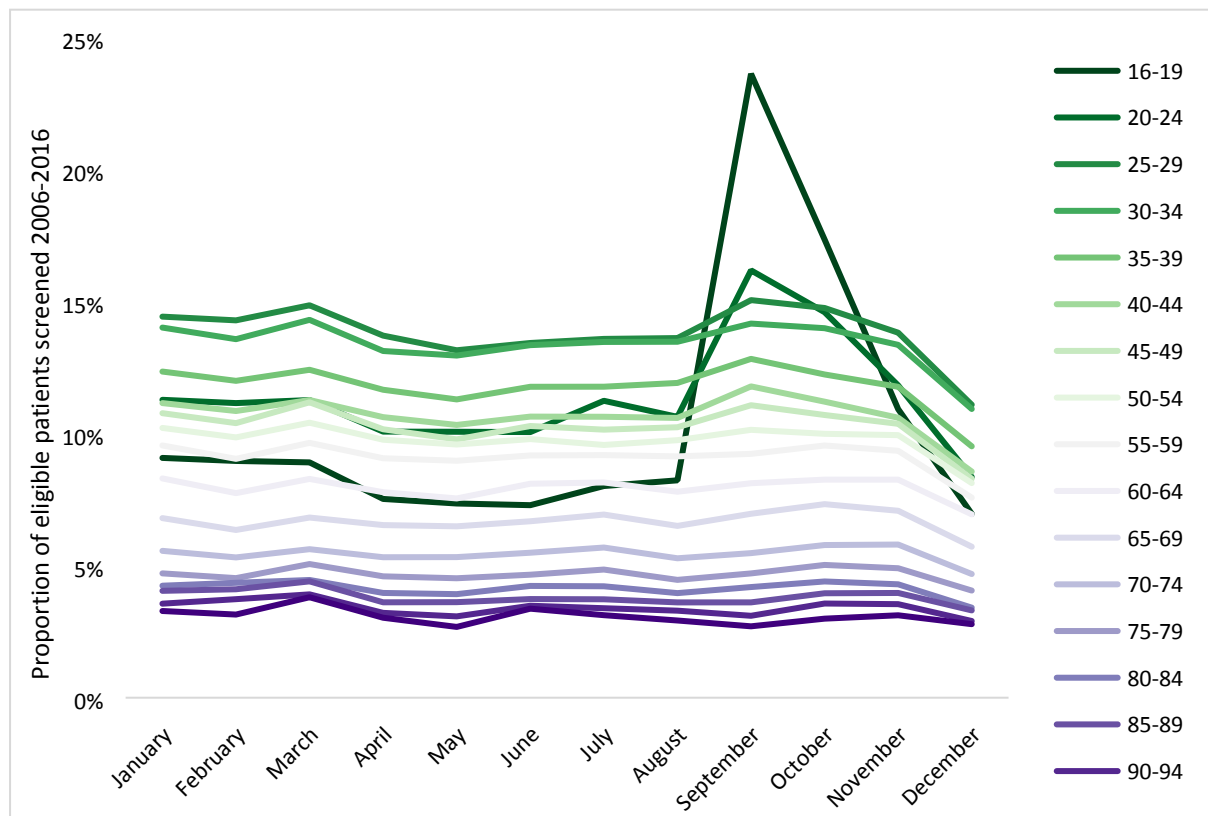
Month	% of new registrants aged 16-24
January	22%
February	22%
March	22%
April	21%
May	21%
June	20%
July	23%
August	21%
September	33%
October	26%
November	23%
December	21%

**Figure 2: 16-24 year old registrants as a proportion of all newly registering patients**



This alone is not sufficient to explain the increase in screening *rates* which we observe in these months. For that we must also look at the proportion of eligible patients who are screened in each month by age. This is illustrated in Figure 6 which shows a significantly elevated rate of screening for 16-24 year olds in September and October (particularly 16-19 year olds for whom the screening rate triples in September compared to August). Taken together, these figures provide compelling evidence for the hypothesis that large numbers of students register with new GP practices in September and October, and that practitioners are more likely to screen these groups at this time than other ages, or at other times of year.

