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Corresponding Author: Mrs. Anne Rosemary Mason, BA MA

Corresponding Author's Institution: University of York

First Author: Anne Rosemary Mason, BA MA

Order of Authors: Anne Rosemary Mason, BA MA; Dan Liu, PhD; Linda Marks; Howard Davis; David Hunter; Llinos Jehu; Shelina Visram; Joanne Smithson

Abstract: In April 2013, the public health function was transferred from the NHS to local government, making local authorities (LAs) responsible for commissioning the NHS Health Check programme. The programme aims to reduce preventable mortality and morbidity in people aged 40 to 74.

The national five-year ambition is to invite all eligible individuals and to achieve an uptake of 75%. This study evaluates the effects of LA expenditure on the programme's invitation rates (the proportion of the eligible population invited to a health check), coverage rates (the proportion of the eligible population who received a health check) and uptake rates (attendance by those who received a formal invitation letter) in the first three years of the reforms. We ran negative binomial panel models and controlled for a range of confounders.

Over 2013/14 to 2015/16, the invitation rate, coverage rate and uptake rate were 57% 28% and 49% respectively. Higher per capita spend on the programme was associated with increases in both the invitation rate and coverage rate, but had no effect on the uptake rate. When we controlled for the LA invitation rate, the association between spend and coverage rate was smaller but remained statistically significant. This suggests that alternatives to formal invitation, such as opportunistic approaches in work places or sports centres, may be effective in influencing attendance.

## Highlights

- The English NHS health check programme aims to prevent morbidity and mortality
- In 2013, local authorities became responsible for health checks
- Higher expenditure is linked to higher invitation and coverage rates
- The amount spent does not influence uptake rates
- Opportunistic approaches may help improve uptake

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# Local authority commissioning of NHS Health Checks: a regression analysis of the first three years

Anne Mason, [1 *] Dan Liu, [1] Linda Marks, [2] Howard Davis, [3] David Hunter, [2]
Llinos Mary Jehu, [4] Shelina Visram,[2] Joanne Smithson [5]

[1] Centre for Health Economics, University of York, York, YO10 5DD, UK;

[2] Centre for Public Policy and Health, Durham University Queen's Campus, Stockton on Tees, TS17 6BH, UK;

[3] Centre for Communities and Social Justice, Coventry University (to 08/2016); Independent researcher (09/2016 onwards)

[4] Department of Social Policy, University of Birmingham, Birmingham, B15 2TT

[5] Voluntary Organisations Network North East, 9th Floor, Cale Cross, 156 Pilgrim Street, Newcastle upon Tyne, NE1 6SU.

* Corresponding author, anne.mason@york.ac.uk

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## Conflicts of interest

Conflicts of interest: none

## Abstract

In April 2013, the public health function was transferred from the NHS to local government, making local authorities (LAs) responsible for commissioning the NHS Health Check programme. The programme aims to reduce preventable mortality and morbidity in people aged 40 to 74.

The national five-year ambition is to invite all eligible individuals and to achieve an uptake of 75%. This study evaluates the effects of LA expenditure on the programme's invitation rates (the proportion of the eligible population invited to a health check), coverage rates (the proportion of the eligible population who received a health check) and uptake rates (attendance by those who received a formal invitation letter) in the first three years of the reforms. We ran negative binomial panel models and controlled for a range of confounders.

Over 2013/14 to 2015/16, the invitation rate, coverage rate and uptake rate averaged 57% 28% and 49% respectively. Higher per capita spend on the programme was associated with increases in both the invitation rate and coverage rate, but had no effect on the uptake rate. When we controlled for the LA invitation rate, the association between spend and coverage rate was smaller but remained statistically significant. This suggests that alternatives to formal invitation, such as opportunistic approaches in work places or sports centres, may be effective in influencing attendance.

## Key words

Cardiovascular Diseases; Preventative Care; Primary Prevention; NHS Health Check

# 1 Introduction

The overarching aim of the national NHS Health Check (NHSHC) programme is to reduce cardiovascular disease (CVD) risks and events by addressing behavioural and physiological risk factors driving premature mortality and preventable morbidity [1, 2]. Considered to be the largest and most ambitious programme of its type worldwide [3], it targets people aged 40 to 74 who have no diagnosed vascular disease such as CVD, diabetes or other cardio-metabolic condition [4].

The programme was introduced in 2009. As part of the April 2013 reforms, responsibility for commissioning health checks was transferred from the NHS to 152 local authorities (LAs) as part of the transfer of the public health function to local government. LAs were given ring-fenced public health grants "to improve significantly" the health and wellbeing of their local populations and to reduce health inequalities by addressing the needs of under-served groups [5]. CVD is strongly associated with health inequalities [6].

Over a five year period, Public Health England's (PHE) ambition is that 100% of eligible individuals are invited for a health check [1], with uptake reaching 75% [6]. The health check begins with a structured assessment of CVD risk, followed by individually tailored risk management advice and/or further clinical assessments, and then by appropriate interventions such as medication, signposting or referral [6-8]. Most of the check can be delivered in settings other than GP practices, but data from these risk assessments must be forwarded to the attendee's registered practice [6].

LAs have a statutory duty to submit annual revenue outturn forms detailing how their public health budget was spent [6]. The risk assessment element of the NHSHC is a mandatory function that LAs are required to commission or provide, and there is a bespoke category in the revenue form to capture this expenditure. It is important to recognise that this category of expenditure excludes the cost of follow-up health care: NHS England funds the costs of additional testing and prevention in primary care, whereas local healthy lifestyle services, such as for smoking cessation and promoting healthy weight, are commissioned by LAs [6].

