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Research: Care Delivery

Timings for HbA_{1c} testing in people with diabetes are associated with incentive payments: an analysis of UK primary care data

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Abstract

Aims Guidelines recommend testing HbA_{1c} every 3–6 months in people with diabetes. In the United Kingdom (UK), primary care clinics are financially incentivized to monitor HbA_{1c} at least annually and report proportions of patients meeting targets on 31 March. We explored the hypothesis that this reporting deadline may be associated with over-frequent or delayed HbA_{1c} testing.

Methods This analysis used HbA_{1c} results from 100 000 people with diabetes during 2005–2014 in the Clinical Practice Research Datalink UK primary care database. Logistic regression was used to explore whether the four months prior to the deadline for quality reporting (December to March) or individual's previous HbA_{1c} were aligned with retesting HbA_{1c} within 60 days or > 1 year from the previous test, and identify other factors associated with the timing of HbA_{1c} testing.

Results Retesting HbA_{1c} within 60 days or > 1 year was more common in December to March compared with other months of the year (odds ratio 1.06, 95% confidence interval 1.04–1.08 for retesting within 60 days). Those with higher HbA_{1c} were more likely to have a repeat test within 60 days and less likely to have a repeat test > 1 year from the previous test.

Conclusions We have found that retesting HbA_{1c} within 60 days and > 1 year from the previous test was more common in December to March compared with the other months of the year. This work suggests that both practice-centred administrative factors and patient-centred considerations may be influencing diabetes care in the UK.

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Introduction

Internationally, guidelines recommend testing HbA_{1c} every 3–6 months in people with Type 2 diabetes depending on recent therapy changes and glycaemic targets [1,2]. Prior to 2015, the United Kingdom's (UK) National Institute of Health and Care Excellence (NICE) recommended testing every 2–6 months [3]. In the UK, most HbA_{1c} monitoring takes place in primary care and samples are analysed in a central hospital laboratory. The UK's Quality and Outcomes Framework (QOF) is a reward scheme using financial reimbursement to incentivize general practitioners (GPs) to achieve target patient health indicators, reporting data annually on 31 March. For diabetes, GP practices receive reimbursement for monitoring of HbA_{1c} every 12 months and for the proportion of their patients achieving pre-defined HbA_{1c} thresholds [4,5]. These incentives should encourage monitoring on at least an annual basis.

Changes in glycaemic control, even after treatment change, take 2–3 months to be reflected in HbA_{1c} [6], and guidelines do not recommend retesting HbA_{1c} within 2 months. Studies from different countries, however, report that HbA_{1c} is often tested more frequently or not frequently enough [7–11], suggesting that resources are not always used optimally even though healthcare budgets are facing pressure to reduce costs. Arguably, monitoring HbA_{1c} more frequently may be clinically appropriate for some people with diabetes, particularly those who have had a recent medication change [6] or those with uncontrolled diabetes. Care delivery and HbA_{1c}

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What's new?

- This is the largest analysis to explore factors associated with timings of HbA_{1c} tests in people with diabetes in the UK.
- Timings of repeat HbA_{1c} tests are associated with the Quality and Outcomes Framework reporting deadline and participants' previous HbA_{1c}.
- People with higher HbA_{1c} were more likely to be retested within 60 days compared with those with well-controlled diabetes.
- Financial incentives appear to result in more over-frequent or catch-up HbA_{1c} testing in the months approaching the reporting deadline than other months of the year in attempts to meet targets.
- This could have implications for future target-based incentive programmes.

testing may vary across GP practices [12] or regions of the UK [13], or differ according to an individual's characteristics or comorbidities [14,15].

We recently carried out an analysis of hospital laboratory data and found that timing of HbA_{1c} testing intervals was less likely to be aligned with guidelines in the four months prior to the QOF reporting deadline on 31 March [16]. In this work, we hypothesize that both an individual's previous HbA_{1c} and the reporting deadline at the end of the administrative year are associated with over-frequent or delayed HbA_{1c} testing in national data in the UK. We also examine whether there are regional differences across the UK and whether other pre-defined participant or GP practice-level variables may be associated with very frequent or delayed HbA_{1c} testing intervals. We used the Clinical Practice Research Datalink (CPRD), a governmental database providing anonymized data from UK primary care for medical research.

