



UNIVERSITY OF LEEDS

This is a repository copy of *Delivery and impact of the NHS Health Check in the first 8 years: a systematic review*.

White Rose Research Online URL for this paper:
<http://eprints.whiterose.ac.uk/127548/>

Version: Accepted Version

Article:

Martin, A orcid.org/0000-0002-2559-6483, Saunders, CL, Harte, E et al. (6 more authors) (2018) Delivery and impact of the NHS Health Check in the first 8 years: a systematic review. *British Journal of General Practice*, 68 (672). e449-e459. ISSN 0960-1643

<https://doi.org/10.3399/bjgp18X697649>

(c) British Journal of General Practice 2018. This is an author produced version of a paper published in *British Journal of General Practice*. Uploaded in accordance with the publisher's self-archiving policy.

Reuse

Items deposited in White Rose Research Online are protected by copyright, with all rights reserved unless indicated otherwise. They may be downloaded and/or printed for private study, or other acts as permitted by national copyright laws. The publisher or other rights holders may allow further reproduction and re-use of the full text version. This is indicated by the licence information on the White Rose Research Online record for the item.

Takedown

If you consider content in White Rose Research Online to be in breach of UK law, please notify us by emailing eprints@whiterose.ac.uk including the URL of the record and the reason for the withdrawal request.



eprints@whiterose.ac.uk
<https://eprints.whiterose.ac.uk/>

Delivery and impact of the NHS Health Check in the first eight years: a systematic review

Martin A^{1,3}, Saunders CL^{2,3}, Harte E³, Griffin SJ^{2,4}, MacLure C³, Mant J², Meads C^{3,5}, Walter FM², Usher-Smith JA²

¹Academic Unit of Health Economics, Leeds Institute of Health Sciences, University of Leeds, Leeds, LS2 9LJ, UK

²The Primary Care Unit, Department of Public Health and Primary Care, University of Cambridge, Cambridge, CB2 0SR, UK

³RAND Europe, Cambridge, CB4 1YG, UK

⁴MRC Epidemiology Unit, Institute of Metabolic Science, University of Cambridge, Cambridge, CB2 0QQ, UK

⁵Faculty of Health, Social Care and Education, Anglia Ruskin University, Cambridge, CB1 1PT, UK

Correspondence to: Adam Martin A.Martin1@leeds.ac.uk

Key words: NHS Health Check, uptake, coverage, impact, systematic review

Word count: 3,489

ABSTRACT

Background: Since 2009, all eligible persons in England have been entitled to an NHS Health Check. Uncertainty remains about who attends and the health-related impact.

Aim: To review quantitative evidence on coverage (the proportion of eligible individuals who attend), uptake (proportion of invitees who attend) and impact of NHS Health Checks.

Design: A systematic review and quantitative data synthesis.

Data sources: Eleven databases and additional internet sources were searched to November 2016.

Inclusion criteria: Studies or data reporting coverage or uptake and studies reporting any health-related impact which used an appropriate comparison group or before-and-after study design.

Results: Twenty-six observational studies and one additional dataset were included. Since 2013, 45.6% of eligible individuals have received an NHS Health Check. Coverage is higher among older people, those with a family history of coronary heart disease, those living in the most deprived areas, and some ethnic-minority groups. Just under half (48.2%) of those invited have taken up the invitation. Data on uptake and impact (especially regarding health-related behaviours) are limited. Uptake is higher in older people and women but lower in those living in the most deprived areas. Attendance is associated with small increases in disease detection, decreases in modelled CVD risk and increased statin and anti-hypertensive prescribing.

Conclusion: Published attendance, uptake and prescribing rates are all lower than originally anticipated and data on impact are limited, with very few studies reporting the effect of attendance on health-related behaviours. High-quality studies comparing matched attendees and non-attendees and health economic analyses are required.

Word count: 250

Key words: NHS Health Check, uptake, coverage, impact, systematic review

How this fits in: Simultaneous nationwide rollout in 2009 of the NHS Health Check programme was based on some strong assumptions about the likely impact of the programme. Almost a decade on, there remains much uncertainty about who attends and the overall health benefits. This article presents the first systematic review of quantitative data from the programme. Although we found attendance is much lower than originally anticipated, attendees cannot be readily characterised as the “worried well” or “easiest to reach.”

INTRODUCTION

The NHS Health Check programme was launched in England in 2009 as part of a healthcare strategy aimed at “empowering patients and preventing illness”. [1] It offers everyone aged 40-74 years without pre-existing cardiovascular disease (CVD), chronic kidney disease (CKD), type 2 diabetes (T2DM) or dementia an assessment of their risk of having or developing such conditions and advice about relevant medications and lifestyle changes every five years. Since 2013, local authorities have had a statutory responsibility to offer the programme to all eligible individuals, with funding provided by Public Health England (PHE) [2]. Echoing similar efforts in other countries to provide preventive health checks [3, 4], the programme is delivered by various providers, predominantly general practices.

The programme was introduced simultaneously nationwide without robust economic evaluation evidence from a randomised controlled trial (RCT), and with very limited available evidence on health check strategies implemented in other countries [5, 6]. However, the Department of Health modelled the potential long-term cost-effectiveness of the programme [7]. In that modelling it was envisaged that all those eligible would be invited for an NHS Health Check during the first five year cycle. Based on evidence from a national breast screening programme it was expected that 75% would attend. [7] Of those attendees with high cholesterol or CVD risk (10-year $\geq 20\%$), it was hoped that 85% would be prescribed statins (in 50% of cases, this was attributed directly to the health check). Using a time horizon of a lifetime, the cost-effectiveness of the programme was predicted in this modelling to be £2,866 per QALY (quality adjusted life year) (2015/16 prices [8]), well within the limit of what would normally be deemed cost-effective by NICE [9].

The objectives of this study were to systematically identify and synthesize available evidence on: (1) coverage (the proportion of the eligible population who have attended an NHS Health Check) and variation in coverage; (2) uptake (the proportion of those invited who have attended an NHS Health Check) and variation in uptake; and (3) the effect of the programme, in order to provide up-to-date estimates of its delivery and impact.