Therefore, LAs have only limited ability to influence health outcomes arising from risk identification.

While the health benefits of general – untargeted – health checks have been questioned [9], both the viability and impact of the programme on health outcomes depend upon uptake rates being sufficiently high [10]. Moreover, significant health benefits, such as reduced morbidity or mortality, are unlikely to arise in the short term. For these reasons, our evaluation of the impact of the 2013 reforms on the NHSHC programme focuses on the relationship between LA spend on the programme and its intermediate outcomes – invitation rates, coverage rates, and uptake rates. This forms part of a wider study on the impact of the public health reforms on commissioning public health services [11].

The expected causal pathway between LA expenditure on the NHSHC programme and its intermediate outcomes merits consideration. Invitational activity is funded directly from this category of the public health budget, with GP practices typically subcontracted to invite patients and provide health checks, although other providers may also be commissioned. The link between spend and coverage rate, defined as count of attendees as a proportion of the eligible population, is also intuitive: practices are paid (partly) according to the number of checks provided which is in turn mediated by invitational activity. However, opportunistic settings, such as workplace checks, also affect coverage and these checks are typically outside of the formal invitation process but are (or should be) captured in counts of attendees. The causal pathway between uptake rates (attendance by those invited) and level of spend is more complicated. The decision to attend for a health check is complex and reasons are not fully understood, but are likely to include personal beliefs [12], invitational level and approach [13, 14], venue [15] and socio-economic factors [15-17]. It is plausible that LAs with a higher per capita spend on the NHSHC programme are offering additional approaches to the formal invitation, such as locally relevant opportunistic screening, and are, therefore, more successful in engaging with their local populations.

By definition, the coverage and uptake rates become equivalent when all the eligible population has been invited.

## 2 Materials and methods

We used count panel models, with LAs as the unit of analysis and ran a series of robustness checks. National data on counts of individuals eligible for, invited to, and attending a health check are reported annually for each LA. For our key explanatory variables, we used annual expenditure returns. LAs submit these returns for each of 18 public health categories (20 categories in 2015/16) and for total public health spend.

The selection of control variables was informed by a literature review and categorised using Andersen's Behavioral Model of Health Services Use [18].

### 2.1 Outcomes

We tested the effect of LA expenditure on the NHSHC programme on three outcomes.

First, the invitation rate is defined as the proportion of the eligible population invited for an NHS health check (the eligible population is defined as people aged 40 to 74 who have no known vascular disease). This captures 'formal' invitational activity by LAs, but excludes opportunistic invitational approaches, e.g. outreach in shopping malls. Second, the coverage rate is the proportion of the eligible population attending for a health check. Lastly, the uptake rate is defined as the proportion of those who received a formal invitation and then attended a health check. This outcome is considered a measure of the effectiveness of the formal screening programme than the coverage rate [4]. The coverage rate measure may be better than the uptake rate for assessing public health impact [4].

### 2.2 Key explanatory variables

The principal explanatory variable of interest is annual expenditure by LAs on the NHSHC programme. These data are reported as part of the annual financial returns. They are freely available to download from the website detailed in Appendix Table 1. We used the variable for net current expenditure to match the approach used by Public Health England in its performance assessment framework.

As the composition and size of LA populations vary considerably, total spend is not a useful measure. Instead, we derived per capita values of spend on the NHSHC programme based

on the eligible population of people aged 40 to 74 and converted these to terciles (thirds). In the sensitivity analyses, we tested two alternative measures of programme spend.

## 2.3 Control variables

To quantify the relationship between expenditure on the NHSHC programme and outcomes, other factors potentially affecting uptake of the programme need to be taken into account. Many of these influences occur at the level of the individual: for example, a person's age, employment status, or the distance from home to their GP practice, could all potentially affect the attendance decision. However, there are no national datasets detailing uptake by individuals, only summary data by LA. Therefore, we used LA characteristics instead of person-level characteristics: for example, LA rurality was used in place of travel distance.

To overcome this limitation, previous studies have used primary care databases [3, 16, 19-22]. However, these databases have drawbacks that make them unsuitable for evaluating the 2013 reforms. First, they cannot give a national picture of performance on the NHSHC programme: they typically cover only a fraction of the English population; participating practices may be unrepresentative of their local areas; and health checks done in other local practices are missed. Second, the databases are expensive to access, and coding of NHSHCs in primary care records has historically been poor [19, 23]. Lastly, linking detailed data on LA characteristics to GP practices increases the risk of identity disclosure: this means that linkage would likely be permitted only for a small number of aggregated LA factors.

We reviewed the literature to identify factors predicting uptake of health check programmes in high income countries (details of the inclusion and exclusion criteria are available on request from the authors). We identified 31 relevant studies [3, 4, 12, 16, 19-45] and grouped factors using Andersen's Behavioral Model of Health Services Use [18]. Predisposing factors included age group, proportion of males, proportion of white ethnicity, and deprivation level (terciles). Enabling factors included rurality, density of GPs and measures of expenditure on the NHSHC programme. We also included a binary variable capturing whether the LA chose the default NHSHC option in the 2014/15 Health Premium Incentive Scheme (HPIS) [46], and adjusted for class (type) of local authority. Need factors

included measures of morbidity, physical activity levels, adult obesity levels and smoking rates. We also included year effects with 2013/14 as the reference. Due to data limitations, measures of need mostly related to the whole adult population, not specifically to people aged 40-74. Some potentially relevant predictors, for example, past consulting behaviour [31, 47], were not included in our analyses because data were unavailable.