Methods

This study presents research from a protocol approved by the Independent Scientific Advisory Committee (ISAC) to the Medicines and Healthcare Products Regulatory Agency (protocol 15_099). The approved protocol was made available to the journal and reviewers during peer review. Ethical approval for observational research using the CPRD with approval from ISAC has been granted by a National Research Ethics Service committee (Trent MultiResearch Ethics Committee, reference 05/MRE04/87).

We used data from 100 000 adults with diabetes randomly selected from the CPRD database over a 10-year period from 1 January 2005 to 31 December 2014. The sample size was estimated from odds ratios (ORs) derived from an analysis of hospital laboratory data [16] and an assumed Type 1 diabetes prevalence of 10% in the cohort. For those with existing diabetes, the baseline HbA_{1c} test was defined as the first HbA_{1c} test after 1 January 2005. Included participants had at least two HbA_{1c} tests prior to the baseline test date and post diagnosis. People with incident diabetes during follow-up, and at least three HbA_{1c} test results post diagnosis, were included in the analysis. For these people, the baseline test was the second test. People with ambiguously recorded gender, gestational diabetes, malnutrition-related diabetes, maturity-onset diabetes of the young, haemochromatosis-related diabetes or steroid-induced diabetes, fewer than three HbA_{1c} measures in total, or cancer or end-stage renal disease, were not included in the analysis.

Data management

Age was set as the age at baseline. For covariates that could change over time, such as BMI total cholesterol or SBP, the latest recorded value from up to two years prior to the baseline test date was used; cases in which no values were available within this time frame were treated as missing data. Those with missing data were not included in the analysis for that variable. Having a diagnosis of microalbuminuria was set at baseline levels. Participants were coded as receiving lipid-lowering medication or antihypertensive medication for the duration of follow-up if they had a product code for these at any time prior to baseline date. Those with missing data on smoking were classed as non-smokers. Diabetes medication type was classified as diet, oral, insulin or both oral and insulin-treated, based on the medication that was prescribed most frequently for that individual. Injectable non-insulin medications such as exenatide were categorized with 'oral' medication. Medication change was defined as addition of a new type of diabetes medication at or following the previous HbA_{1c} test. Participants remained in the analysis until the end of follow-up on 31 December 2014, or when they left the surgery, died or developed cancer or end-stage renal disease.

Statistical analyses

Stata 14.1 SE (StataCorp, College Station, TX, USA) was used to carry out all analyses. Results were reported as mean and standard deviation (SD) or percentages for the full cohort, and stratified by sex, diabetes type and insulin use. Numbers of tests performed each year and mean numbers of test requests for each month were presented graphically in bar charts.

The unit of analysis was an HbA_{1c} test; participants had a minimum of two HbA_{1c} tests for inclusion in the analysis. The outcome measure was the time interval between a test and the previous test, coded as dichotomous variables: (i) short time interval (< 60 days vs. ≥ 60 days); and (ii) longer time interval (> 366 days vs. ≤ 366 days). The pre-specified

exposures of interest in the pre-specified hypothesis-testing analyses were HbA_{1c} value at previous test [coded as HbA_{1c} ≥ 58 mmol/mol (7.5%) vs. < 58 mmol/mol)] and time of year of HbA_{1c} test (coded as December to March inclusive vs. April to November inclusive).

Because of the nested structure of the data (HbA_{1c} test interval, participant and GP practice), three-level mixed effects logistic regression models were used with random effect elements for participant and GP practice. The analyses were run for the full cohort, and separately for those with Type 1 (n = 6208) and Type 2 diabetes (n = 86 495).