METHODS

Search strategy and study selection

Full details of the search strategy are given in Appendix 1 and the study selection process is described in detail elsewhere [10]. Briefly, searches included eleven literature databases and additional internet sources encompassing both peer-reviewed and grey literature relevant to NHS Health Checks published up to November 2016.

Inclusion criteria

Quantitative observational data or analyses (cross-sectional or longitudinal) which included people eligible for an NHS Health Check and reported evidence on coverage or uptake were included. Impact studies reporting any health-related outcome which used an appropriate comparison group or a before-and-after study design were also included. Data or analyses relating to other screening or health check services which were not NHS Health Checks were excluded, as were editorials and opinion pieces.

Data extraction, quality assessment and synthesis

Data were extracted independently by three researchers (JUS, AM and CS) using forms devised for this study. Reflecting the wide range of study designs, data and methods identified, existing CASP checklists[11] were adapted for the quality assessment of identified studies.

For each objective, we grouped studies according to their design. Since the programme runs in 5 year cycles, where necessary we adjusted reported coverage to a standardised measure of coverage per year per one fifth of the total eligible population (which can lead to coverage exceeding 100% if more than 20% of the eligible population attend in a given year). We categorised the health-related impact studies (objective 3) into four groups (disease detection, health-related behaviours, prescribing and individual-risk factors) and report the results in order of the degree to which observed differences between groups can be attributed to NHS Health Check attendance.

RESULTS

Overview of included studies

The searches identified 18,524 articles. We reviewed 178 full-text articles and 26 (including five from the grey literature[12–16]) were deemed relevant (Figure 1). All were observational studies. Seven used data from large, routine, consolidated datasets with nationwide reach (including the Clinical Practice Research Datalink (CPRD)[17–20], QResearch[21] and prescribing data[15]); 19 used local data from general practices (n=17) or community settings (n=2) collected in particular geographic areas [12, 16]. Eleven studies were assessed as high quality (Appendix Table A1). In addition to the 26 included observational studies, data identified in the additional internet searches were also extracted from PHE's website.[22]

Objective 1: Coverage (n=10)

The PHE website included data on national-level coverage during the first 3.5 years of the current five year cycle (2013-4, when the NHS Health Check became a statutory requirement, to second quarter (Q2), 2016-7) as well as variation in coverage over time (per quarter) and by area (at the county level). Nine further studies reported data on coverage[13, 18, 21, 23–28] (Table 1).

1a. Reported coverage

The PHE website reported coverage of 45.6% for the whole of England (2013-4 to Q2, 2016-7), ranging from 18.9% in Surrey to 109.2% in Newham[22]. Where full-year data were available, national coverage varied between 48.1% in 2014-15 to 45.0% in 2015-6. Three of the nine published studies used national-level data from earlier years. [18, 21, 24] The reported coverage ranged from 8.1% (2011-2012)[24] to 26.7% (2009-2013)[18]. The other six studies reported data from samples of general practices, with coverage ranging from 20% (2010-11 in Hammersmith and Fulham) [23] to 73% (2011-12 in north-east London) [29] (Table 1).

1b Variation in coverage

Three studies used multiple regression to identify factors associated with differences in coverage between population groups.[18, 23, 24] The findings from these are summarised in Table 2. Two used patient-level data. Both showed higher coverage among older people and those with a family history of coronary heart disease. The study by Artac et al. additionally reported higher coverage amongst non-smokers, those in the most deprived tertile, those without CVD co-morbidities, those registered with larger general practices, and among people from Black and South Asian ethnic groups.[23] By contrast, the study by Chang et al. found no significant association between coverage and deprivation and a lower coverage among people from Black African and Other Black ethnic groups.[18] The third study used data from 151 primary care trusts (PCT) and found those in the most deprived tertile were significantly more likely to have attended a health check, but no significant associations for age, ethnicity, population size and other PCT-level measures.[24]

A further five studies reported coverage for different population sub-groups without adjustment for covariates (Appendix Table A2) [18, 21, 23, 26, 27] The two that used data from large datasets with nationwide reach during the programme's first four years showed higher coverage amongst females, older people and those living in more deprived areas.[18, 21]

Objective 2: Uptake (n=11)

The PHE website included data on national-level uptake (2013-4 to Q2, 2016-7) as well as variation in uptake over time (per quarter) and by area (at the county level). Eleven studies reported uptake and socioeconomic factors associated with uptake in general practices (n=9) [12, 14, 16, 26, 27, 30–35] and community-based settings (n=2).[12, 16] The study samples were different from those used in the coverage studies and generally smaller, ranging from two[30] to 40[31] general practices incorporating between 1,380[34] and 50,485[26] patients.

2a: Reported uptake

Table 3 shows the reported uptake across the data sources. The PHE website reported uptake of 48.2% for the whole of England (2013-4 to Q2, 2016-7), ranging from 20.1% in East Riding of Yorkshire to 100% in Leicester. Where full-year data were available, national uptake varied between 47.9% in 2015-6 to 49.0% in 2013-14. Uptake in the general practice studies (n=9) ranged from 27% (four practices in eastern England)[34] to 52.9% (13 practices in north-western England) [27]. Uptake in the community settings was 45.9% (a football ground) [16] and 71.8% (a mental healthcare unit).[12]

2b: Variation in uptake

Five studies reported associations between patient characteristics and the likelihood of attending, using multivariable regression (Table 3). These consistently showed that the odds of taking up an invitation increased significantly with age and lower deprivation. Of the five studies reporting associations between uptake and sex, four also showed women were more likely to take up invitations. The fifth, a study of 37 practices in Stoke-on-Trent[32], reported the opposite with men more likely to take-up invitations. Only two studies reported the effects of ethnicity. One was in 29 practices in Ealing (West London) and found invitees of South Asian or mixed ethnicity were more likely to attend than white British, whilst there was no difference for Black or Other groups and those with missing data were less likely to attend. [32] The other was across four general practices in the East of England and found no difference in uptake between participants of white and non-white ethnicity. [34]

