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Title page

Cardiovascular risk profiles and the uptake of the NHS Healthcheck Programme in male prisoners in six UK prisons.

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Cardiovascular risk profiles and the uptake of the NHS Healthcheck Programme in male prisoners in six UK prisons.

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Abstract

Introduction

Half of all deaths in custody are due to natural causes, the commonest being cardiovascular disease (CVD). NHS Healthchecks should be available to all eligible prisoners but it is not clear who receives them. Mental health issues are very common in prisoners and may affect how healthcare interventions should be delivered. Current policy is to offer Healthchecks to those serving over 2 years in prison.

Objectives, Methods, Setting and Design

An observational cross-sectional survey was carried out in six male prisons in England between September 2017 and January 2019. Of those prisoners aged 35-74, it identified who was eligible for a Healthcheck and compared CVD risk data with those that were not, and with subsequent uptake.

Outcome measures

Characteristics of those accepting a Healthcheck were compared with those declining. Assessments of anxiety and depression were made and results compared with CVD risk factors.

Results

1207 prisoners completed a Healthcheck. 21.8% of prisoners were ineligble due to existing comorbidities. 76.4% of those invited took up a Healthcheck, and of those, 12.1% were found to have new significant CVD comorbidity. CVD risk was similar to community levels but this population was 10 years younger. Definite case-level depression or anxiety was present in 20.7% and 18.0% respectively of participants. Prisoners from ethnic minorities were less likely to be invited (P=0.023) or to accept (P=0.008) a Healthcheck. Prisoners serving less than 2 years had similar CVD risk profiles but much higher levels of anxiety (P<0.001) or depression (P=0.009) than those serving 2 years or more.

Conclusion

Cardiovascular risk was comparable with community rates and in some prisons, much higher. Rates of anxiety and depression were high and there appeared to be inequities in access. The national policy for selecting prisoners for Healthchecks may leave many high-risk prisoners without appropriate cardiovascular preventative assessments.

ARTICLE SUMMARY : **Strengths and Limitations of the study**

- This study is the largest study of its kind to report cardiovascular risk in male prisoners, and allowed the measurement of CVD risk across the whole eligible prison population not only those who took part in a Healthcheck
- Generally, levels of missing data were low except for blood results. Estimation of QRISK2 by SystmOne is guided by an internal algorithm (based on community data) for dealing with missing values; we were unable to adjust for possible differences in prison population risk profiles, although we compared estimated QRISK2 scores assuming missing lipid values with scores based on actual lipid results in the study population and showed that QRISK2 scores were statistically worse (greater CVD risk) when using the actual scores (Supplementary Table s1). This suggests that any bias introduced as a result of missing blood values in QRISK2 calculations may have been to under- estimate CVD risks found in this population.
- The self-rating measures used to assess anxiety and depression are not the same as clinical diagnosis although scores recorded implied high levels of definite or probable depression and anxiety cases in this population.
- The logistics of conducting research in prison settings were challenging with security, staffing and clinic capacity issues all impacting on the ability to deliver Healthchecks and to engage participants in research. The volume of throughput of prisoners (between 15-100 prisoners per establishment per month) meant that the research team were unable to invite all eligible participants. The variability of recruitment between establishments (10-57% invited from the eligible population in each prison) largely reflecting these pressures and between different prison types (Supplementary Table s2). Fewer long-term prisoners were invited which is contrary to the guidance on delivery of Healthchecks, but this reflected greater logistic problems in prisons D and F related to staffing, organisation and clinic capacity.
- Smoking, alcohol use and activity status appeared to be subject to error as both prisoners and health care staff interpreted current status differently; some recording their behaviour before coming into prison, and others describing literally since being in custody, at reception screen or subsequently. Some prisoners also classed themselves as 'smokers' if they used e-cigarettes.