A hypothesis-generating analysis was then used to examine the association of variables that may reflect participant health status or changes in treatment with retesting HbA_{1c} at < 60-day or > 366-day test intervals. The exposure variables examined were: age, sex, absolute change in HbA_{1c} between the two previous measures, year of test, BMI, SBP, total cholesterol, smoking status, diagnosis of microalbuminuria, type of diabetes, having had a medication change at the previous visit, having a prescription for lipid-lowering or antihypertensive medication, geographic location of the GP practice (Scotland, Wales, England, and regionally within England) and medications taken (no medication prescription, insulin, oral medication or both). The analyses were run for the full cohort, and separately for those with Type 2 diabetes.

ORs and 95% confidence intervals (95% CI) were reported for each variable from the multivariate models. Because of potential bias of the longitudinal model to favour shorter testing intervals (with longer intervals disproportionately likely to be censored by end of follow-up), sensitivity analyses were carried out using two-level logistic regression models based on a single random measurement selected from each participant, to ensure that results were robust. Further sensitivity analyses using multinomial logistic regression models and different comparator groups were carried out detailed in Doc. S1. A P-value < 0.05 was considered significant.

Results

The cohort of 100 000 participants had a total of 953 634 HbA_{1c} tests over the 10 years of follow-up. Mean age of participants was 63.4 years, 44.7% were women, mean BMI was 30.6 kg/m^2. Some 86 495 had Type 2 diabetes, 6208 had Type 1 diabetes, 7297 had unknown diabetes status and 16 260 were insulin users. Mean HbA_{1c} at index date was higher in insulin users (70 mmol/mol, 8.54%) than in non-insulin users (56 mmol/mol, 7.23%) (Table 1).

There was an increase in the total number of HbA_{1c} tests each year between 2005 and 2011, and thereafter a decrease from 2011 to 2014 (Fig. 1a). Fewer tests were performed in April, August and December than in other months of the year (Fig. 1b).

Table 1 Characteristics (mean ± SD, or %) of individuals included in analysis

	Total data set	Women	Men	Type 1 diabetes	Type 2 diabetes	Unknown diabetes type	Insulin use	No insulin
Total number	100 000	44 655	55 345	6208	86 495	7297	16 260	83 740
Age (years)	63 ± 14	65 ± 15	62 ± 14	43 ± 16	65 ± 13	65 ± 14	55 ± 17	65 ± 13
Women (%)	44.7			42.8	44.5	48.5	45.1	44.6
BMI (kg/m^2)	30.6 ± 6.5	31.3 ± 7.2	30.1 ± 5.8	27.0 ± 5.3	30.9 ± 6.4	30.6 ± 6.7	29.2 ± 6.5	30.9 ± 6.4
SBP (mmHg)	136 ± 17	136 ± 17	135 ± 16	129 ± 17	136 ± 16	136 ± 17	133 ± 18	136 ± 16
Mean no. of tests per participant	8.9 ± 6.9	8.9 ± 6.9	9.0 ± 6.8	9.3 ± 7.1	9.1 ± 6.8	6.3 ± 6.1	10.6 ± 7.7	8.6 ± 6.6
Mean HbA_{1c} at index (mmol/mol)	58 ± 17.2	57 ± 17.1	58 ± 17.3	71 ± 19.1	57 ± 16.6	52 ± 16.4	70 ± 15.7	56 ± 12.8
Mean HbA_{1c} at index (%)	7.4 ± 1.6	7.4 ± 1.6	7.5 ± 1.6	8.6 ± 1.8	7.4 ± 1.52	6.9 ± 1.5	8.5 ± 1.4	7.2 ± 1.2
Mean test interval (days)	192 ± 135	192 ± 135	192 ± 134	203 ± 165	189 ± 126	218 ± 210	183 ± 143	194 ± 132
No. of tests < 60 days (%)	83 496 (9.4)	37 848 (9.6)	45 648 (9.2)	6503 (12.0)	71 418 (9.0)	4253 (9.6)	23 199 (13.5)	60 297 (8.4)
No. of tests > 366 days (%)	83 579 (9.4)	37 093 (9.4)	46 486 (9.4)	6701 (12.3)	70 429 (8.9)	5983 (13.6)	15 469 (9.0)	68 110 (9.4)