Five studies also reported unadjusted comparisons between invited attendees and non-attendees (Appendix Table A3).[26, 27, 32–34] All reported higher uptake in older people, but findings for deprivation were more mixed with two reporting higher uptake in those in the least deprived areas[26, 33], one with higher uptake in the most deprived[34], and two with no significant differences[27, 32]. Notably, the association between deprivation and uptake in the unadjusted analysis of the study across four general practices in the East of England was in the opposite direction to the multivariable analysis which adjusted for GP practice (greater deprivation was associated with a higher odds of attending in unadjusted analysis in the study). As the authors of that study note, the GP practices had different distributions of deprivation and used different invitation methods, highlighting the importance of GP surgery characteristics when assessing uptake. Two studies also reported higher uptake in women and, where reported, uptake was higher in non-smokers, those with higher CVD risk and those with hypertension or raised cholesterol.

Objective 3: Impact (n=12)

Twelve studies reported evidence on short-term impact. Five included a comparison group (Table 4). Of these, two used CPRD data to examine individual-level differences over time between matched attendees and non-attendees[19, 20]. The other three reported population-level associations between coverage and outcome[15, 36, 37]. The remaining seven studies were before-and-after studies without

comparison groups (Appendix Table A4). No studies of long-term health impacts or economic evaluations were identified.

3a: Disease detection (n=4)

The CPRD study by Chang et al. showed more frequent diagnosis of familial hypercholesterolemia, hypertension, CKD, peripheral vascular disease and T2DM amongst attendees compared to non-attendees during the two years following attendance, whilst stroke diagnosis was significantly less likely. [20] No significant differences in diagnoses of atrial fibrillation, coronary artery disease, heart failure or transient ischemic attack were observed. [20] The CPRD study by Forster et al. also showed more frequent diagnosis of hypercholesterolemia (high cholesterol), and of hypertension amongst men (but not women)[19].

Two further studies used small samples of general practices and reported associations between NHS Health Check coverage and disease detection after controlling for area-level characteristics (e.g. age profile and deprivation).[36, 37] The study by Caley et al.[36] identified no statistically significant associations between coverage and change in the prevalence of T2DM, hypertension, coronary heart disease, CKD or atrial fibrillation. However, the study only included 79 general practices and only 13.6% of the eligible population had received an NHS Health Check so it was under-powered to detect small differences. The second study by Lambert et al.[37] reported that the number of NHS Health Checks performed explained between 6% and 60% of the variance in incident hypertension across the different practices.

3b: Health-related behaviour (n=4)

The only study with a comparison group to report health-related behaviour reported no significant association between change in smoking prevalence (recorded within primary care records over a median of two years) and attendance at a health check.[20] Three studies reported change in smoking amongst individuals after attendance at a health check (Appendix Table A4). Two[17, 38] showed a significant reduction of at least ten percentage points in the proportion of attendees who smoked, whereas in the other the change was not statistically significant[39]. Without a comparison group, however, it is not possible to attribute these changes to the NHS Health Check. No other health-related behaviours were reported.

3c: Prescribing (n=9)

The two CPRD studies [19, 20] identified significantly greater increases in statin and anti-hypertensive prescriptions amongst attendees than matched non-attendees. For example, new statin prescriptions were initiated for 5.6% of attendees, versus 1.2% of non-attendees over a median of two-years in one of the studies[20], and by 11.0% and 7.6% over four years in the other.[19] Another study investigated

national-level prescribing data and showed a significant association between coverage and high-dose statin prescribing at the PCT level in 2011, however the association was not significant for low-dose statins.[15]

Six before-and-after studies all showed an increased likelihood of a statin prescription following attendance (Appendix Table A4).[17, 18, 21, 27, 32, 39] The proportion prescribed statins after the health check ranged from 18.3% in one of the CPRD studies[17] to 49.9% in Hammersmith and Fulham[39].

3d: Individual risk factors and CVD risk (n=5)

The CPRD study by Chang et al.[20] showed significant differences in BMI, blood pressure (BP) (systolic and diastolic), modelled CVD risk and total cholesterol between attendees and matched non-attendees during a two-year period.[20] For example, the QRISK2 mean score (% 10-year risk) fell by 0.21 (95% CI: 0.19 to 0.24), from 5.1 to 4.9 amongst non-attendees, compared to 6.7 to 6.2 amongst attendees, which is equivalent to the prevention of one cardiovascular event per 4,762 attendees. However, the sample used in the analysis was limited by missing data: only 2.3% of non-attendees had a follow-up QRISK2 score recorded. The population-level cross-sectional study by Lambert et al. also reported a strong negative association between the number of health checks provided in a particular area and incident cases of CVD.[37]

Three further before-and-after studies of attendees[17, 38, 39] identified significant reductions in diastolic BP and cholesterol levels after 12-15 months (Appendix Table A4). Two of these also reported significant reductions in obesity, CVD risk and systolic BP. [17, 39] However, the samples used in the analyses were also limited by missing data (e.g. follow-up data was unavailable for 50% of attendees in one study).[39]

DISCUSSION

Summary of main findings

In the current five year cycle starting in 2013, the most recent available evidence shows that 45.6% of eligible adults across England have attended an NHS Health Check. This percentage varies substantially across the country, from 18.9% in some areas to over 100% in others. Data from the identified studies shows higher coverage among older people, those with a family history of coronary heart disease, those living in the most deprived areas, and some ethnic groups. Uptake also varies substantially with just under half (48.2%) of all those invited taking up the invitation. In the selected samples of patients and general practices in the identified studies, the proportion accepting the invitation is also higher in older people and women but, in contrast with coverage, is lower in those living in the most deprived areas. The

impact studies comparing attendees with matched non-attendees showed that attendance is associated with small increases in disease detection above routine practice, an increased likelihood of statin and anti-hypertensive prescribing (with the percentage of those with a modelled 10-year CVD risk $\geq 20\%$ prescribed statins following a health check ranging between 18% to 63%), and small decreases in modelled CVD risk (the best current evidence suggests that one cardiovascular event is prevented per 4,762 attendees, equating to over 1,400 events across the country during a five year cycle). Very few studies have reported the impact of attendance on health-related behaviours.