**Figure 3: Proportion of eligible patients screened for heavy drinking by month and age**

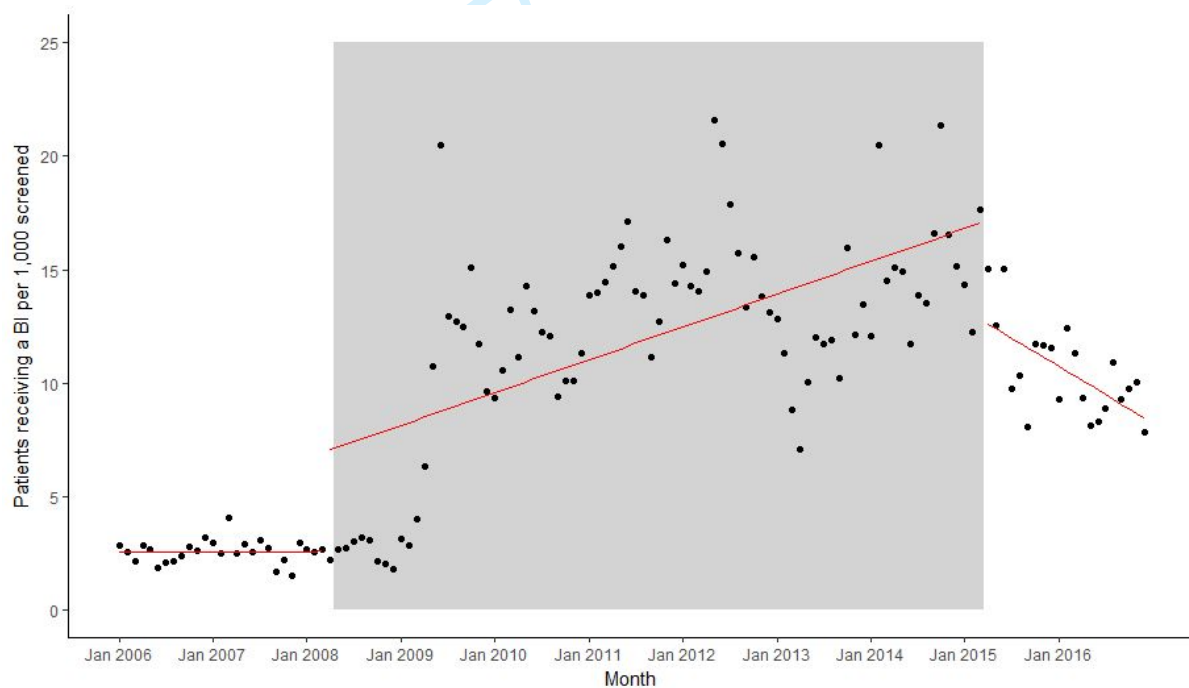


### Supplementary file (4) Sensitivity analyses

**Table 1: All patients recorded as being screened and receiving brief advice, irrespective of whether screening result is recorded**

	Coefficient	p-value	95% CI	
Months since 1st Jan 2006	0.00	0.976	-	0.02
Effect of intervention 1	4.48	<0.001	2.51	6.45
Months since intervention 1 introduced	0.12	<0.001	0.08	0.16
Effect of intervention 2	-4.46	<0.001	-	-
Months since intervention 2 introduced	-0.33	<0.001	0.45	0.20
Intercept	2.56	<0.001	2.28	2.85