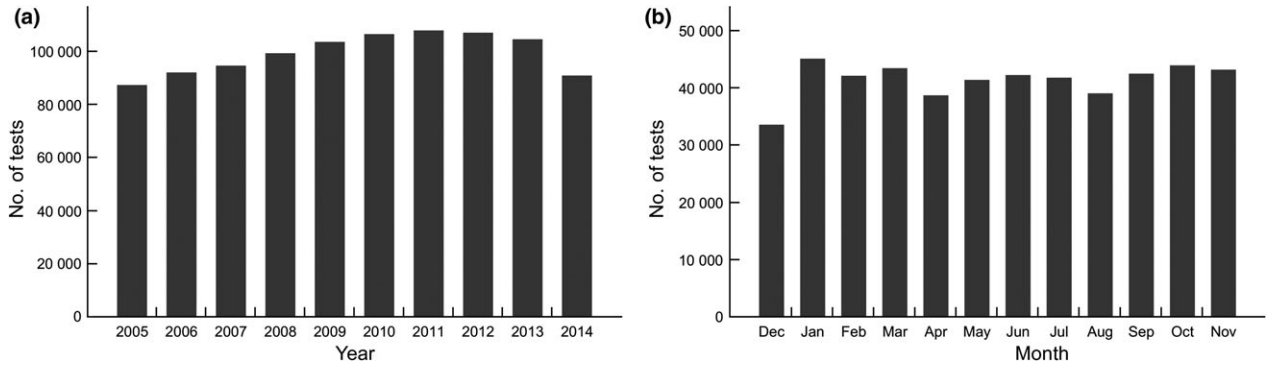

FIGURE 1 Number of HbA_{1c} tests (a) per year and (b) per month in cohort. Error bars not shown (SE < 90 everywhere).

Table 2 Unadjusted and adjusted regression analysis of whether testing between December and March, and having a previous HbA_{1c} > 58 mmol/mol (7.5%) are associated with testing intervals < 60 or > 366 days from the previous test

	Odds ratio (95% CI) for test < 60 days after previous test				Odds ratio (95% CI) for test > 366 days from previous test			
	Univariate	*P*-value	Multivariate*	*P*-value	Univariate	*P*-value	Multivariate*	*P*-value
All participants								
Test Dec–Mar vs. rest of year	1.06 (1.05–1.08)	< 0.0001	1.06 (1.04–1.08)	< 0.0001	1.07 (1.05–1.08)	< 0.0001	1.07 (1.06–1.09)	< 0.0001
Previous HbA_{1c} > 58mmol/mol vs. ≤ 58 mmol/mol	2.21 (2.18–2.25)	< 0.0001	2.21 (2.18–2.25)	< 0.0001	0.48 (0.47–0.49)	< 0.0001	0.45 (0.47–0.49)	< 0.0001
Type 1 diabetes only								
Testing Dec–Mar vs. rest of year	1.05 (1.01–1.09)	0.024	1.04 (1.00–1.09)	0.039	1.08 (1.04–1.12)	< 0.0001	1.08 (1.04–1.13)	< 0.0001
Previous HbA_{1c} > 58 mmol/mol vs. ≤ 58 mmol/mol	1.58 (1.51–1.65)	< 0.0001	1.58 (1.51–1.65)	< 0.0001	0.56 (0.53–0.59)	< 0.0001	0.56 (0.53–0.59)	< 0.0001
Type 2 diabetes only								
Testing Dec–Mar vs. rest of year	1.06 (1.05–1.08)	< 0.0001	1.06 (1.04–1.08)	< 0.0001	1.06 (1.04–1.08)	< 0.0001	1.07 (1.05–1.09)	< 0.0001
Previous HbA_{1c} > 58 mmol/mol vs. ≤ 58mmol/mol	2.29 (2.25–2.33)	< 0.0001	2.29 (2.25–2.33)	< 0.0001	0.43 (0.42–0.44)	< 0.0001	0.43 (0.42–0.44)	< 0.0001

*Timing (Dec–Mar vs. rest of year) and previous HbA_{1c} (> 58 mmol/mol vs. ≤ 58 mmol/mol; 7.5%) both included in the model.