We checked the covariates for pairwise correlations and tested significance at the 5% level using Bonferroni adjustments to counteract the problem of multiple comparisons.

## 2.4 Modelling

For the base case analyses, we used random effects negative binomial models For cases where the outcome is a count variable (i.e. non-negative integer), these statistical models offer a flexible approach for analysing the relationship between the outcome and explanatory variables whilst allowing for unobserved LA characteristics that persist over time [48]. We ran three models to test the effects of spend on health checks on each of the three outcome variables:

1. Model 1: Invitation rate: count of NHSHC invitees (exposure: eligible population)
2. Model 2: Coverage rate: count of NHSHC attendees (exposure: eligible population)
3. Model 3: Uptake rate: count of NHSHC attendees (exposure: count of NHSHC invitees)

The size of the eligible population is reported in the annual NHSHC datasets (Appendix Table 1). It comprises the LA population aged 40-74 without an existing diagnosis of vascular disease, diabetes or chronic kidney disease. The 'exposure' is the pool of individuals from which an outcome is observed, and its inclusion in the model effectively converts the count variable into a rate.

The effects of expenditure may not be linear, i.e. the impact of an increase in per capita spend of £1 may vary depending on the level of baseline expenditure. For example, the effect of a £1 increase in spend may be different in an LA with a per capita spend of £0.24 to

the effect in another authority with spend of £24. Similarly, the effects of deprivation may be non-linear, and previous studies have used deprivation terciles [4, 21-23, 26, 27, 33]. In the base case, we used terciles both for each type of spend, and for deprivation.

## 2.5 Sensitivity analyses

For each of the three outcome measures, we tested three sets of control variables that differed in terms of how deprivation and expenditure were measured.

In the first sensitivity analysis, we tested continuous measures of spend (i.e. per capita values) and deprivation scores (range: 0 to 100). In the second sensitivity analysis, we used total programme spend as a proportion of the public health budget and measured deprivation in terciles. In the third sensitivity analysis, to identify the influence of invitational activity on coverage, we re-ran Model 2 but also controlled for the LA invitation rate.

By way of robustness checks, we tested linear models with the dependent variables converted to rates; Poisson models (a special case of the negative binomial model); and fixed effects models. In all checks, only the base case model was explored. Analyses were run in a statistical software package (Stata 14.2).

## 2.6 Data sources

All our data were sourced from publicly available datasets (Appendix Table 1), with one exception: details of LA participation in the Health Premium Incentive Scheme (HPIS) [46] were provided by the Department of Health and Social Care. We merged the datasets using LA codes and (for time-varying variables) the year to which data related. Estimations were based on a balanced panel of data from 150 LAs: data for City of London and the Isles of Scilly are incomplete so these LAs were excluded. In 2015/16, one LA did not report expenditure outturn data and we instead used revenue account budget data (planned spend) for this organisation.

# 3 Results

Over the first three years of the public health reform, the cumulative number of individuals invited to and attending a health check increased (Figure 1). When converted to rates, these cumulative totals translate into increasing invitation and coverage rates but the national uptake rate – the proportion of invitees who attend a health check – remained stable at slightly under 50% over the study period (Figure 2).

INSERT FIG 1 AND FIG 2 HERE

As the invitation rate, coverage rate and uptake rate were heavily skewed, we report results as medians. Across LAs, the median annual invitation rate was 19.6% (range: 0.8% to 74.6%). The median coverage rate was 9.1% (0.9% to 29.1%) and the median uptake rate was 49.1% (7.6% to 234.9%). Uptake rates above 100% may be due to opportunistic checks of local and/or transient populations – this activity is recorded in attendance numbers (numerator) but is not captured in counts of invitees (denominator). There was remarkably little variation by class of LA, and the extreme outliers in uptake rate are mostly London boroughs.

## 3.1 Explanatory variables

In the unadjusted data, per capita spend on the NHSHC programme was positively correlated with higher proportions of the eligible population aged 40 to 50 and negatively associated with larger proportions of people 65 to 74. Spend was negatively correlated with white ethnicity (rho: -0.261) and positively associated with greater deprivation (0.199). There were small but significant correlations between per capita spend on the NHSHC programme and spend on wider tobacco control (0.245) and adult physical activity (0.161).

Descriptive statistics for the explanatory variables in the analysis are presented in Table 1.

INSERT TABLE 1 HERE

## 3.2 Regression results

Table 2 shows results from the base case regressions. Compared with LAs in the lowest tercile of per capita expenditure on the NHSHC programme, authorities with medium or high levels of expenditure had significantly higher invitation rates and significantly higher coverage rates. However, programme spend was not significantly associated with uptake rate. These findings were consistent: the direction and significance of the effect was independent of whether expenditure was measured in monetary per capita values, terciles or as a proportion of total public health spend, and results were also robust to model specification. In addition, the impact of programme spend on coverage rate remained statistically significant after controlling for the LA invitation rate (Appendix Table 2), although its magnitude was smaller: a one percentage point increase in NHSHC programme spend per head was associated with an increase in the coverage rate of 3.7% before controlling for invitational activity, and an increase of 2.0% after this was taken into account. This suggests that factors other than invitation are effective in increasing the attendance rate for a health check.

INSERT TABLE 2 HERE

Most of the predisposing factors, such as the age distribution of the local population, gender, ethnicity and deprivation, did not explain variations in outcome rates (Table 2). Compared with the reference group (aged 40-44), coverage rates were significantly lower in LAs with a higher percentage of people aged 65-69, and uptake rates were significantly lower in LAs with a higher percentage of 50-54 year olds. Of the 'enabling' factors, rurality, LA class, GPs per head of population, and participation in the NHSHC part of the Health Premium Incentive Scheme (HPIS) [46] were not statistically significant predictors. Compared with LAs within the lowest tercile of expenditure on adult obesity, those in the highest tercile achieved significantly higher invitation rates but also significantly lower uptake rates.

