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Coverage of a national cardiovascular risk assessment and management programme (NHS Health Check): retrospective database study

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ABSTRACT

Objective

To determine coverage of NHS Health Check, a national cardiovascular risk assessment programme in England, in the first four years after implementation, and to examine prevalence of high cardiovascular disease (CVD) risk and uptake of statins in high risk patients.

Method

Study sample was 95,571 patients in England aged 40-74 years continuously registered with 509 practices in the Clinical Practice Research Datalink between April 2009 and March 2013. Multilevel logistic regression models were used to assess predictors of Health Check attendance; elevated CVD risk factors and statin prescribing among attendees.

Results

Programme coverage was 21.4% over four years, with large variations between practices (0%-72.7%) and regions (9.4%-30.7%). Coverage was higher in older patients (adjusted odds ratio 2.88, 95% confidence interval 2.49-3.31 for patients 70-74 years) and in patients with a family history of premature coronary heart disease (2.37, 2.22-2.53), but lower in Black Africans (0.75, 0.61-0.92) and Chinese (0.68, 0.47-0.96) compared with White British. Coverage was similar in patients living in deprived and affluent areas. Prevalence of high CVD risk ($QRISK2 \geq 20\%$) among attendees was 4.6%. One third (33.6%) of attendees at high risk were prescribed a statin after Health Checks.

Conclusions

Coverage of the programme and statin prescribing in high risk individuals was low. Coverage was similar in deprived and affluent groups but lower in some ethnic minority groups, possibly widening inequalities. These findings raise a question about whether recommendations by WHO to develop CVD risk assessment programmes internationally will deliver anticipated health benefits.

HIGHLIGHTS

- Coverage of the programme examined nationally was low in the first four years.
- Wide variation in coverage was observed between practices and English regions.
- Increases in statin prescribing were found in both high and lower risk patients.
- Only 1/3 of attendees at high risk were prescribed a statin after Health Check.
- Almost five times more patients at lower risk than high risk were offered a statin.

INTRODUCTION

The burden of cardiovascular disease (CVD), type 2 diabetes mellitus and chronic kidney disease is substantial in developed countries and rising rapidly in developing countries.¹ Despite downward secular trends, CVD remains the largest single cause of mortality in England, accounting for around 34% of deaths annually.² Cardiovascular disease also contributes significantly to health inequalities, with prevalence of risk factors, established disease, adverse health outcomes and premature death being disproportionately high in people in lower socio-economic classes and ethnic minority groups.²

Many countries have begun prioritising cardiovascular risk assessment programmes with CVD prevention strategies, for instance the Million Hearts initiative in the United States and More Heart and Diabetes Checks in New Zealand.^{3,4} Recently the World Health Organisation published a global action plan for 2013-2020,⁵ with targets to achieve 25% relative reduction in premature mortality from non-communicable diseases including CVD and diabetes; and at least 50% of eligible people (aged 40 or above with a 10-year CVD risk $\geq 30\%$) to receive drug therapy and counselling by 2025.

The National Health Service (NHS) Health Check programme implemented by the Department of Health in April 2009, invites all people in England aged 40-74 years, who are not currently on a vascular disease register, for a CVD risk assessment every five years. Attendees are communicated their CVD risk in a Health Check and provided with tailored risk management strategies and healthy lifestyle advice.

Evaluation of the NHS Health Check programme is facilitated by the very high use of electronic health records in English primary care, though current evidence mostly comes from local studies with short follow up of patient outcomes. Therefore the main aim of this study was to evaluate coverage of the NHS Health Check programme nationally in the first four years following its implementation. Secondary aims were to assess the prevalence of cardiovascular risk factors and statin uptake among Health Check attendees.

METHODS

Data source

We obtained a longitudinal dataset from the Clinical Practice Research Datalink (CPRD), one of the world's largest primary care databases. CPRD continuously collects anonymised electronic medical records from participating general practices in the United Kingdom,⁶ it is nationally representative and covers approximately 8% of the population.^{7,8} Recent research has found good validity in CPRD data, and the database has been extensively used in epidemiological studies and health services research.^{7,9} The dataset contains information for patient visits using Read codes which support structural encoding of clinical medical records used by general practices in UK.¹⁰ CPRD also includes patient's demographic information, medical history, test results, treatments (including statin prescription and

brief interventions) and referrals to secondary care.⁶ Ethical approval for the study protocol was granted by the CPRD Independent Scientific Advisory Committee (protocol number: 12_039).