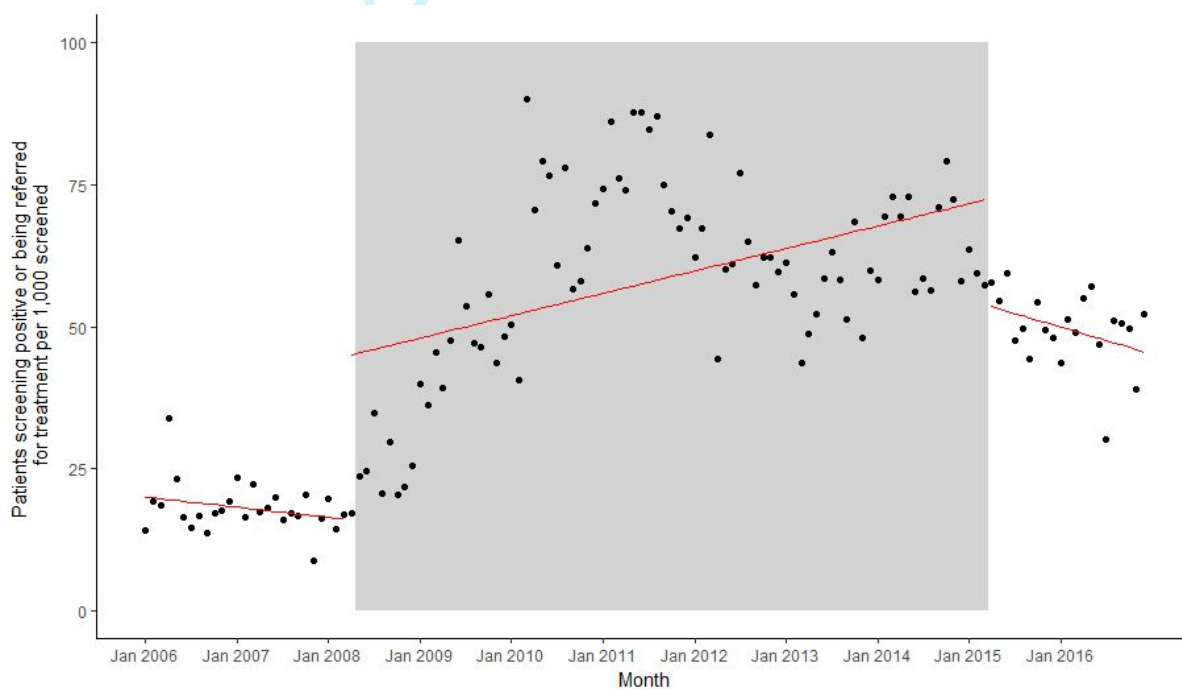
**Figure 1: All patients recorded as being screened and receiving brief advice, irrespective of whether screening result is recorded**



**Table 2: All patients recorded as receiving brief advice or being referred to treatment who were recorded as screening positive**

	Coefficient	p-value	95% CI	
Months since 1st Jan 2006	-0.15	0.22	-0.39	0.02
Effect of intervention 1	29.09	<0.001	20.90	37.27
Months since intervention 1 introduced	0.48	<0.001	0.20	0.75
Effect of intervention 2	-19.14	<0.001	25.79	12.49
Months since intervention 2 introduced	-0.72	<0.001	-1.17	-0.28
Intercept	20.01	<0.001	15.82	24.21

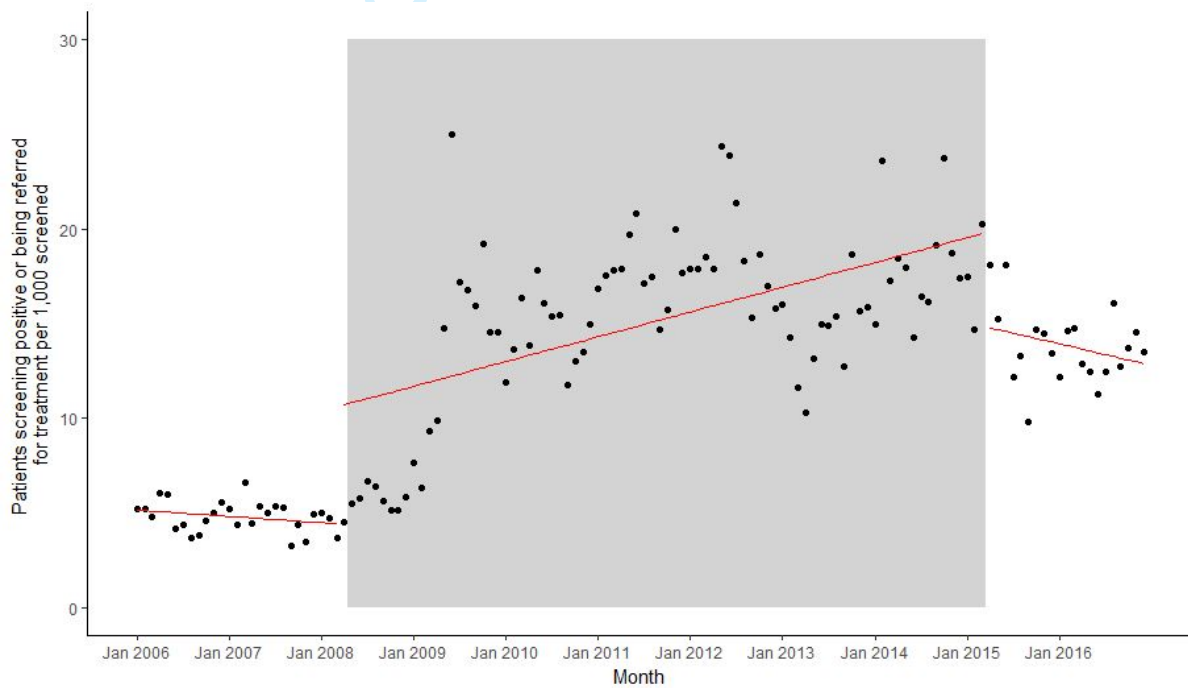
**Figure 2: All patients recorded as receiving brief advice or being referred to treatment who were recorded as screening positive**