With regard to need factors, in the base case model LAs with a higher prevalence of smokers had a higher invitation rate but findings from the robustness checks were mixed. LAs with a

higher percentage of the population on the GP disease registers for obesity had significantly higher invitation rates, coverage rates and uptake rates.

# 4 Discussion

In 2013, responsibility for commissioning the NHSHC programme was transferred from the NHS to upper tier and single tier LAs. Our evaluation covered the first three years of these reforms and included all upper tier and single tier English local authorities except for the City of London and Isles of Scilly. Findings on the impact of programme expenditure are consistent: higher spend by LAs is associated with both higher invitation rates and higher coverage rates. When controlling for invitation rate, the magnitude of the association between spend and coverage rate is reduced but remains statistically significant. As formal invitation only partly explains attendance, this means that LAs expenditure on non-invitational activity is, by definition, associated with higher attendance rates. One possible explanation is that alternative approaches, such as opportunistic invitations, are driving this observed effect.

Uptake rates – the proportion of invitees who attend a health check – appear unrelated to the level of programme spend. Uptake depends primarily on individuals' responses to the invitation, although LAs can influence uptake, for example by follow up of non-responders or by careful framing of the invitation letter. Gidlow and colleagues (2015) analysed patient records from five GP practices in Stoke-on-Trent and found that telephone or verbal invitations were associated with a higher uptake rate than postal invitations [16]. Qualitative research suggests that community venues may offer greater convenience [15]. Uptake also depends on actual and perceived access to local services[18], and LA commissioners can facilitate access, for example through innovation in terms of venues or providers. For example, the high uptake rate observed in some London boroughs may represent commuters attending checks in venues other than GP practices (e.g. workplaces, sports centres or pharmacies). There are no national data on the types, location and providers of lifestyle services commissioned by LAs, nor on how budgets are used across directorates or pooled with other agencies. As part of the broader evaluation, we conducted national surveys to try to address these evidence gaps, but response rates were insufficient to be used in the analyses [11].

Compared with previous evaluations [19], our study found less regional variation in coverage rates. We identified one study with a similar unit of analysis: Artac and colleagues (2013) explored variation in coverage rates amongst local health authorities (Primary Care Trusts (PCTs)) in 2011 [4] and found higher coverage in PCTs with greater levels of deprivation. This contrasts with our finding that deprivation is not associated with coverage; a possible explanation for the discrepancy is that mandatory commissioning of the NHSHC programme following the 2013 reforms has made programme performance more geographically consistent.

The NHSHC programme has been criticised for differential uptake, favouring the least disadvantaged groups, although evidence is mixed [1, 15, 49]. PHE has emphasised the importance of supporting approaches that prioritise invitations to those at highest risk [50] and that address equity and health inequalities [51]. LAs have several options for addressing these challenges: for instance, they could extend training for carrying out health checks to a wider workforce, provide health checks through community-based services and work across different LA directorates to target outreach to vulnerable groups. They could also capitalise on their voluntary sector and community networks, and on their public profile, making use of these to advertise opportunities to local populations [11].

Interviews from the case study component of our broader evaluation demonstrated a spectrum of engagement with the NHSHC programme [11]. At one extreme was a combination of GP provision, extensive outreach programmes (sometimes provided through social enterprises), and integration with healthy lifestyle services. At the other was scepticism about the programme's value for money and potential to reduce inequalities, combined with implementation challenges due to attrition from GPs and rationing of follow-on lifestyle services in response to budgetary cuts. Outreach activities were widespread across our 10 case study sites, covering locations such as supermarkets, town centres, leisure centres, roadshows, farmers' markets, well-point kiosks and mobile health checks around estates, workplaces and through a health check bus.

There were initiatives targeted at underserved groups, such as traveller communities, examples of collaboration with providers of mental health services to improve uptake and targeting of younger people within the eligible population who were thought less likely to respond to invitations. However, whilst LAs appear to be moving towards a more targeted approach, a robust evaluation of its impact on health and health inequalities requires national data to be collected at ward-level.

## 5 Conclusions

In the first three years since LAs became responsible for the NHS Health Checks programme, invitational activity has risen, but uptake has remained static and appears unresponsive to higher levels of spend. Our study suggests that approaches other than formal invitation, such as opportunistic offers of checks, may be effective in increasing attendance rates and that assessment of the NHSHC requires evaluation of all three outcomes described in this study if effective local action is be to further developed by LAs The extent of unidentified need revealed through the health check is also an important consideration in assessing the benefits of different approaches to invitation and outreach, coverage and uptake, and further research is needed to address this gap in the evidence base.