Study sample

A random sample of 300,000 age eligible patients was obtained from CPRD for the intervention period of April 1st 2009 (i.e. start date of the programme) to March 31st 2013. For the purposes of this study we employed the following exclusion criteria (Figure 1): not living in England; previous diagnosis of vascular disease before or during the study period (vascular disease exclusions were based on the NHS Health Check Exclusion Read Codes approved by the NHS Information Standards Board in July 2011);¹¹ not aged between 40 and 74 years or alive throughout the study period; and not continuously registered with a general practice during the study period. Our exclusion criteria resulted in a final sample of 95,571 patients for our study.

Outcome measures

The primary outcome measure was Health Check coverage, defined as the proportion of total eligible population who attended a Health Check in the first four years after programme implementation. Although there has been some use of Read codes to record a Health Check attendance in general practices, their usage remained low until late in the study period (Appendix Table A). We therefore defined Health Check attendance, based on the Best Practice Guidance of the programme,¹² by the measurement of four risk factors: blood pressure; body mass index; cholesterol ratio; and smoking status recorded within a six-month window during the intervention period. We built a search algorithm based on this definition with attendance date assigned when the last of four risk factors was recorded. We validated the algorithm against available Read coded Health Check data (Appendix Table A). The algorithm identified 84.9% of the Health Check attendances which were Read coded, and assigned 59.0% of the attendances on the same date, and 82.4% within six months from the Read coded Health Check date (Appendix Table B).

Secondary outcome measures included levels of risk factors (blood pressure, body mass index, cholesterol, smoking status) and global CVD risk scores calculated by both National Institute for Health and Care Excellence (NICE) Framingham and QRISK2 algorithms at the time of Health Check, and whether patients attending a Health Check were prescribed a statin in the 12 months before and 12 months after completion of their Health Checks. Risk factor thresholds we used were $\geq 140/90$ mm Hg for elevated blood pressure, a body mass index of ≥ 30 kg/m² for obesity, and ≥ 5 mmol/l for raised total cholesterol. High CVD risk was defined as having a 20% or higher global CVD risk score. We generated CVD risk scores rather than using existing scores in the medical record as these were poorly recorded and were occasionally derived from old risk factor data. The NICE Framingham risk scores were calculated using the 1991 Framingham equation but adjusted by a factor of 1.4 for South Asian men and 1.5 for family history of premature coronary heart disease (CHD) as

per NICE lipid modification guidance.^{13 14} QRISK2 scores were generated using the QRISK2 batch processor, .NET version 2013.0, obtained from ClinRisk Limited.

Smoking status was verified from patient records. Patients were assumed to be non-smokers if their medical record never indicated them being a smoker.¹⁵ Cholesterol ratio was calculated by the ratio of total cholesterol to high density lipoprotein cholesterol where high density lipoprotein cholesterol was assumed to be 1 mmol/l if missing.¹⁶ We assigned ethnicity as “missing” if not recorded, and as having no family history of premature CHD if this was not recorded. Since CPRD only provides an individual’s quintile of the Townsend (2001) deprivation index, we assigned the median Townsend score nationally for each quintile to calculate each patients’ QRISK2 score.¹⁷ Patients with missing Townsend data (27.4%) were assigned a score of 0 as this is the default value in the QRISK2 algorithm. We assigned patients as being on statins before Health Checks if they had a prescription in the 12 months prior to their first risk factor being recorded. Patients were defined as being on statins after Health Checks if they had a prescription within the 12 months after their algorithm generated Health Check date.

Predictor variables

Predictor variables were individual’s age (40-49, 50-59, 60-69, 70-74) in 2009, gender, ethnicity, family history of premature CHD in a first degree relative, socioeconomic status based on quintile of the 2010 Index of Multiple Deprivations determined by practice postcode,¹⁸ and English region. Ethnicity groupings were built upon the 2001 Census categories as suggested in the Health Check secondary use dataset.¹⁹ We merged ethnic groups and age groups in some analyses as appropriate due to small sample size in some categories. Index of Multiple Deprivations is a summary measure of deprivation assigned to each Lower Layer Super Output Area in England.¹⁸ The index has combined measures from seven major deprivation domains (e.g. income, employment). We decided not to use patient Townsend data as our deprivation variable because 27.4% of data was missing.

Statistical analysis

We calculated the overall coverage for the programme in the first four years after implementation, and assessed unadjusted differences in Health Check coverage by population subgroup using two-tailed z-tests for proportions. We calculated means, proportions and their respective 95% confidence intervals of risk factor levels and global CVD risk scores in Health Check attendees.

We built multilevel logistic regression models to examine associations between Health Check attendance and potential predictors; between elevated risk factor levels and demographic characteristics; and between statin prescribing and predictor variables for high or lower CVD patients separately.