Results from the logistic regression models are shown in Table 2. Both pre-specified primary outcomes of HbA_{1c} test date between December and March and having a previous HbA_{1c} > 58 mmol/mol (7.5%) were found to be significantly associated with timing of HbA_{1c} tests for the full cohort and separately for Type 1 and Type 2 diabetes.

Short testing interval (< 60 days)

In the univariate analysis, test intervals of < 60 days were more common during December to March than in other months of the year (OR 1.06, 95% CI 1.05–1.08; $P < 0.0001$) and those with a previous HbA_{1c} > 58 mmol/mol (7.5%) had significantly higher odds of receiving a repeat HbA_{1c} test within 60 days compared with those with HbA_{1c} ≤ 58 mmol/mol (7.5%) (OR 2.21, 95% CI 2.18–2.25; $P < 0.0001$) (Table 2). Results were similar for those with Type 1 and Type 2 diabetes, inclusion of both variables in the analysis (Table 2) and after adjustment for all pre-defined covariates (Table 3). Sensitivity analyses using different statistical models were broadly similar to the main analysis (Doc. S1). The sensitivity analysis, using a single random test for each participant, gave results consistent with the main analysis, although time of year was no longer significant due to the smaller sample size (not shown).

Other covariates found to be significantly associated with increased odds of retesting HbA_{1c} within 60 days were increasing age, higher BMI, a diagnosis of microalbuminuria,

Table 3 Multivariate logistic regression analysis of covariate factors are associated with testing intervals < 60 or > 366 days from the previous test

	Odds ratio (95%CI) for test <60 days after previous test		Odds ratio (95%CI) for test >366 days after previous test	
	Multivariate*	*P*-value	Multivariate*	*P*-value
Testing Dec–Mar vs. rest of year	1.06 (1.04–1.08)	< 0.0001	1.05 (1.03–1.07)	< 0.0001
Previous HbA_{1c} > HbA_{1c} > 58 mmol/mol vs. ≤ 58 mmol/mol (7.5%)	2.00 (1.96–2.04)	< 0.0001	0.46 (0.45–0.47)	< 0.0001
Age (years)	1.01 (1.01–1.01)	< 0.0001	0.99 (0.99–0.99)	< 0.0001
Sex (women vs. men)	1.01 (0.99–1.04)	0.26	1.00 (0.97–1.02)	0.87
Change in HbA_{1c} between previous two measurements (%)	1.00 (0.99–1.01)	0.79	1.02 (1.01–1.03)	< 0.0001
Increasing year of test	0.97 (0.97–0.97)	< 0.0001	1.04 (1.04–1.05)	< 0.0001
Increasing baseline BMI (kg/m^2)	1.01 (1.00–1.01)	< 0.0001	1.00 (1.00–1.01)	0.017
Increasing SBP (mmHg)	1.00 (1.00–1.00)	< 0.0001	1.01 (1.00–1.01)	< 0.0001
Increasing total cholesterol (mmol/l)	1.00 (0.99–1.00)	0.25	1.01 (1.01–1.02)	< 0.0001
Smoking status				
Non-smoker	Reference		Reference	
Ex-smoker	0.99 (0.96–1.02)	0.46	0.99 (0.96–1.02)	0.33
Current smoker	0.98 (0.95–1.01)	0.24	1.25 (1.21–1.30)	< 0.0001
Diagnosis of micro-albuminuria vs. no diagnosis	1.15 (1.10–1.19)	< 0.0001	1.05 (1.00–1.10)	0.044
Type of diabetes				
Type 1	Reference		Reference	
Type 2	1.06 (1.00–1.12)	0.046	0.63 (0.59–0.68)	< 0.0001
Unknown	1.24 (1.15–1.34)	< 0.0001	0.94 (0.86–1.03)	0.172
Medication change; recent vs. none	0.34 (0.33–0.35)	< 0.0001	1.18 (1.15–1.21)	< 0.0001
Lipid-lowering or antihypertensive medication vs. no medications	1.07 (1.03–1.11)	0.001	0.85 (0.82–0.89)	< 0.0001
Geographic region of GP practice	Inclusion of region in model	< 0.0001	Inclusion of region in model	< 0.0001
Diabetes treatment				
No medication prescription	Reference		Reference	
Oral only	1.67 (1.60–1.75)	< 0.0001	0.77 (0.72–0.82)	< 0.0001
Insulin only	2.26 (2.12–2.41)	< 0.0001	0.55 (0.53–0.57)	< 0.0001
Both	3.50 (3.33–3.69)	< 0.0001	0.45 (0.43–0.48)	< 0.0001