Strengths and limitations

Almost a decade since the programme was introduced, and five since it became a statutory responsibility of local authorities, this is the first synthesis of quantitative evidence related to delivery or impact. A strength of our study is the systematic searches, including the OpenGrey database and additional internet-based searches. However, in the absence of randomised trials or a step wedge evaluation of a gradual roll-out of NHS Health Checks, the synthesis is limited by the quality of the included studies. Studies used different populations, time points (including before the programme become statutory in 2013), databases, methods for identifying attendance, and (where multivariable regression was used) adjusted for different observable patient and general practice characteristics. Even for studies using electronic health records, coding was not reliable and so led to some researchers using combinations of entries to classify attendance[20]. This precluded the pooling of data from different studies. Whilst some studies (including the multivariable analyses of uptake (Table 3)) relied on relatively small samples of general practices and patients, even the larger consolidated databases did not include nationally representative samples of patients or general practices. For example, general practices in the North of England are poorly represented in CPRD, and those which contribute data are larger[40] and potentially more engaged with research and preventive medicine than those who do not. Almost all studies relied on routinely collected data for patient characteristics and health outcomes. Missing outcome data is therefore a particular problem as data are likely to be less complete in those people who have not attended a health check. This may be the reason why those who have attended are more likely to have a family history of coronary heart disease recorded, for example. There may also be systematic differences in those who attend health checks and those who don't, leading to bias in the estimates of the impact of the programme based on studies with control groups. For example, those who have not attended a health check but do have a disease or risk factor recorded may be those in whom healthcare professionals have already clinically suspected disease, or those who consult more often.

Implications for clinical practice, policy and research

This study identified data showing that the anticipated coverage and uptake used in the Department of Health model were both too optimistic. When judged against the (ambitious) objective of inviting all eligible individuals in each five year cycle, and the expected aggregate gains in population health arising

from high coverage (expected in the model to be 75%), the evidence shows the programme has fallen considerably short of expectations. Since this remains the objective[2], a question needs to be addressed about where the necessary resources and capacity should come from to achieve it. Conversely, when judged against any reasonable value for money criteria, the identified evidence on attendance is insufficient to indicate a lack of cost-effectiveness. In the economic models, lower than anticipated coverage, for example, would merely reduce aggregated costs and aggregated health gains, without affecting the cost per QALY estimates[7, 41]. Like other interventions (bariatric surgery for instance) and some pharmaceuticals (which might be subjected to a “budget impact test”[42]), it seems NHS health checks may thus be simultaneously cost-effective and unaffordable[41]. A pragmatic response might be to focus attention on targeting the distribution of NHS Health Checks towards those who would benefit most and/or towards reducing health inequalities. The finding that coverage (the proportion of the eligible population who have attended an NHS Health Check) amongst those in the most deprived areas was higher than average despite uptake (the proportion of those invited who have attended an NHS Health Check) amongst those groups being lower and the findings from the study by Attwood et al. in which the direction of association between socio-demographic characteristics and uptake was reversed after adjusting for GP practice[34] suggest that this is already happening to some degree. Together with the finding that coverage was higher among older people, who will be at higher risk of CVD than younger people, this may go some way towards alleviating concerns amongst health professionals that attendees are predominantly the ‘worried well’ or those least likely to benefit[43]. However, given that much of the data on coverage and uptake were from different sources, we suggest that this should be the focus of future research. This could be supported, to some degree, through development of a slightly broader PHE dataset for the routine collection of a small number of variables on those invited and those who subsequently attend. In future years it will also be important to distinguish between those attending for the first time and those attending follow-up NHS Health Checks after five years.

Whilst this study also showed statin prescribing to be below expectations, potentially increasing the cost per QALY, there remains a significant shortage of data on the health impacts, particularly longer term, and costs of health checks. Alongside the data on attendance identified in this study, such data is necessary for revising key assumptions in economic models of health checks,[44, 45] not only in England, but potentially also internationally where similar data is also currently limited[46, 5]. There is also a need for further high-quality studies comparing matched attendees and non-attendees, including follow-up studies to quantify the impact of health check attendance on physical activity, diet, alcohol consumption, smoking, and potential harms such as false reassurance and anxiety which are currently unknown.

Funding

This work was funded by a grant from Public Health England. JUS was funded by an NIHR Clinical Lectureship and FW by an NIHR Clinician Scientist award. JUS is now funded by a Cancer Research UK Prevention Fellowship (C55650/A21464). The views expressed in this publication are those of the authors and not necessarily those of the NHS, the NIHR or the Department of Health.

All researchers were independent of the funding body and the funder had no role in data collection, analysis and interpretation of data; in the writing of the report; or decision to submit the article for publication.

Acknowledgements

We thank our patient and public representatives Kathryn Lawrence and Chris Robertson for providing helpful comments on the findings and the NHS Health Checks Expert Scientific and Clinical Advisory Panel working group for providing us with the initial literature search conducted by Public Health England.

Contributors

AM screened articles for inclusion, extracted and synthesised the data, interpreted the findings and wrote the first draft of the manuscript. CS extracted the data, interpreted the findings and critically revised the manuscript. EH screened articles for inclusion, interpreted the findings and critically revised the manuscript. CMA interpreted the findings and critically revised the manuscript. SG, JM, CM and FW developed the protocol, interpreted the findings and critically revised the manuscript. JUS developed the protocol, screened articles for inclusion, extracted and synthesised the data, interpreted the findings and wrote the first draft of the manuscript.

Competing Interests

None declared.