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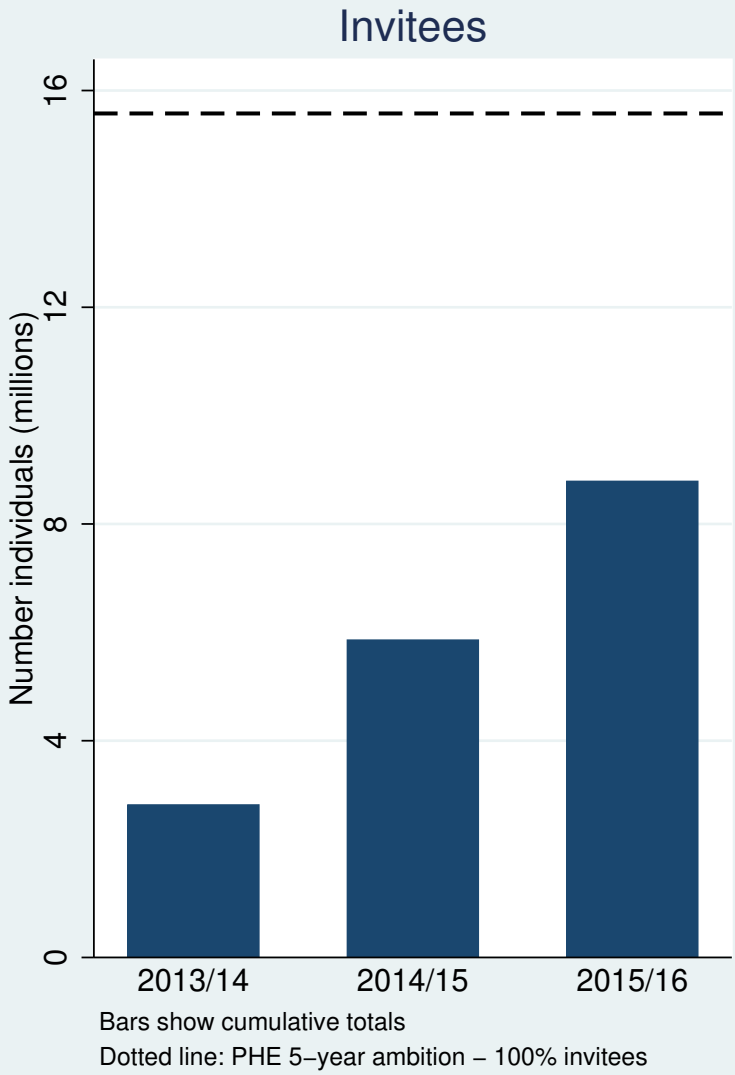
**Figure 1**


Invitees
Number individuals (millions)
0
4
8
12
16
2013/14
2014/15
2015/16
Bars show cumulative totals
Dotted line: PHE 5–year ambition – 100% invitees

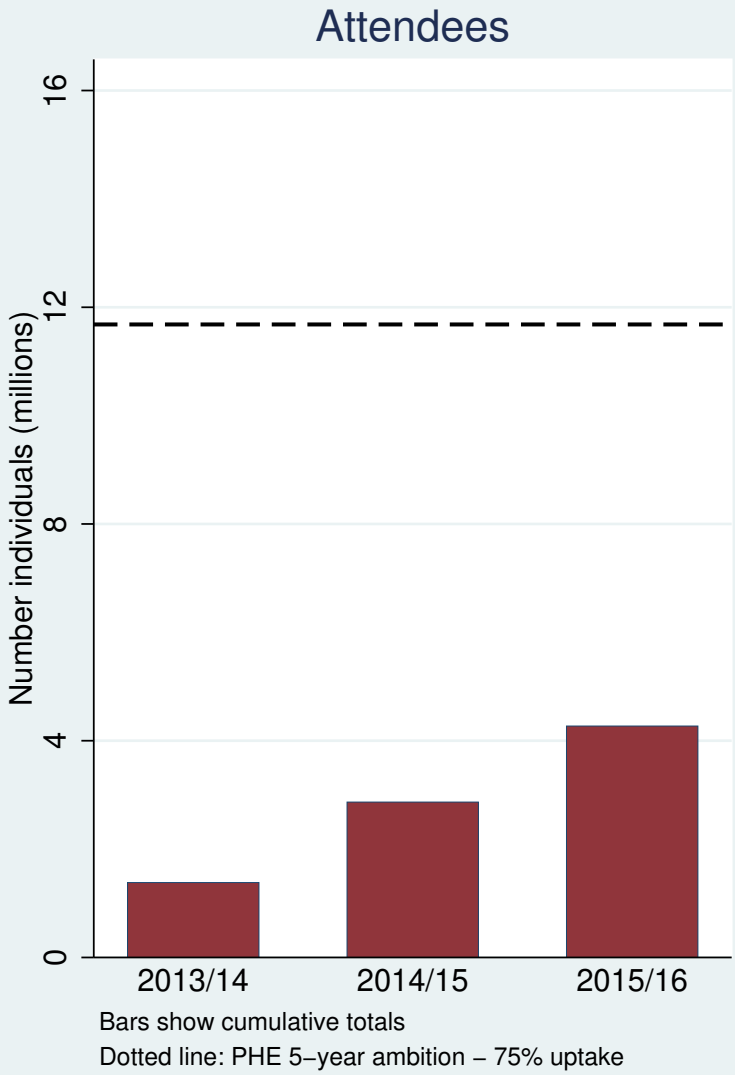

Attendees
Number individuals (millions)
0
4
8
12
16
2013/14
2014/15
2015/16
Bars show cumulative totals
Dotted line: PHE 5–year ambition – 75% uptake