*All factors listed in column 1 included in model.

having Type 2 diabetes compared with Type 1 diabetes, taking lipid-lowering or antihypertensive drugs, living in Northern Ireland or Scotland compared with the North of England or taking oral and/or insulin-treatment compared to no medication prescription (Table 3; Table S1).

A more recent calendar year, higher SBP, having had a recent medication change and location in the East or West of England or London and the South East compared with the North of England, were all associated with lower odds of retesting HbA_{1c} within 60 days (Table 3; Table S1).

Long testing interval (> 366 days)

Those whose HbA_{1c} tested between December and March had significantly higher odds of their test being > 366 days from their previous test than those tested at other times of the year (OR 1.07, 95% CI 1.05–1.08; $P < 0.0001$). Those with a previous HbA_{1c} > 58 mmol/mol (7.5%) were significantly less likely to have had a test > 1year from the previous test (OR 0.48, 95% CI 0.47–0.49; $P < 0.0001$). Results were similar for those with Type 1 and Type 2 diabetes, when both variables were included in the analysis (Table 2) and after adjustment for all pre-defined covariates (Table 3). Sensitivity analyses using different statistical models were broadly similar to the main analysis (Doc. S1). The sensitivity analysis, using a single random test for each participant, gave results consistent with the main analysis, although time of year was no longer significant due to the smaller sample size (not shown).

Other covariates found to be significantly associated with increased odds of retesting HbA_{1c} > 1 year from the previous test were an increase in HbA_{1c} between the previous two measurements, increasing test year, higher BMI, higher SBP, higher total cholesterol, being a current smoker compared with non-smokers, having a diagnosis of microalbuminuria, having had a recent medication change and GP practice location in London or the South East of England, compared with the North of England (Table 3; Table S1).

Older age, having Type 2 diabetes relative to Type 1 diabetes, taking lipid-lowering or antihypertensive medication, GP practice location in Scotland compared with North of England and taking oral and/or insulin treatment compared with diet-control were significantly associated with a lower odds of retesting HbA_{1c} > 1 year from the previous test (Table 3; Table S1). Results for those with Type 2 diabetes only and the sensitivity analysis using a random

measurement from each participant, gave results consistent with the full analysis, but with fewer significant findings (not shown).

Discussion

The frequency of HbA_{1c} testing is, appropriately, related to the HbA_{1c} level at the previous visit, as more frequent testing is carried out when HbA_{1c} is above target. However, the approach of the QOF administrative reporting deadline is also associated with time intervals for HbA_{1c} testing in the UK. Specifically, there is an increased volume of retesting within 60 days in the 4 months leading up to the deadline. Because a 60-day interval is too short for changes in HbA_{1c} to reliably reflect change in glycaemic status following a treatment change [2,3,6], this may represent a rush to reduce HbA_{1c} ahead of the reporting deadline, rather than an optimally timed attempt to assess diabetes control for patient benefit. The same time of year is also associated with an increased rate of testing in those who have not had an HbA_{1c} test for > 1 year. This may represent the QOF deadline successfully incentivizing a 'catch-up' test in people who might otherwise go untested for longer still.