FIGURE LEGENDS

Figure 1: PRISMA diagram

Figure 2: Change in the percentage of people being prescribed statins before and after attending an NHS Health Check

REFERENCES

1. **Announcement of health checks**
[<http://webarchive.nationalarchives.gov.uk/+/www.dh.gov.uk/en/Healthcare/Longtermconditions/Vascular/NHShealthcheck/index.htm>]

2. **NHS Health Checks: applying All Our Health** [<https://www.gov.uk/government/publications/nhs-health-checks-applying-all-our-health/nhs-health-checks-applying-all-our-health>]
3. Perk J, De Backer G, Gohlke H, Graham I, Reiner Ž, Verschuren WMM, Albus C, Benlian P, Boysen G, Cifkova R, Deaton C, Ebrahim S, Fisher M, Germano G, Hobbs R, Hoes A, Karadeniz S, Mezzani A, Prescott E, Ryden L, Scherer M, Syväne M, Scholte Op Reimer WJM, Vrints C, Wood D, Zamorano JL, Zannad F: **European Guidelines on cardiovascular disease prevention in clinical practice (version 2012): The Fifth Joint Task Force of the European Society of Cardiology and Other Societies on Cardiovascular Disease Prevention in Clinical Practice (constituted by representatives of nine societies and by invited experts)**. *Atherosclerosis* 2012, **223**:1–68.
4. **Package of Essential Noncommunicable (PEN) Disease Interventions for Primary Health Care in Low-Resource Settings** [http://apps.who.int/iris/bitstream/10665/44260/1/9789241598996_eng.pdf]
5. Schuetz CA, Alperin P, Guda S, van Herick A, Cariou B, Eddy D, Gumprecht J, Nicolucci A, Schwarz P, Wareham NJ, Witte DR, Smith U: **A Standardized Vascular Disease Health Check in Europe: A Cost-Effectiveness Analysis**. *PLoS One* 2013, **8**:e66454.
6. Lee JT, Lawson KD, Wan Y, Majeed A, Morris S, Soljak M, Millett C: **Are cardiovascular disease risk assessment and management programmes cost effective? A systematic review of the evidence**. *Prev Med (Baltim)* 2017, **99**:49–57.
7. **Department of Health. Economic Modelling for Vascular Checks** [www.healthcheck.nhs.uk/document.php?o=225]
8. **Unit Costs of Health and Social Care 2016** [<http://www.pssru.ac.uk/project-pages/unit-costs/unit-costs-2016/>]
9. Claxton K, Martin S, Soares M, Rice N, Spackman E, Hinde S, Devlin N, Smith PC, Sculpher M: **Methods for the estimation of the National Institute for Health and Care Excellence cost-effectiveness threshold**. *Health Technol Assess (Rockv)* 2015, **19**:1–504.
10. Usher-Smith J, Harte E, MacLure C, Martin A, Saunders C, Meads C, Walter F, Griffin S, Mant J: **Patient experience of NHS Health Checks: a systematic review and qualitative synthesis**. *BMJ Open* 2017.
11. **Critical Appraisal Skills Programme (CASP) Checklists** [<http://www.casp-uk.net/casp-tools-checklists>]
12. Coffee S: **Engaging Mental Health Service Users in Solihull with the NHS Health Check programme: a community pilot project**. 2015.

13. Coffey M, Cooper AM, Brown TM, Cook PA, Clarke-Cornwell AM: **Vascular Health Checks in Salford: An exploration using FARSITE data.** 2014.
14. Coghill N: **Improving the uptake of NHS Health Checks in more deprived communities using “ outreach ” telephone calls made by specialist health advocates from the same communities : A quantitative service evaluation.** 2016.
15. Jamet G, Tubeuf S, Meads D: **Leeds Institute of Health Sciences Has the introduction of NHS health checks increased the prescription of statins for CVD prevention ?** 2014.
16. NHS Greenwich: **Evaluation of NHS Health Check PLUS Community Outreach Programme in Greenwich.** 2011:1–61.
17. Forster AS, Dodhia H, Booth H, Dregan A, Fuller F, Miller J, Burgess C, McDermott L, Gulliford MC: **Estimating the yield of NHS Health Checks in England: A population-based cohort study.** *J Public Heal (United Kingdom)* 2015, **37**:234–240.
18. Chang K-M, Soljak M, Lee JT, Woringer M, Johnston D, Khunti K, Majeed A, Millett C: **Coverage of a national cardiovascular risk assessment and management programme (NHS Health Check): Retrospective database study.** *Prev Med (Baltim)* 2015, **78**:1–8.
19. Forster AS, Burgess C, Dodhia H, Fuller F, Miller J, McDermott L, Gulliford MC: **Do health checks improve risk factor detection in primary care? Matched cohort study using electronic health records.** *J Public Health (Bangkok)* 2015:1–8.
20. Chang K, Lee J, Vamos E, Solijak M, Johnston D, Khunti K, Majeed A, Millett C: **Impact of the National Health Service Health Check on cardiovascular disease risk: a difference-in-differences matching analysis.** *CMAJ* 2016, **188**:E228-238.
21. Robson J, Dostal I, Sheikh A, Eldridge S, Madurasinghe V, Griffiths C, Coupland C, Hippisley-Cox J: **The NHS Health Check in England: an evaluation of the first 4 years.** *BMJ Open* 2016, **6**:e008840.
22. **Public Health England data on NHS Health Checks** [<http://fingertips.phe.org.uk/profile/nhs-health-check-detailed/data#page/0>]
23. Artac M, Dalton ARH, Majeed A, Car J, Huckvale K, Millett C: **Uptake of the NHS Health Check programme in an urban setting.** *Fam Pract* 2013, **30**:426–35.
24. Artac M, Dalton ARH, Babu H, Bates S, Millett C, Majeed A: **Primary care and population factors associated with NHS Health Check coverage: A national cross-sectional study.** *J Public Heal (United Kingdom)* 2013, **35**:431–439.
25. Baker C, Loughren EA, Crone D, Kallfa N: **A process evaluation of the NHS Health Check care pathway in a primary care setting.** *J Public Health (Oxf)* 2015, **37**:202–209.
26. Cook EJ, Sharp C, Randhawa G, Guppy A, Gangotra R, Cox J: **Who uses NHS health**

checks? Investigating the impact of ethnicity and gender and method of invitation on uptake of NHS health checks. *Int J Equity Health* 2016, **15**:13.