All logistic regression models used were first tested to determine if a two-level random intercept model was substantively better than a single-level model. Multilevel models were fitted with individuals nested within practices. Predictor variables were added into the model one at a time to assess their significance but variable selection was not applied. Significance of random slope was tested for each of the predictor variables. Better models were determined by a significant reduction in deviance compared to a chi-squared distribution with suitable degrees of freedom at 5% level. Multicollinearity was tested among independent variables but was not found.

We present the final fitted models with their variance partition coefficient and median odds ratio calculated from their practice level variance. A higher variance partition coefficient suggests larger variation in the propensity of attending a Health Check between practices. Median odds ratio is directly comparable to the adjusted odds ratios presented in the fixed effect and its concept has been documented elsewhere.²⁰ A median odds ratio of one means no differences in the probability of attending a Health Check. Data manipulation was performed in SAS version 9.3 and statistical analyses were conducted in STATA/SE version 12.

RESULTS

Variation in Health Check coverage

Health Check coverage was 21.4% (20,409/95,571) during the first four years of the programme, with wide variations between general practices (0%-72.7%). Characteristics of Health Check eligible patients and programme coverage by patient subgroups are displayed in Table 1. There was significant variation in coverage between English regions from 9.4% in Yorkshire and Humber to 30.7% in the North East.

Adjusted results for coverage are also shown in Table 1. We observed a strong practice effect via the large median odds ratio (2.95) and variance partition coefficient (28%). Health Check coverage was significantly higher in older patients (adjusted odds ratio 2.88, 95% confidence interval 2.49 to 3.31 in those aged 70-74 years compared with those aged 40-49 years) and in those with a family history of CHD (2.37, 2.22 to 2.53). Compared with White British patients, patients who had no ethnicity recorded (0.18, 0.17 to 0.19) or preferred not to state it (0.47, 0.41 to 0.53); patients who were Black African (0.75, 0.61 to 0.92), Chinese (0.68, 0.47 to 0.96), or from other White (0.35, 0.33 to 0.37) or other Black backgrounds (0.58, 0.46 to 0.74) had significantly lower coverage. There was no significant difference in coverage observed by gender or by deprivation group.

Table 1 Health Check eligible population characteristics and coverage in England (April 2009-March 2013)

	n	Coverage	AOR (95% CI)
Gender			
Male ^a	45708	20.2%	1.00
Female	49863	22.4%*	1.01 (0.98-1.05)
Age group			
40-49 ^a	44561	17.0%	1.00
50-59	30494	22.4%*	1.60 (1.54-1.67)
60-69	19331	29.0%*	2.47 (2.36-2.58)
70-74	1185	31.2%*	2.88 (2.49-3.31)
Family history of CHD			
No ^a	90286	20.2%	1.00
Yes	5285	41.6%*	2.37 (2.22-2.53)
Ethnicity			
British ^a	28619	35.8%	1.00
Irish	348	43.4%*	1.00 (0.79-1.27)
Other White background	20687	20.2%*	0.35 (0.33-0.37)
Indian	725	42.8%*	0.99 (0.83-1.17)
Pakistani/Bangladeshi	348	44.5%*	1.08 (0.84-1.38)
Other Asian background	450	42.0%*	1.07 (0.86-1.32)
Caribbean	369	37.1%	0.84 (0.66-1.07)
African	515	33.4%	0.75 (0.61-0.92)
Other Black background	420	27.4%*	0.58 (0.46-0.74)
Chinese	176	30.1%	0.68 (0.47-0.96)
Others ^b	625	36.8%	0.91 (0.76-1.09)
Not stated	2354	22.0%*	0.47 (0.41-0.53)
Missing	39935	9.9%*	0.18 (0.17-0.19)
IMD quintile			
1 - Least deprived ^a	17236	21.8%	1.00
2	20953	21.3%	0.79 (0.56-1.13)
3	21152	19.0%*	0.72 (0.51-1.03)
4	20001	21.3%	0.82 (0.58-1.17)
5 - Most deprived	16229	24.0%*	0.91 (0.63-1.31)
Region			
London ^a	11827	28.5%	1.00
North East	2064	30.7%*	0.90 (0.43-1.87)
North West	13933	27.6%	1.09 (0.76-1.57)
Yorkshire & The Humber	5852	9.4%*	0.11 (0.06-0.19)
East Midlands	6053	10.8%*	0.24 (0.13-0.41)
West Midlands	9922	23.8%*	0.77 (0.35-0.82)
East of England	12156	17.3%*	0.54 (0.35-0.82)
South West	9696	18.1%*	0.70 (0.46-1.04)
South Central	12840	22.9%*	1.05 (0.70-1.57)
South East Coast	11228	19.5%*	1.01 (0.69-1.49)
Total	95571	21.4%	

Measures of clustering:

Practice level variance	1.30 (1.11-1.52)
Median Odds Ratio	2.95
Variance partition coefficient	0.28

Notes: n=number eligible; Coverage=attended/eligible; AOR=adjusted odds ratio; CHD=coronary heart disease; IMD=index of multiple deprivation; AOR was adjusted by all the other variables in the model; ^a Reference group. ^b Others - mixed background (White and Black Caribbean, White and Black African, White and Asian, other mixed background) and others. *p<0.05 in z-test.