**Table 3: All patients recorded as receiving brief advice or being referred to treatment who were recorded as being screened**

	Coefficient	p-value	95% CI	
Months since 1st Jan 2006	-0.03	0.10	-	0.01
Effect of intervention 1	6.30	<0.001	4.17	8.44
Months since intervention 1 introduced	0.14	<0.001	0.09	0.19
Effect of intervention 2	-5.08	<0.001	-	-
Months since intervention 2 introduced	-0.20	0.01	-	-
Intercept	5.15	<0.001	4.63	5.67

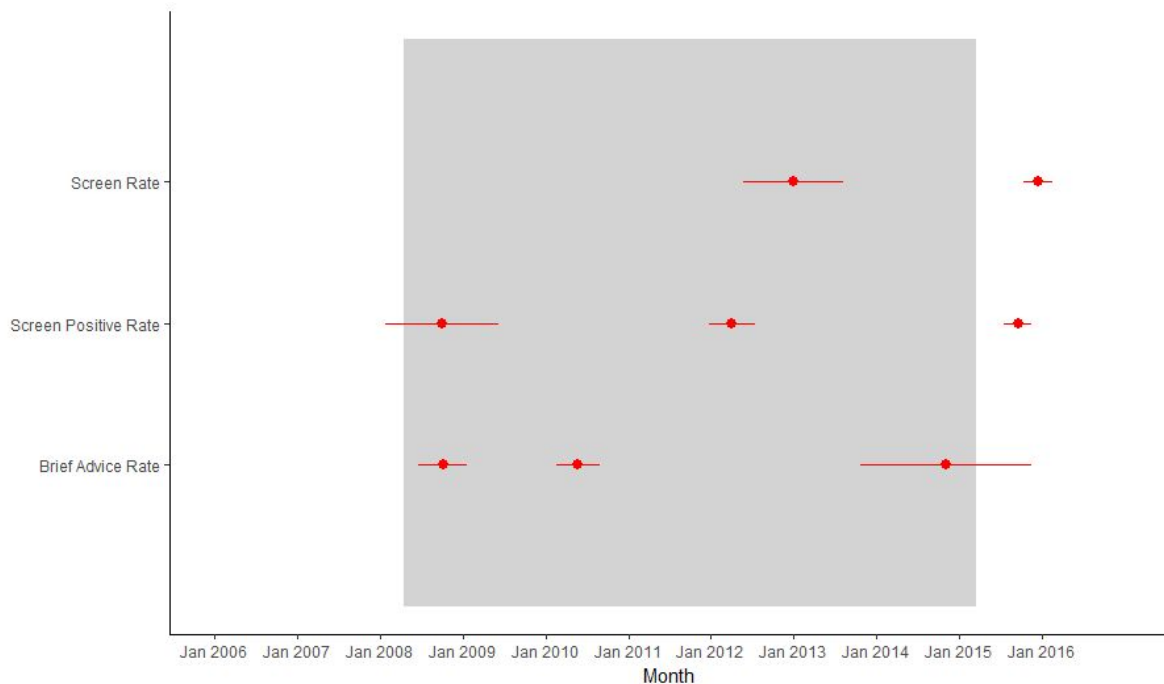
**Figure 3: All patients recorded as receiving brief advice or being referred to treatment who were recorded as being screened**



### **Supplementary file (5) Change point analysis**

The R package *changepoint* was used to identify turning points in each of the three main outcomes. This suggested results as illustrated in Figure 5, with the dots representing change points and the bars representing 95% confidence intervals around these.

**Figure 1: Changepoint analyses of rate of alcohol screening, screen positive and brief advice delivery**



These results provide some evidence for a 6-month lag on the initial effects of introducing the intervention, and a 7-10-month lag on the effects or removing it. There is also some evidence for a change point in the middle of the intervention period for each outcome, although these do not all occur at the same point in time.