27. Krska J, du Plessis R, Chellaswamy H: **Implementation of NHS Health Checks in general practice: variation in delivery between practices and practitioners.** *Prim Health Care Res Dev* 2015(April 2009):1–8.

28. Robson J, Dostal I, Madurasinghe V, Sheikh a., Hull S, Boomla K, Page H, Griffiths C, Eldridge S: **The NHS Health Check programme: implementation in east London 2009-2011.** *BMJ Open* 2015, **5**:e007578–e007578.

29. Robson J, Dostal I, Madurasinghe V, Sheikh A, Hull S, Boomla K, Page H, Griffiths C, Eldridge S: **The NHS Health Check programme: implementation in east London 2009-2011.** *BMJ Open* 2015, **5**:e007578.

30. Kumar J, Chambers R, Mawby Y, Leese C, Lqbal Z, Picariello L, Richardson D: **Delivering more with less? Making the NHS Health Check work in financially hard times: Real time learning from Stoke-on-Trent.** *Qual Prim Care* 2011, **19**:193–199.

31. Hooper J, Chohan P, Caley M: **Case detection of disease by NHS Health Checks in Warwickshire, England and comparison with predicted performance.** *Public Health* 2014, **128**:475–477.

32. Dalton ARH, Bottle A, Okoro C, Majeed A, Millett C: **Uptake of the NHS Health Checks programme in a deprived, culturally diverse setting: cross-sectional study.** *J public Heal (Oxford, Engla* 2011, **33**:422–9.

33. Cochrane T, Gidlow CJ, Kumar J, Mawby Y, Iqbal Z, Chambers RM: **Cross-sectional review of the response and treatment uptake from the NHS Health Checks programme in Stoke on Trent.** *J Public Heal (United Kingdom)* 2013, **35**:92–98.

34. Attwood S, Morton K, Sutton S: **Exploring equity in uptake of the NHS Health Check and a nested physical activity intervention trial.** *J Public Health (Bangkok)* 2015, **38**:fdv070.

35. Sallis A, Bunten A, Bonus A, James A, Chadborn T, Berry D: **The effectiveness of an enhanced invitation letter on uptake of National Health Service Health Checks in primary care: a pragmatic quasi-randomised controlled trial.** *BMC Fam Pract* 2016, **17**:35.

36. Caley M, Chohan P, Hooper J, Wright N: **The impact of NHS health checks on the prevalence of disease in general practices: A controlled study.** *Br J Gen Pract* 2014, **64**:516–521.

37. Lambert MF: **Assessing potential local routine monitoring indicators of reach for the NHS health checks programme.** *Public Health* 2016, **131**:92–98.

38. Cochrane T, Davey R, Iqbal Z, Gidlow C, Kumar J, Chambers R, Mawby Y: **NHS health**

checks through general practice: randomised trial of population cardiovascular risk reduction. BMC Public Health 2012, **12**:944.

39. Artac M, Dalton ARH, Majeed A, Car J, Millett C: **Effectiveness of a national cardiovascular disease risk assessment program (NHS Health Check): results after one year.** Prev Med (Baltim) 2013, **57**:129–34.

40. Campbell J, Dedman D, Eaton S, Gallagher A, Williams T: **Is the CPRD GOLD Population Comparable to the U.K. Population?** Pharmacoepidemiol Drug Saf 2013, **22**:280.

41. Hinde S, Bojke L, Richardson G, Retat L, Webber L: **The cost-effectiveness of population Health Checks: have the NHS Health Checks been unfairly maligned?** J Public Health (Bangkok) 2017, **25**:425–431.

42. National Institute for Health and Care Excellence.: Budget Impact Test. 2017.

43. Mills K, Harte E, Martin A, MacLure C, Griffin SJ, Mant J, Meads C, Saunders CL, Walter FM, Usher-Smith JA: **Views of commissioners, managers and healthcare professionals on the NHS Health Check programme: a systematic review.** BMJ Open 2017, **7**:e018606.

44. Crossan C, Lord J, Ryan R, Nherera L, Marshall T: **Cost effectiveness of case-finding strategies for primary prevention of cardiovascular disease: a modelling study.** Br J Gen Pract 2016(August):1–11.

45. Kypridemos C, Allen K, Hickey GL, Guzman-Castillo M, Bandosz P, Buchan I, Capewell S, O’Flaherty M: **Cardiovascular screening to reduce the burden from cardiovascular disease: microsimulation study to quantify policy options.** BMJ 2016, **353**:i2793.

46. Lee JT, Lawson KD, Wan Y, Majeed A, Morris S, Soljak M, Millett C: **Are cardiovascular disease risk assessment and management programmes cost effective? A systematic review of the evidence.** Prev Med (Baltim) 2017, **99**:49–57.

Table 1: Overall Coverage

Author / Year	Setting and time period	Coverage per one fifth of the total eligible population
NATIONAL LEVEL		
Public Health England[22]	England 2013-4 to Q2 2016-7	45.6%
Artac 2013[24]	England 2011-12	8.1%
Chang 2015[18]	England 2009-13	26.7%
Robson 2016[21]	England 2009-12	12.8%
REGIONAL LEVEL		
Artac 2013[23]	27 (of 31) PCTs in Hammersmith and Fulham 2008-09 2010-11	2008-09:32.7% 2010-11:20.0%
Baker 2015[25]	83 (of 85) practices in Gloucestershire 2011-12	49.8%
Coffey 2014[13]	40 (of 47) practices in Salford 2013-14	34%
Cook 2016[26]	Not reported 2013-14	56.5%
Krska 2015[27]	13 (of 55) GP practices in Sefton, North West England 2011-12	47.2%
Robson 2015[29]	3 PCTs in East London 2009-10 2010-11 2011-12	2009-10: 33.9% 2010-11: 60.6% 2011-12: 73.4%