Risk factor levels in Health Check attendees

Risk factor levels and global CVD risk scores in those who attended a Health Check are summarised in Table 2. More than one third (34.5%) of Health Check attendees had blood pressure $\geq 140/90$ mm Hg, 26.3% were obese (≥ 30 kg/m²), 70.1% had total cholesterol ≥ 5 mmol/l, and 17.3% were current smokers. A total of 14.4% attendees were at high risk of CVD using the NICE Framingham equation and 4.6% using QRISK2.

Predictors of elevated risk factors are shown in Table 3. Advanced age was associated with elevated blood pressure (1.99, 1.84 to 2.14 in those aged 60-74 years v patients aged 40-49 years) and raised total cholesterol (1.73, 1.60 to 1.87). In the contrary, an inverse association with increasing age was found for obesity (0.68, 0.62 to 0.73) and being a current smoker (0.58, 0.53 to 0.64). Having a family history of CHD was only significantly associated with a higher odds of having a total cholesterol ≥ 5 mmol/l.

Patients registered with practices in the most deprived quintile were significantly more likely to be current smokers (2.60, 2.19 to 3.09) and obese (1.32, 1.15 to 1.51) compared with those registered with practices from the least deprived quintile. Comparing with White patients, South Asian patients were significantly less likely to be obese (0.68, 0.56 to 0.84), less likely to be current smokers (0.40, 0.30 to 0.52); and less likely to have raised blood pressure (0.73, 0.60 to 0.89).

Table 4 shows demographic predictors of patients at high CVD risk determined by each of the risk algorithms, but results were similar. While all predictors were significant in the model, advanced age had the largest adjusted odds ratio (41.6, 32.8 to 52.8 in those aged 60-74 years v patients aged 40-59 years), followed by having a family history of CHD compared to those without (6.54, 5.28 to 8.08).

Table 2 Risk factor level summary of Health Check attendees (n=20409) at their Health Checks between April 2009 and March 2013 in England

Blood pressure		
	Mean SBP (95%CI)	131.2 (131.05-131.51)
	Mean DBP (95%CI)	79.82 (79.68-79.96)
	$\geq 140/90$ mmHg	34.5%
Body Mass Index		
	Mean (95%CI)	27.4 (27.3-27.5)
	BMI ≥ 30 kg/m ²	26.3%
	BMI ≥ 25 kg/m ²	65.9%
Total cholesterol		
	Mean (95%CI)	5.54 (5.52-5.55)
	≥ 6 mmol/l	33.1%
	≥ 5 mmol/l	70.1%
HDL cholesterol		
	Mean (95%CI)	1.44 (1.42-1.45)
Total/HDL ratio		
	Mean (95%CI)	4.16 (4.14-4.18)
Smoking status		
	Current smoker	17.3%
CVD risk score		
	QRISK2 mean (95%CI)	7.62 (7.53-7.70)
	QRISK2 $\geq 20\%$	4.6%
	QRISK2 $\geq 10\%$	28.8%
	NICE Framingham mean (95%CI)	11.4 (11.3-11.5)
	NICE Framingham $\geq 20\%$	14.4%

Notes: SBP=systolic blood pressure; DBP=diastolic blood pressure; CI=confidence interval; HDL=high density lipoprotein; CVD=cardiovascular disease.

Table 3 Two-level multivariate logistic regression on risk factor thresholds among Health Check attendees (n=20409), Health Checks done between April 2009 and March 2013 in England