**Figure 2**

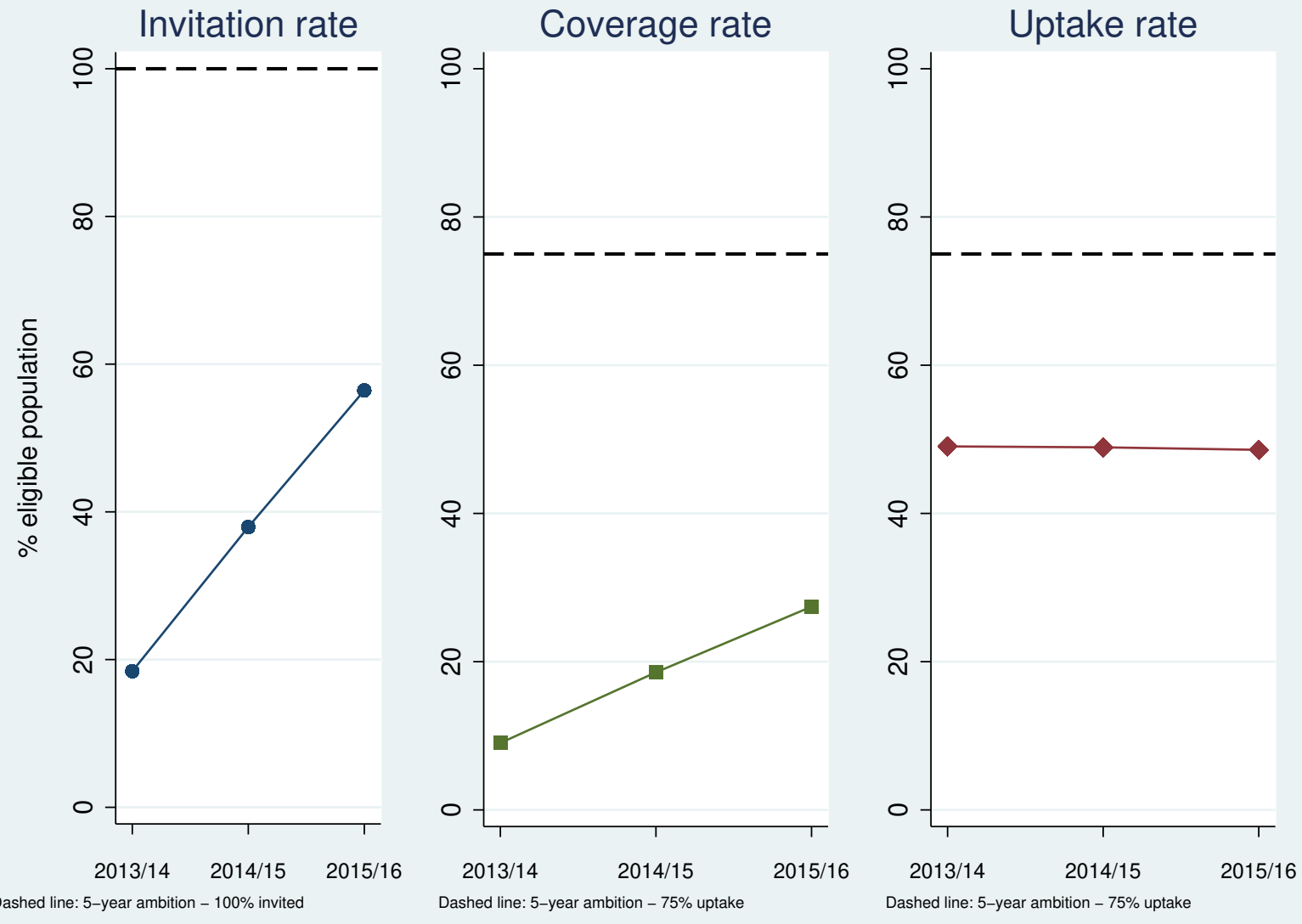

Invitation rate
Coverage rate
Uptake rate
% eligible population
0
20
40
60
80
100
2013/14
2014/15
2015/16
Dashed line: 5–year ambition – 100% invited
Dashed line: 5–year ambition – 75% uptake
Dashed line: 5–year ambition – 75% uptake