Table 2: Associations between coverage and area-level or individual-level characteristics from multivariable adjusted studies

Author / Year	Description of analysis	Age	Gender	Ethnicity	Deprivation	Smoker	Family history of CHD	Other
Artac 2013[24]	Multivariable linear regression comparing PCT-level characteristics	Highest proportion of PCT population in 40-74 age range compared to lowest Coefficient -0.03 (-0.87-0.36) p=0.668	Not reported	Highest proportion of PCT population of minority ethnicity compared to lowest Coefficient 0.08 (-0.17-0.95) p=0.424	Least deprived tertile compared to most deprived: Coefficient -0.51 (-1.88-0.0) p=0.035*	---	---	Population size, QOF points, patient experience, FTE GPs, estimated proportion at high-risk and estimated CVD prevalence: ns
Chang 2015[18]	Multilevel logistic regression of individual-level patient characteristics	Compared to 40-49 years: Aged 50-59: 1.60 (1.54-1.67)* Aged 60-69: 2.47 (2.36-2.58)* Aged 70-74: 2.88 (2.49-3.31)*	Female: 1.01 (0.98-1.05)	Compared to White: Black African: 0.75 (0.61-0.92)* Chinese: 0.68 (0.47-0.96)* Other White: 0.35 (0.33-0.37)* Other Black: 0.58 (0.46-0.74)* Not recorded: 0.18 (0.17-0.19)* Prefer not to state: 0.47 (0.41-0.53)* Irish: ns Indian: ns Pakistani/Bangladeshi: ns Other Asian: ns Caribbean: ns	Most deprived quintile compared to least deprived: 0.91 (0.63-1.31)	---	Positive family history compared to no family history: 2.37 (2.22-2.53)*	---
Artac 2013[23]	Multilevel logistic regression of individual-level patient characteristics using data on 27 (of 31) PCTs in London	Compared to 40-54 years: Aged 55-64 Y1: 1.34 (1.11-1.61)* Y2: 1.79 (1.67-1.93)* Aged 65-74 Y1: 2.05 (1.67-2.52)* Y2: 2.79 (2.49-3.12)*	Female: Y1: 0.80 (0.67-0.94)* Y2: 1.27 (1.20-1.35)*	Compared to White: Black Y1: 1.05 (0.78-1.41) Y2: 1.58 (1.43-1.75)* South Asian Y1: 1.27 (0.88-1.87) * Y2: 1.50 (1.25-1.78)* Not recorded: Y1: 0.11 (0.07-0.17)* Y2: 0.08 (0.07-0.10)*	Least deprived tertile compared to most deprived: Y1: 0.84 (0.69-1.01) Y2: 0.80 (0.73-0.87)*	Current smokers compared to non-smokers: Y1: 0.71 (0.61-0.83)* Y2: 0.83 (0.77-0.90)*	Positive family history compared to no family history: Y1: 2.49 (2.15-2.90)* Y2: 2.01 (1.87-2.16)*	Presence of non-CVD co-morbidities: Y1: 1.53 (1.13-1.80)* Y2: 1.75 (1.64-1.87)* Practice list size: >10,000 compared to <6000 Y1: 1.16 (0.51-2.65) Y2: 6.05 (0.85-43.4)*

* p<0.05 ns: not significant. Results presented as adjusted odds ratios unless stated otherwise. PCT – Primary Care Trust; QOF – Quality Outcomes Framework; FTE – full time equivalent; CVD – cardiovascular disease;

Table 3: Uptake and variation in uptake of NHS Health Checks

Study characteristics			Uptake	Multi-variable logistic regression analysis of individual-level factor affecting uptake of NHS Health Checks				
Author / Year	Study design/setting	Sample characteristics where reported		Age	Gender	Ethnicity	Deprivation (area-level)	Other
Public Health England [22]	Published data, whole of England	Whole population data	48.2%	Not reported				
Attwood 2015[34]	Trial ^a set in 4 GP practices in the East of England	1,380 patients Mean age: 52.4 Male: 49.7% White: 72.9%	27.0%	For each increasing year: 1.05 (1.04-1.07)*	Female: 1.29 (0.95-1.76)	Compared to white: 0.85 (0.29-2.52)	Most deprived quintile compared to least deprived: 0.42 (0.20-0.88)*	--- ^c
Cochrane 2013[33]	Observational study using electronic practice records from 37 (of 57) GP practices in Stoke on Trent	10,483 high risk patients Aged >55: 79.6% Aged >65: 36.4% Male: 81.3%	43.7%	Change in odds moving to next category higher for age ≥30-<55, ≥55-<65 and ≥65: 1.64 (1.51-1.77)*	Female: 0.70 (0.58-0.84)*	---	Change in odds moving to next deprivation tertile from least deprived: 1.12 (0.96-1.30)	Change in odds moving to next: Higher risk category ≥15-<25%, ≥25-<35% and ≥35% estimated 10 year risk: 0.90 (0.80-1.02) Larger practice size <3500, ≥3500-<7000 and ≥7000 1.03 (0.88-1.20)
Coffee 2015 ^d [12]	Observational study using data from 2 community medical centres in Birmingham	188 patients already using secondary mental health services	71.8%	Not reported				
Coghill 2016 ^d [14]	Quasi-experimental study/Electronic practice records of 17 GP practices in Bristol	5,678 patients	34.1%	Compared to age 40-69: Age 70-74: 2.09*	Male: 0.82*	---	Least deprived quintile most likely to attend	---
Cook 2016[26]	Observational study using electronic practice records from 30 (all) GP practices in Luton	50,485 patients Aged>55: 30.5% Aged>65: 7.6% Male: 53.3% White British: 32.5%	43.7%	Not reported / Unadjusted differences reported in Appendix Table A3				
Dalton 2011[32]	Observational study using electronic practice records	5,294 high risk patients	44.8%	Compared to age 35-54:	Age 35-54^b: Female	Compared to white:	---	Practice size: Compared to 3000-5999