	n	% attendees	BP $\geq$ 140/90mm Hg AOR	BMI $\geq$ 30kg/m ² AOR	TC $\geq$ 5mmol/l AOR	Current smoker AOR
Gender						
Male	9250	45.3%	1.00	1.00	1.00	1.00
Female	11159	54.7%	0.63 (0.60-0.67)	1.04 (0.97-1.11)	1.20 (1.13-1.27)	0.79 (0.74-0.85)
Age group						
40-49	7584	37.2%	1.00	1.00	1.00	1.00
50-59	6841	33.5%	1.49 (1.38-1.60)	0.85 (0.79-0.92)	1.67 (1.55-1.80)	0.80 (0.73-0.87)
60-74	5984	29.3%	1.99 (1.84-2.14)	0.68 (0.62-0.73)	1.73 (1.60-1.87)	0.58 (0.53-0.64)
Family history of CHD						
No	18210	89.2%	1.00	1.00	1.00	1.00
Yes	2199	10.8%	0.98 (0.89-1.08)	1.06 (0.96-1.18)	1.17 (1.06-1.30)	0.99 (0.88-1.12)
Ethnicity^a						
White	14562	71.4%	1.00	1.00	1.00	1.00
South Asian	654	3.2%	0.73 (0.60-0.89)	0.68 (0.56-0.84)	0.91 (0.77-1.09)	0.40 (0.30-0.52)
Black	424	2.1%	0.99 (0.79-1.24)	1.65 (1.33-2.03)	0.72 (0.58-0.89)	0.47 (0.34-0.63)
Others	283	1.4%	0.80 (0.61-1.05)	0.60 (0.44-0.82)	0.90 (0.70-1.17)	0.73 (0.52-1.02)
Not stated	519	2.5%	1.00 (0.82-1.22)	1.06 (0.86-1.31)	0.97 (0.79-1.19)	1.09 (0.86-1.40)
Missing	3967	19.4%	1.16 (1.07-1.26)	0.97 (0.89-1.06)	1.12 (1.03-1.22)	0.86 (0.77-0.96)
IMD quintile						
1 - Least deprived	3759	18.4%	1.00	1.00	1.00	1.00
2	4457	21.8%	1.12 (0.98-1.28)	1.04 (0.91-1.20)	0.89 (0.78-1.01)	1.37 (1.15-1.63)
3	4023	19.7%	1.08 (0.94-1.23)	1.19 (1.04-1.36)	0.91 (0.80-1.03)	1.60 (1.35-1.91)
4	4267	20.9%	1.08 (0.94-1.23)	1.27 (1.11-1.45)	0.94 (0.83-1.07)	2.00 (1.69-2.37)
5 - Most deprived	3903	19.1%	1.10 (0.96-1.27)	1.32 (1.15-1.51)	0.89 (0.78-1.02)	2.60 (2.19-3.09)
Total	20409	100.0%				
Measures of clustering:						
Practice level variance			0.07 (0.05-0.10)	0.06 (0.04-0.09)	0.05 (0.03-0.08)	0.10 (0.07-0.14)
Median Odds Ratio			1.29	1.26	1.24	1.35
Variance partition coefficient			0.02	0.02	0.01	0.03

Notes: BP=blood pressure; BMI=body mass index; TC=total cholesterol. AOR=adjusted odds ratio; IMD=index of multiple deprivation; CHD=coronary heart disease; AOR was adjusted by all the other variables in the model. Age group has been collapsed for 60-74 olds.

^a Ethnicity: White – British, Irish, Other White background; Others - mixed background (White and Black Caribbean, White and Black African, White and Asian, other mixed background), Chinese, other ethnic backgrounds; South Asian – Indian, Pakistani, Bangladeshi, Other Asian background; Black – Caribbean, African, Other black background.

Table 4 Two-level multivariate logistic regression on global risk scores threshold among Health Check attendees (n=20409), Health Checks done between April 2009 and March 2013 in England

			NICE Framingham $\geq 20\%$	QRISK2 $\geq 20\%$
	n	% attendees	AOR	AOR
Gender				
Male	9250	45.3%	1.00	1.00
Female	11159	54.7%	0.07 (0.06-0.08)	0.08 (0.06-0.10)
Age group				
40-59	14425	70.7%	1.00	1.00
60-74	5984	29.3%	8.09 (7.30-8.90)	41.6 (32.8-52.8)
Family history of CHD				
No	18210	89.2%	1.00	1.00
Yes	2199	10.8%	4.54 (3.98-5.17)	6.54 (5.28-8.08)
IMD quintile				
1 - Least deprived	3759	18.4%	1.00	1.00
2	4457	21.8%	1.38 (1.14-1.67)	1.24 (0.93-1.66)
3	4023	19.7%	1.27 (1.05-1.54)	1.43 (1.07-1.91)
4	4267	20.9%	1.24 (1.02-1.51)	1.25 (0.93-1.68)
5 - Most deprived	3903	19.1%	1.57 (1.29-1.91)	1.78 (1.32-2.39)
Total	20409	100.0%		
Measures of clustering:				
Practice level variance			0.11 (0.07-0.17)	0.17 (0.09-0.32)
Median Odds Ratio			1.37	1.48
Variance partition coefficient			0.03	0.05

Notes: AOR=adjusted odds ratio; IMD=index of multiple deprivation; CHD=coronary heart disease; AOR was adjusted by all the other variables in the model; Age group has been collapsed into 40-59 and 60-74 age groups.