**Table 1**

Table 1: Covariates: summary statistics, 2013/14 to 2015/16

| | 2013/14 | | | 2014/15 | | | 2015/16 | | | All years | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **mean** | **sd** | **N** | **mean** | **sd** | **N** | **mean** | **sd** | **N** | **mean** | **sd** | **N** |
| ***Predisposing factors*** | | | | | | | | | | | | |
| Age 40 to 44 (ref) | 17.58 | 2.70 | 150 | 17.09 | 2.80 | 150 | 16.64 | 2.94 | 150 | 17.10 | 2.84 | 450 |
| Age 45 to 49 | 17.87 | 1.44 | 150 | 17.67 | 1.45 | 150 | 17.39 | 1.47 | 150 | 17.64 | 1.46 | 450 |
| Age 50 to 54 | 16.33 | 0.73 | 150 | 16.62 | 0.71 | 150 | 16.87 | 0.69 | 150 | 16.61 | 0.74 | 450 |
| Age 55 to 59 | 13.90 | 0.55 | 150 | 14.11 | 0.58 | 150 | 14.40 | 0.60 | 150 | 14.14 | 0.61 | 450 |
| Age 60 to 64 | 12.85 | 1.14 | 150 | 12.66 | 1.07 | 150 | 12.54 | 1.01 | 150 | 12.68 | 1.08 | 450 |
| Age 65 to 69 | 12.44 | 1.98 | 150 | 12.60 | 2.00 | 150 | 12.69 | 1.99 | 150 | 12.57 | 1.99 | 450 |
| Age 70 to 74 | 9.03 | 1.36 | 150 | 9.25 | 1.53 | 150 | 9.47 | 1.71 | 150 | 9.25 | 1.55 | 450 |
| % male (40-74) | 49.21 | 0.77 | 150 | 49.22 | 0.78 | 150 | 49.22 | 0.80 | 150 | 49.22 | 0.78 | 450 |
| % white (2011) * | | | | | | | | | | 77.27 | 20.74 | 450 |
| % living in 20% most deprived LSOAs (2015) * | | | | | | | | | | 24.85 | 18.98 | 450 |
| ***Enabling factors*** | | | | | | | | | | | | |
| %LA rural pop (2011) * | | | | | | | | | | 17.51 | 24.49 | 450 |
| FTE GPs per 10,000 pop ** | 6.59 | 0.95 | 150 | 6.62 | 0.98 | 150 | 5.13 | 0.76 | 150 | 6.11 | 1.14 | 450 |
| Per capita spend on NHSHC (£) | £4.17 | £2.97 | 150 | £4.46 | £2.51 | 150 | £4.16 | £2.36 | 150 | £4.26 | £2.62 | 450 |
| Per capita spend on adult obesity (£) | £1.65 | £2.04 | 150 | £1.67 | £1.79 | 150 | £1.60 | £1.62 | 150 | £1.64 | £1.82 | 450 |
| Per capita spend on adult physical activity (£) | £1.37 | £1.92 | 150 | £1.89 | £2.49 | 150 | £1.95 | £2.47 | 150 | £1.73 | £2.32 | 450 |
| Per capita spend: stop smoking services (£) | £2.74 | £1.56 | 150 | £2.53 | £1.31 | 150 | £2.33 | £1.25 | 150 | £2.53 | £1.39 | 450 |
| Per capita spend: wider tobacco control (£) | £0.40 | £0.78 | 150 | £0.34 | £0.50 | 150 | £0.31 | £0.44 | 150 | £0.35 | £0.59 | 450 |
| Spend on NHSHC as % PH budget | 2.37% | 1.50% | 150 | 2.45% | 1.37% | 150 | 1.98% | 1.08% | 150 | 2.27% | 1.34% | 450 |
| Spend on adult obesity as % PH budget | 2.31% | 2.38% | 150 | 2.21% | 2.08% | 150 | 1.86% | 1.57% | 150 | 2.13% | 2.04% | 450 |
| Spend on adult physical activity as % PH budget | 1.84% | 2.24% | 150 | 2.36% | 2.47% | 150 | 2.18% | 2.21% | 150 | 2.12% | 2.32% | 450 |
| Spend on stop smoking services as % PH budget | 5.30% | 2.84% | 150 | 4.53% | 2.10% | 150 | 3.60% | 1.62% | 150 | 4.47% | 2.34% | 450 |
| Spend on wider tobacco control as % PH budget | 0.75% | 1.24% | 150 | 0.60% | 0.89% | 150 | 0.45% | 0.53% | 150 | 0.60% | 0.94% | 450 |
| Spend on lifestyle interventions as % PH budget | 10.19% | 4.45% | 150 | 9.69% | 4.09% | 150 | 8.09% | 3.59% | 150 | 9.32% | 4.15% | 450 |
| Participated in NHSHC HPIS *** | | | | 70.67% | 45.68% | 150 | | | | 70.67% | 45.68% | 150 |
| ***Need factors*** | | | | | | | | | | | | |
| Adult obesity: % LA population (QOF registers) | 10.46 | 2.28 | 150 | 10.00 | 2.26 | 150 | 10.23 | 2.32 | 150 | 10.23 | 2.29 | 450 |
| PHOF 2.14: smoking prevalence (%) | 18.78 | 3.27 | 150 | 18.20 | 3.32 | 150 | 17.33 | 3.12 | 150 | 18.10 | 3.29 | 450 |

| | 2013/14 | | | 2014/15 | | | 2015/16 | | | All years | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **mean** | **sd** | **N** | **mean** | **sd** | **N** | **mean** | **sd** | **N** | **mean** | **sd** | **N** |
| PHOF 2.13ii: % physically inactive adults | 28.88 | 4.54 | 150 | 28.34 | 4.51 | 150 | 29.21 | 4.78 | 150 | 28.81 | 4.62 | 450 |
| PHOF 4.04ii: preventable CVD deaths / 100,000 in <75s | 54.10 | 11.83 | 150 | 52.61 | 11.85 | 150 | 51.44 | 11.93 | 150 | 52.72 | 11.89 | 450 |
| CVD prevalence, 2011* | | | | | | | | | | 0.12 | 0.02 | 450 |

* time-invariant;
** excludes GPs employed by CCGs
*** HPIS: health premium incentive scheme (operated in 2014/15 only)