	from 29 (of 86) GP practices in Ealing, London	Aged>55: 80.8% Aged >65: 40.8% Male: 80.9% White British: 21.7%			Age 55-64: 1.74 (1.34-2.25)* Age 65-74: 2.27 (1.47-3.50)*	1.71 (1.03-2.85)* Aged 55-64: Female 1.22 (0.89-1.67) Aged 65-74: Female 0.96 (0.76-1.22)	South Asian: 1.71 (1.29-2.27)* Mixed race: 2.42 (1.50-3.89)* Black: 1.34 (0.91-1.98) Other: 1.15 (0.76-1.74) Missing: 0.51 (0.30-0.88)*	<3000: 2.53 (1.09-5.84)* ≥6000: 0.79 (0.33-1.88) Hypertension: 1.31 (1.15-1.51)* Smoker: 0.88 (0.75-1.02)
Hooper 2014[31]	Observational study using data from 40 GP practices in Warwickshire	37,236 patients	44.8%	Not reported				
Krska 2015[27]	Observational study using electronic practice records in 13 (of 55) GP practices in Sefton, North West England	2,892 high risk patients Aged >65: 69.4% Male: 78.3% White: 99.1%	52.9%	Not reported / Univariate analyses in Appendix Table A3				
Kumar 2011[30]	Observational study using data from 2 (of approx. 57) GP practices in Stoke on Trent	1,606 patients (of whom 661 were high risk patients) Aged >60: 31.5% Male: 56.7%	30.9%	Not reported				
NHS Greenwich [16]	Observational study using data from 5 community based venues in South East London	1,400 patients Aged >65: 27.5% Male: 45.1%	45.9%	Not reported				
Sallis 2016[35]	Pragmatic quasi-randomised controlled trial in 4 GP practices in Medway	3511 patients Mean Age: 53.1 Male: 49.1%	31.4%	For each increase in 10 years: 1.62 (1.50-1.75) *	Female: 1.50 (1.29-1.74) *	---	Least deprived quintile compared to most deprived 1.61 (1.14-2.26)*	---

Results presented as adjusted odds ratios

* p<0.05 ns: not significant

^a data from control arm of trial who attended NHS health checks; ^b reported with age interaction; ^c the model also controlled for GP practice (n=4).

Table 4. Studies with a comparison group reporting the health-related impact of the NHS Health Check

Study characteristics			RESULTS			
Author / Year	Study design/Setting / Study time period	Comparison and Statistical Method	Disease detection	Health-related behaviours	Individual-risk factors / CVD risk reduction	Prescribing
Chang 2016[20]	Individual-level matched cohort study using CPRD data Baseline: April 2009 - March 2013 Follow-up: Median of 2 years	Difference in difference analysis comparing attendees with non-attendees with propensity score matching on age, gender, ethnicity, deprivation and region	AF: 0.02 (-0.02 to 0.06) CKD: 0.17 (0.11 to 0.23)* CAD: 0.02 (-0.04 to 0.08) FH: 0.09 (0.07 to 0.11)* Heart failure: 0.01 (-0.01 to 0.03) Hypertension: 2.99 (2.77 to 3.21)* PVD: 0.03 (0.01 to 0.05)* Stroke: -0.03 (-0.05 to -0.01)* TIA: 0.008 (-0.01 to 0.03) T2DM: 1.31 (1.17 to 1.45)*	Smoking prevalence: -0.11 (-0.35 to 0.13)	CVD risk: -0.21% (-0.24 to -0.19)* SBP: -2.51mmHg (-2.77 to -2.25)* DBP: -1.46mmHg (-1.62 to -1.29)* BMI: -0.27 (-0.34 to -0.20)* Cholesterol: -0.15mmol/L (-0.18 to -0.13)*	Increase in statin prescribing: 3.83 (3.52 to 4.14)* Increase in anti-hypertensive prescribing: 1.37 (1.08 to 1.66)*
Forster 2015[19]	Individual-level matched cohort study using CPRD data April 2009 - March 2013	Cohort study comparing attendees with non-attendees matched on age, gender and general practice	Hypertension: Men: +5%*; Women: ns Hypercholesterolemia: Men: +33%* ; Women +32%*	---	---	New statin prescribing: HR 1.58 (1.53 to 1.63)* New antihypertensive drug prescribing: HR 1.06 (1.03 to 1.10)*
Caley 2014[36]	Observational study using electronic medical records in 79 GP practices in Warwickshire June 2010 – March 2013 (39 months)	Multivariable regression analysis reporting association between % eligible completing an NHS Health Check at practice level and change in prevalence of five conditions	Observed change in prevalence of T2DM, hypertension, CHD, CKD, AF was not statistically significant	---	---	---
Jamet 2014[15]	Observational study using prescription data in 145 PCTs in England 2012 (1 year)	Multivariable regression analysis reporting association between number of NHS Health Checks completed and statin prescribing at PCT level	---	---	---	Prescriptions of high dose statins: regression coefficient 0.094* Prescriptions of low dose statins: Not significant
Lambert 2016[37]	Observational study using local data returned from GP practices to commissioners in 3 health districts (101 practices) in North East England Unclear year 30 months	Univariate regression models reporting association between number of NHS Health Checks provided in the health district and incident cases of disease	The number of health checks performed explained almost none (1% or less) of the growth in hypertension or diabetes registers and 6-60% of incident cases of hypertension	---	77–92% of variance between practices in numbers of incident high risk of cardiovascular disease was explained by the number of health checks performed.	---

* $p < 0.05$; CPRD – Clinical Practice Research Datalink; AF- atrial fibrillation; CKD – chronic kidney disease; CAD – coronary artery disease; FH – familial hypercholesterolaemia; PVD – peripheral vascular disease; TIA – transient ischaemic attack; T2DM – type 2 diabetes; DBP – diastolic blood pressure; SBP – systolic blood pressure; BMI – body mass index; HR – hazard ratio; CHD – coronary heart disease