Statin prescribing before and after Health Checks

Results for statin prescribing stratified by (QRISK2) high and lower CVD risk groups are presented in Table 5. A threefold increase in statin prescribing was observed in high risk patients (11.1% to 33.6%) while an approximately 1.5-times increase (7.0% to 11.7%) in statin prescribing were observed in lower risk patients after Health Check attendance. Most of the increase in statin prescribing seen in patients with lower global CVD risk occurred in those with high (≥ 5 mmol/l) total cholesterol (data not shown). In absolute terms, almost five times more lower risk patients were prescribed a statin after their Health Check than higher risk patients (1025/226).

Family history of CHD was the only significant predictor of higher statin prescribing in high risk patients (1.43, 1.02 to 2.01). The strongest and most significant predictor of statin prescribing in the lower risk group was older age (3.19, 2.90 to 3.50 in 60-74 years v patients aged 40-59 years). Lower risk patients were significantly more likely to be prescribed statins if they had a family history of CHD (1.69, 1.47 to 1.95); or registered with practices in more deprived areas than those in the least deprived areas (1.36, 1.08 to 1.70 in the most deprived quintile). Similar results were obtained using NICE Framingham (Appendix Table C).

Table 5 Statin prescribing in Health Check attendees (n=20409) by high or low CVD risk groups determined by QRISK2 scores, England

	QRISK2≥20%					QRISK2<20%				
	n	Pre ^a	AOR (95%CI)	Post ^b	AOR (95%CI)	n	Pre ^a	AOR (95%CI)	Post ^b	AOR (95%CI)
Gender										
Male	803	11.7%	1.00	34.6%	1.00	8447	7.8%	1.00	13.6%	1.00
Female	140	7.8%	0.56 (0.28-1.12)	27.8%	0.70 (0.46-1.07)	11019	6.4%	0.70 (0.62-0.79)	10.3%	0.63 (0.57-0.69)
Age group										
40-59	90	12.2%	1.00	38.8%	1.00	14335	4.6%	1.00	8.4%	1.00
60-74	853	11.0%	1.29 (0.62-2.71)	33.0%	0.95 (0.58-1.54)	5131	13.4%	3.51 (3.12-3.94)	20.8%	3.19 (2.90-3.50)
Family history of CHD										
No	714	9.2%	1.00	31.7%	1.00	17496	6.7%	1.00	11.4%	1.00
Yes	229	17.0%	2.27 (1.40-3.70)	39.7%	1.43 (1.02-2.01)	1970	9.7%	1.90 (1.60-2.25)	14.9%	1.69 (1.47-1.95)
IMD quintile										
1 – Least deprived	142	7.8%	1.00	36.6%	1.00	3617	6.6%	1.00	10.2%	1.00
2	202	11.9%	1.82 (0.80-4.17)	29.7%	0.76 (0.47-1.25)	4255	7.6%	1.20 (0.92-1.57)	11.6%	1.18 (0.95-1.48)
3	212	9.0%	1.21 (0.52-2.82)	30.2%	0.75 (0.46-1.21)	3811	6.7%	1.05 (0.80-1.38)	11.1%	1.13 (0.90-1.42)
4	182	10.4%	1.47 (0.62-3.45)	29.1%	0.71 (0.43-1.18)	4085	7.9%	1.29 (0.99-1.69)	13.4%	1.46 (1.17-1.82)
5 – Most deprived	205	15.6%	2.18 (0.98-4.85)	42.9%	1.27 (0.79-2.04)	3698	6.1%	1.02 (0.77-1.35)	12.2%	1.36 (1.08-1.70)
Total	943	11.1%		33.6%		19466	7.0%		11.7%	
Measures of clustering:										
Practice level variance			0.41 (0.06-2.54)		0.11 (0.009-1.35)			0.33 (0.24-0.45)		0.24 (0.18-0.32)
Median Odds Ratio			1.84		1.37			1.73		1.59
Variance partition coefficient			0.11		0.03			0.09		0.07

Notes: AOR=adjusted odds ratio; IMD=index of multiple deprivation; CHD=coronary heart disease; AOR was adjusted by all the other variables in the model; Age group has been collapsed into 40-59 and 60-74 age groups.

^a Before Health Check.

^b After Health Check.

DISCUSSION

Key findings and comparison with other studies

Coverage of the NHS Health Check programme was low at 21.4% in the first four years after programme implementation. Coverage ranged from 9.4% to 30.7% between English regions, and varied widely between general practices (0%-72.7%). The large variation in coverage present is consistent with previous studies and may reflect the phased initial roll-out of the programme.²¹⁻²³ Our findings are consistent with previous local studies which found higher attendance in older patients and in those with a family history of CHD.²²⁻²⁴ Previous studies suggest attendance may be higher in ethnic minority groups but have produced mixed findings on whether men or women were more likely to attend.²²⁻²⁴ We identified no significant gender differences in coverage using national data. Our large sample size allowed us to assess coverage by ethnic group in greater detail than previous studies. We found significantly lower coverage in patients from Black African; other Black; Chinese and Other ethnic groups when compared with White British. Importantly, we found no difference in coverage between patients living in deprived and affluent areas of England. In addition, we did not find any pattern suggesting a relationship between coverage of the English regions and the proportion of high risk patients identified (results not shown).