Introduction

The NHS Healthchecks programme[1] is designed to identify individuals with a high risk of future cardiovascular disease, people with diabetes, and those with chronic renal disease, and then offer interventions to help reduce that risk. Although its effectiveness has attracted controversy [2,3,4,5] it remains government policy and and appears to be an important public health intervention with benefits especially for more disadvantaged communities.[6] Uptake of Healthchecks is variable but there is evidence it has improved between 2009 and 2013.[6] A particular feature of the delivery of NHS Healthchecks is that they appear to successfully target higher risk patients in more deprived areas.[4,6,7]

In prison, around 56% of deaths are due to natural causes[8] and of those it is estimated that 35% are due to cardiovascular disease.[9] The prison population is aging with a rise in the proportion over 50 from 7% in 2002 to 16% in 2018,[8] so the burden of cardiovascular disease Is likely to rise. The Chief Medical Officer for England has previously identified prisoner health as a priority[10] and there is growing awareness of the need to improve services and offer parity of care with community settings.[11]

Studies of cardiovascular risk factor profiles in prisoners within the last 15-20 years are rare in the UK[12] but more common in the US and Australia.[13,14,15,16] Reports describing the results of Healthchecks in prisoners generally summarise only those prisoners who undertake a Healthcheck. While there is good data comparing the characteristics of those that do or don't take up Healthchecks in community settings,[6] such data has not been published in prisoner populations.

There is an established relationship between cardiovascular risk and mental health with depression and anxiety symptoms and disorders both arising from, and a possible causative agent for, cardiovascular disease.[17,18,19] There is a high prevalence of mental disorder in prisoner populations,[4] but patterns of anxiety or depression in those taking up a healthcheck in this setting are unknown. Designing interventions to reduce cardiovascular risk requires a good understanding of the pattern of risk factors present in the target population.

Recent national advice from Public Health England[20] has restated the value and need for a high uptake of Healthchecks in prisoners. It has lowered the age of first invitation (from 40 to 35) because prisoners are perceived to be at higher risk of cardiovascular ill-health than the general population. The advice also specifies targeting prisoners with expected incarceration of two years or more.[20] This study was designed to describe the burden of cardiovascular risk of male prisoners and measure indicators of mental illness in study participants.

Methods

Ethics

Ethical approval was obtained from North-East York Research Ethics Committee (16/NE/0133). NHS England Health Research Authority (HRA) approval was given prior to commencement. As with all prison research, Her Majesty's Prison and Probation Service approval was obtained and individual prison governors' permission sought to conduct the research on their site. All participating prisoners in the research study provided written informed consent.

Study Design

An observational cross-sectional survey was conducted in prison healthcare services in the East Midlands. In the period of data collection from September 2017 to January 2019, there were 13 male prisons in the region, with the healthcare services at six prisons agreeing to contribute to the research. The prisons were chosen to cover a broad spectrum of remand through to longer stay. They held NHS (n=4) or private (n=2) contracts for prison healthcare The total number of potential eligible participants from these prisons was approximately 3600 over a 12 month period, calculated by utilising 'churn' (turnover) of the eligible prison population and the actual recorded population at a point in time. This identified the annual churn of prisoners between 5-35%, depending upon the prison site, with a consistent month by month churn of between 15-100 eligible new prisoners.

The outcomes variables were the physical measures from the NHS Healthcheck and mental health measures of depression and anxiety. All prisoners irrespective of sentence length were eligible for this study.

Sampling procedure

All prisoners (regardless of sentence length or time served) who were deemed eligible for the NHS Healthcheck Programme adapted for prison settings[20] were scheduled to be invited to participate (aged between 35-74 years old with no exclusion diagnosis as per NHS Healthcheck criteria). Eligibility was sought using clinic reports from SystmOne, an NHS clinical record system, where those ineligible were subsequently filtered. As per the NHS Healthcheck programme guidance, those excluded were prisoners with established cardiovascular disease: coronary heart disease; strokes; transient ischaemic attacks; diabetes; atrial fibrillation; heart failure; peripheral artery disease and chronic kidney disease and those prisoners already taking statins.

Each prison had a new report run every 2-3 weeks to allow for new prisoner receptions and to discount released or transferred prisoners from being invited.