**Table 2**

Table 2: Regression results – base case models, 2013/14 to 2015/16

| Factor type | Explanatory variables | Model 1: Invitation rate | | Model 2: Coverage rate | | Model 3: Uptake rate | |
|---|---|---|---|---|---|---|---|
| | | IRR | 95%CI | IRR | 95%CI | IRR | 95%CI |
| Predisposing | % aged 45-49 | 0.814* | [0.694,0.955] | 0.831* | [0.716,0.964] | 1.029 | [0.898,1.179] |
| | % aged 50-54 | 0.947 | [0.828,1.083] | 0.853* | [0.754,0.965] | 0.845** | [0.753,0.947] |
| | % aged 55-59 | 0.783** | [0.668,0.917] | 0.854* | [0.740,0.985] | 1.098 | [0.968,1.245] |
| | % aged 60-64 | 0.921 | [0.785,1.081] | 0.939 | [0.810,1.090] | 1.039 | [0.904,1.194] |
| | % aged 65-69 | 0.918 | [0.804,1.049] | 0.848** | [0.750,0.958] | 0.864** | [0.774,0.964] |
| | % aged 70-74 | 0.952 | [0.853,1.062] | 0.992 | [0.897,1.097] | 1.060 | [0.968,1.162] |
| | % male | 0.982 | [0.909,1.062] | 1.001 | [0.931,1.077] | 1.035 | [0.971,1.104] |
| | % white | 1.001 | [0.995,1.007] | 0.999 | [0.993,1.005] | 1.000 | [0.995,1.006] |
| | Deprivation level: medium (IMD 2015) | 1.009 | [0.887,1.148] | 0.941 | [0.832,1.065] | 0.966 | [0.865,1.078] |
| | Deprivation level: high (IMD 2015) | 0.957 | [0.788,1.162] | 0.868 | [0.724,1.041] | 0.892 | [0.758,1.050] |
| Enabling | % rural (incl. hub towns), 2011 | 0.999 | [0.996,1.002] | 1.000 | [0.997,1.002] | 0.998 | [0.995,1.000] |
| | FTE GPs per 10,000 pop (excl CCGs) | 0.999 | [0.957,1.042] | 0.993 | [0.954,1.033] | 1.015 | [0.979,1.052] |
| | **Per capita spend, NHSHC: medium** | **1.168*** ** | **[1.087,1.255]** | **1.198*** ** | **[1.123,1.278]** | **1.044** | **[0.985,1.106]** |
| | **Per capita spend, NHSHC: high** | **1.288*** ** | **[1.182,1.404]** | **1.260*** ** | **[1.166,1.362]** | **1.003** | **[0.935,1.077]** |
| | Per capita spend, adult physical activity: medium | 1.140** | [1.050,1.237] | 1.083* | [1.005,1.168] | 0.942 | [0.881,1.008] |
| | Per capita spend, adult physical activity: high | 1.127* | [1.017,1.250] | 1.011 | [0.921,1.110] | 0.866*** | [0.795,0.943] |
| | Per capita spend, adult obesity: medium | 0.951 | [0.881,1.026] | 0.971 | [0.906,1.041] | 0.982 | [0.922,1.046] |
| | Per capita spend, adult obesity: high | 0.928 | [0.846,1.018] | 0.973 | [0.895,1.059] | 1.057 | [0.980,1.139] |
| | Per capita spend, stop smoking services: medium | 1.054 | [0.975,1.139] | 1.034 | [0.964,1.109] | 0.990 | [0.932,1.053] |
| | Per capita spend, stop smoking services: high | 1.034 | [0.940,1.138] | 1.044 | [0.959,1.138] | 0.997 | [0.922,1.077] |
| | Per capita spend, wider tobacco control: medium | 1.014 | [0.939,1.094] | 1.055 | [0.984,1.130] | 1.064 | [0.998,1.135] |
| | Per capita spend, wider tobacco control: high | 1.051 | [0.963,1.146] | 1.041 | [0.962,1.127] | 1.033 | [0.960,1.112] |
| | Participated in NHSHC Health Premium Incentive Scheme | 1.000 | [0.906,1.103] | 1.054 | [0.964,1.151] | 1.044 | [0.963,1.132] |
| | Class: County | 0.963 | [0.847,1.095] | 0.966 | [0.849,1.100] | 1.070 | [0.954,1.199] |
| | Class: London Borough | 1.111 | [0.892,1.384] | 1.077 | [0.873,1.329] | 0.937 | [0.771,1.138] |
| | Class: Metropolitan District | 0.909 | [0.794,1.042] | 0.962 | [0.846,1.094] | 0.996 | [0.886,1.120] |

| Factor type | Explanatory variables | Model 1: Invitation rate | | Model 2: Coverage rate | | Model 3: Uptake rate | |
|---|---|---|---|---|---|---|---|
| | | IRR | 95%CI | IRR | 95%CI | IRR | 95%CI |
| Need | Adult obesity: % LA population (QOF registers) | 1.062*** | [1.027,1.099] | 1.096*** | [1.062,1.130] | 1.036* | [1.007,1.067] |
| | PHOF 2.14: smoking prevalence | 0.999 | [0.981,1.017] | 0.995 | [0.979,1.012] | 0.993 | [0.979,1.007] |
| | PHOF 2.13ii: physically inactive adults | 0.988 | [0.975,1.001] | 0.985** | [0.973,0.996] | 0.999 | [0.989,1.009] |
| | PHOF 4.04ii: preventable CVD deaths per 100,000 (<75s) | 1.000 | [0.993,1.007] | 1.001 | [0.995,1.008] | 1.000 | [0.994,1.006] |
| | Cardiovascular disease prevalence, 2011 | 0.045 | [0.000,36.905] | 0.167 | [0.000,94.501] | 17.917 | [0.054,5962.981] |
| | 2014/15 | 1.120* | [1.004,1.251] | 1.092 | [0.988,1.208] | 1.023 | [0.934,1.120] |
| | 2015/16 | 1.095 | [0.946,1.268] | 1.091 | [0.953,1.250] | 1.064 | [0.935,1.211] |
| | Observations | 450 | | 450 | | 450 | |
| | Likelihood ratio test (Chi-squared) | 56.548 | | 74.279 | | 75.436 | |

IRR, Incidence rate ratio: exponentiated coefficients; 95% confidence intervals in brackets; * p < 0.05, ** p < 0.01, *** p < 0.001
Base case (A): spend as terciles; deprivation as terciles
Reference groups: % aged 40-44; Deprivation level (tercile): low; Per capita spend (tercile): low; Class: unitary authority; Year: 2013/14

**Appendix Table 1**

**Click here to download e-component: Appendix Table 1(new).docx**

**Appendix Table 2**

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**Data Statement**

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