Health Check attendees in our study had lower risk factor levels than those found in previous studies as those evaluated local programmes which initially targeted patients at high CVD risk.^{22 23} Risk factor levels in our sample were broadly similar to nationally representative estimates derived from the Health Survey for England, which found that 32.8% of respondents had elevated blood pressure, 29.3% were obese and 19.8% smoked.²⁵ Our findings on statin prescribing activity are consistent with previous studies which report underuse of statins in high risk patients with potential overuse in lower risk patients. Statin prescribing in patients with lower global CVD risk was higher in patients with higher total cholesterol, older patients and those with a family history of CHD which is consistent with previous studies.^{8 22 23 26 27} Despite a threefold increase in the number of high risk patients prescribed statins, our findings suggest only one in three (33.6%) high risk patients were prescribed a statin after their Health Checks. The use of statins for primary prevention of CVD has been subject to much debate.^{28 29} The recent update of the lipid guidance NICE has lowered the risk threshold to 10%.³⁰ Based on our QRISK2 data this would make one third of Health Check attendees potentially eligible for a statin therapy.

Strengths and limitations of this study

This study is the first to evaluate national coverage of the NHS Health Check programme. Using CPRD data allows nationally representative estimates of programme performance, including the examination of patient, practice and regional level variations in coverage and risk factor management. However, our study has highlighted poor recording of Health Check invitation and attendance Read

codes in general practice data. Lack of data on invitations offered meant that we were only able to quantify programme coverage, not uptake. We restricted our sample to persons without vascular disease, registered with a CPRD practice and eligible for a Health Check throughout the study period. While our study design provides a robust and fair assessment of performance against programme objectives, it precludes us reporting incident cases of CVD, diabetes or chronic kidney disease identified as a result of Health Checks. However, screening for diabetes and chronic kidney disease were not core components of the programme during the study period. Our findings are restricted to patients who were continuously registered with participating practices during the first four years of Health Checks (2009-13), but were substantially unchanged when we included patients who were registered for only part of this time period (results not shown). People who were prescribed statins before their Health Check were not excluded in this study as this was not an eligibility criterion listed in the 2009 Best Practice Guidance.¹²

Due to the large size of sample we obtained, we were able to compare coverage by more detailed ethnic categories than in previous work, but the study is limited by 41.8% of the patients with no ethnicity status recorded. This 'missing' category should not be interpreted as a distinctive group but rather an indication that these patients either consulted their general practices infrequently or were registered with practices with lower recording of ethnicity. We defined Health Check attendance by the measurement of four risk factors (blood pressure, body mass index, cholesterol ratio, smoking status) within a six-month window. Our validation of this algorithm showed it captured 84.9% of the Health Check attendances recorded using Read codes. However, there is still no single standard Read code for Health Check attendance. Individual level deprivation measures (based on patient's area of residence) were not available for 27.4% of the study sample. This meant we had to assign Index of Multiple Deprivation 2010 quintiles based on practice postcode for our deprivation predictor variable and assigned a default value for Townsend scores in QRISK2 calculations in these patients. Adherence to statins could not be examined in this study as CPRD only provides data on drug prescriptions by general practitioners but not on drug collection and use by patients.

CONCLUSIONS

Coverage of the NHS Health Check programme and statin prescribing in high risk individuals was low in the first four years of the programme. Substantial work needs to be undertaken to standardise operating procedures for the programme, to raise awareness about potential benefits among the public and NHS professionals, and to reduce barriers to attendance. Our finding of very low programme coverage and statin prescribing in a health system with universal health coverage and well developed primary care raise a question about whether plans to develop CVD risk assessment programmes internationally, as recently recommended by the WHO,³¹ will deliver the anticipated public health benefits.

FOOTNOTES

Contributors: KC, MS, JL, AM and CM designed the study, MS and MW acquired the data. KC analysed the data, JL advised on statistical issues. All authors discussed data analyses and interpreted the results. KC, CM, MS and AM wrote the first draft of the manuscript. All authors critically revised and approved the final manuscript. KC had full access to all the data used in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis. KC is the guarantor.

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Conflict of Interest: KK is an advisor to the NHS Health Check programme and informed some elements of the programme. This study was conducted as part of activities supported by National Institute for Health Research Collaboration for Leadership in Applied Health Research and Care East Midlands.