We found evidence that there were differences in rates of HbA_{1c} testing across the UK, with Scotland and Northern Ireland being most likely to retest HbA_{1c} very frequently, whereas London and the South East of England were less likely to retest within 60 days. Conversely, GPs in London were more likely to have > 1 year between HbA_{1c} tests compared with other parts of the UK, and those in Scotland the least likely. These variations in HbA_{1c} testing across the UK may result from differences in population demographics, deprivation and local resources [13,17,18]. The data suggest that retesting > 1 year from the previous test is less common in Scotland than in other parts of the UK. This may be because GPs are proactively inviting their patients to diabetes reviews as part of one of the quality improvement initiatives in Scotland [19–23]. Crucially, the significant association between HbA_{1c} testing intervals and times of year suggests that GPs may be following-up those who are late for appointments or not meeting targets more closely in the months before the QOF reporting deadline.

To our knowledge, this is the largest analysis to explore factors associated with timings of HbA_{1c} tests in the UK, but there are some limitations with this work. Each participant in the analysis had a minimum of three HbA_{1c} tests, which may have favoured short testing intervals over long testing intervals. To test this, we carried out sensitivity analyses using a randomly selected test interval from each individual and found similar results, suggesting that these findings are robust. We were unable to examine GP-level differences in testing, which might have provided information on differences in practices or professional opinion.

Some findings in the exploratory analyses may not be clinically significant or may be chance findings. However, our main findings, time of year and previous HbA_{1c}, were pre-specified as the primary hypotheses tested, and were statistically significant in both adjusted and unadjusted analyses.

Although people with some life-threatening conditions were excluded from this analysis, it is acknowledged that some people included in the analysis may have been exempt from QOF due to age, frailty or existing comorbidities [4] making regular monitoring or tight glycaemic control inappropriate or unfeasible, which is a limitation of this work. Our analysis has, however, found that those with microalbuminuria or who were taking lipid-lowering or antihypertensive medications (surrogates for comorbidities) are more likely to be monitored very frequently and less likely to have delayed testing than those without. This is consistent with reports that people with multiple comorbidities receive higher quality care [14,24,25].

We dichotomized the HbA_{1c} monitoring interval using cut-offs that lay beyond the outer limits of international guidelines and incentive schemes. In doing this we may have missed some trends associated with increasing or decreasing HbA_{1c} testing interval measured as a continuous outcome.

Previous reports have described HbA_{1c} testing practices in UK primary care [8,11,26], with outcomes ranging from the numbers of inappropriate test requests [8] to implications of testing frequency on HbA_{1c} change [11,26]. Re-testing HbA_{1c} within very short time intervals may be appropriate for some individuals who had recently been prescribed a new medication to monitor response or adherence [6]. Data from our analysis have shown that retesting HbA_{1c} within 60 days was more common in participants with the highest HbA_{1c}. So, although this testing interval is shorter than guidelines recommend, this work suggests that GPs believe that retesting HbA_{1c} within a short time interval is appropriate for some people.

QOF has been reported to improve performance in GP practices [27]. Our study has found that QOF may be incentivizing GPs to monitor some people more closely to meet targets, but does not tell us how this goes on to affect longer-term outcomes. It is also not clear whether the participants who were more closely monitored in December to March were those who would benefit most from closer monitoring and treatment changes, were 'easy targets' who were already close to one of the QOF thresholds, or were those who were most adherent to appointments and medication.

The long-term health implications for those individuals who do not receive HbA_{1c} testing aligned with guidelines, may be greatest for those with uncontrolled diabetes who are not receiving annual HbA_{1c} tests. Exposure to high levels of glycaemia over extended periods increases the risk of diabetes-related complications, which may then result in more consultations for other health-related problems [28]. Although causation cannot be inferred from this analysis, the approach of the QOF deadline is associated with more of those with uncontrolled diabetes receiving their HbA_{1c} test.

These findings suggest that QOF may be encouraging GPs to monitor their patients in attempts to meet targets, but results in more over-frequent or catch-up HbA_{1c} testing in the months approaching the end of March deadline for reporting indicators of patients' health status. This may have wider implications for those considering introducing incentive-based interventions in the future.

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Competing interests

None declared.

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Supporting Information

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

Doc S1. Sensitivity analyses.
Table S1. Rate of HbA_{1c} testing by geographic area.