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APPENDIX

Table A - NHS Health Check related attendance/follow-up READ codes used by CPRD practices (based on 95571 Health Check eligible patients)

READ code	READ term	2009/10	2010/11	2011/12	2012/13	Total
9NdT.11	Consent given for CV health check	-	-	-	1	1
9NdT.00	Consent given for CV health risk assessment	-	-	5	2	7
8BAg.00	NHS Health Check completed	35	625	2078	3019	5757
8BR2.00	NHS Health Check indicated	-	61	134	339	534
6B5..00	NHS Health Check programme	-	209	204	409	822
38B1.11	CVD risk assessment	9	15	5	-	29
9OhA.00	CVD risk assessment done	231	746	668	379	2024
8BR1.00	CVD risk assessment indicated	37	46	87	61	231
38B1000	CVD risk assessment by third party	-	3	32	31	66
68...11	Screening - health check	31	59	31	24	145
38B1.00	Vascular disease risk assessment	197	322	235	193	947
6AH..00	NHS Health Check annual review	1	2	63	98	164
Total		541	2088	3542	4556	10727

Table B – Health Check search algorithm validation (based on 10727 READ coded Health Checks from Table A)

	Risk factors clustering period	
	6 Months	3 Months
Number of RCHC identified by AGHC	9112	8823
Proportion RCHC identified by AGHC	84.9%	82.3%
<i>--For those RCHCs identified by AGHC--</i>		
AGHC date = RCHC date	5379	5417
	59.0%	61.4%
Health Check dates diff <= 3 months	7271	7264
	79.8%	82.3%
Health Check dates diff <= 6 months	7512	7445
	82.4%	84.4%

Notes: RCHC – Read coded Health Check; AGHC – algorithm generated Health Check;

Table C - Statin prescribing in Health Check attendees by high or low CVD risk groups determined by NICE Framingham scores

	NICE Framingham $\geq$ 20%					NICE Framingham<20%				
	n	Pre	AOR (95%CI)	Post	AOR (95%CI)	n	Pre	AOR (95%CI)	Post	AOR (95%CI)
Gender										
Male	2442	9.5%	1.00	27.6%	1.00	6808	7.6%	1.00	11.1%	1.00
Female	455	7.2%	0.58 (0.39-0.86)	29.5%	1.04 (0.82-1.32)	10704	6.4%	0.65 (0.57-0.74)	9.7%	0.70 (0.63-0.78)
Age group										
40-59	1116	6.7%	1.00	24.4%	1.00	12352	4.5%	1.00	7.3%	1.00
60-74	1781	10.7%	1.95 (1.46-2.61)	30.1%	1.42 (1.18-1.71)	642	14.0%	3.96 (3.48-4.49)	19.3%	3.45 (3.10-3.84)
Family history of CHD										
No	2308	8.1%	1.00	27.3%	1.00	15902	6.6%	1.00	10.0%	1.00
Yes	589	13.4%	2.12 (1.57-2.87)	30.2%	1.21 (0.97-1.50)	1610	9.4%	1.93 (1.59-2.34)	12.9%	1.68 (1.42-1.99)
IMD quintile										
1 - Least deprived	461	7.4%	1.00	24.3%	1.00	3298	6.5%	1.00	9.4%	1.00
2	664	9.8%	1.42 (0.89-2.27)	25.0%	1.09 (0.78-1.54)	3793	7.4%	1.19 (0.90-1.57)	10.2%	1.11 (0.87-1.41)
3	596	8.4%	1.16 (0.71-1.88)	26.9%	1.19 (0.84-1.68)	3427	6.5%	1.02 (0.77-1.37)	9.6%	1.01 (0.79-1.30)
4	578	9.5%	1.42 (0.87-2.29)	27.5%	1.25 (0.88-1.77)	3689	7.7%	1.27 (0.96-1.68)	12.0%	1.37 (1.08-1.75)
5 - Most deprived	598	10.4%	1.54 (0.96-2.48)	35.5%	1.87 (1.33-2.63)	3305	5.9%	0.98 (0.73-1.32)	9.9%	1.14 (0.89-1.47)
Total	2897	8.8%		27.9%		17512	6.9%		10.2%	
Measures of clustering:										
Practice level variance			0.16 (0.03-0.78)		0.26 (0.14-0.47)			0.35 (0.25-0.48)		0.28 (0.21-0.38)
Median Odds Ratio			1.46		1.62			1.75		1.65
Variance partition coefficient			0.05		0.07			0.10		0.08

Notes: AOR=adjusted odds ratio; IMD=index of multiple deprivation; CHD=coronary heart disease; AOR was adjusted by all the other variables in the model; Age group has been collapsed into 40-59 and 60-74 age groups.

Figure 1 Exclusions from the study sample