Variables collected and outcomes measured

Physical Measures:

All variables as per NHS Healthcheck guidance were collected; age, ethnicity (census categories), height, weight, body mass index (BMI), waist circumference, systolic and diastolic blood pressure (BP), smoking status (current, ex- and never smoked), family history of cardiovascular disease, alcohol intake using the Alcohol Use Disorders Identification Test (AUDIT). The AUDIT-C is a shortened version of the 10 question AUDIT tool used to help identify individuals who may have active hazardous drinking habits or have alcohol drinking disorders.[21] The full 10 question AUDIT was undertaken if prisoners scored 5 or above on the AUDIT-C. Physical activity was recorded using the General Practice Physical Activity Questionnaire (GPPAQ), a validated screening tool used in physical health.[22] This is a simple 4-level Physical Activity Index (PAI) categorising patients as: Active, Moderately Active, Moderately Inactive, and Inactive and is correlated to CVD risk. The questions were phrased so they gathered information about each prisoner's lifestyle habits prior to their current detainment in the criminal justice system and how active they are currently in prison.

Blood tests for creatinine, plasma glucose, lipids and HbA1c were requested. If participants had blood tests within 15 months, such results were utilised. Last known postcodes were recorded and Index Multiple Deprivation (IMD) codes applied;[23] IMD 1 being the most deprived area. A large percentage of prisoners were of no fixed abode (NFA) prior to incarceration which does not have a standardised IMD code. For this analysis, these postcodes were given NFA as a discreet categorical value.

As stated in the PHE Programme Guidance, the physical healthcheck in prison risk assessment requires the use of a risk engine to calculate the individual's risk of developing CVD in the next 10 years. As advised by national guidance,[1] this study used QRISK2 [24] as the risk engine.

Mental Health Measures:

Two mental health screens were utilised: the Patient Health Questionnaire (PHQ-9)[25,26] and the Generalised Anxiety Disorder Assessment (GAD-7).[27] The PHQ-9 is a self-rated tool consisting of 9 items which has been found to have good sensitivity (88%) and specificity (88%) to detect major depressive disorder. [25,26]

The GAD-7 is a 7-item self-reported anxiety scale which has been found to have sensitivity of 89% and specificity of 82% for generalised anxiety disorder.[27] Both screens require the individuals to rate their symptoms and feelings related to the previous 2 week period, with items measuring the frequency of symptoms on a scale of 0 (not at all), to 3 (nearly every day). The screens both have cut-off scores ≥ 10. The thresholds mild=0-5, moderate=6-10, moderate/severe=11-14 and severe ≥15 are used in this study. These two mental health measures were utilised following a small-scale pilot at one prison. Participants (n=9) were administered either the Hospital Anxiety and Depression Scale (HADS)[28] or the PHQ-9 and GAD-7. Feedback highlighted that participants and administering staff favoured the PHQ-9 and GAD-7 over the HADS due to time and ease of completion. In addition, the PHQ-9 and GAD-7 are used nationally within services Improving Access to Psychological Therapies (IAPT) therefore allowing potential continuity in referrals and benchmarking against established scoring patterns.

SystmOne was also used to collect monthly anonymised denominator reports at each prison site to compare the whole population characteristics with those eligible to have an NHS Healthcheck and those eligible but declined active participation so differences in the CVD risk profiles between eligible, ineligible, responders and non-responders could be described.

The descriptive analysis compared: those invited for an NHS Healthcheck with those who were invited but did not attend; the eligible population invited with the eligible population uninvited; the whole prison population (age 35-74) with the eligible prison population.

Statistical Analysis

Summary measures were described using mean (standard deviation) or median (interquartile range) for continuous variables, categorical data were given as count (percentage). Means were compared using a two-sample t-test and medians with a two-sample Wilcoxon test. Count data were compared using a Chi-squared test, or in the case of small counts, Fisher's exact test.

Baseline characteristics were taken from the first month a prisoner was recorded in the denominator data for all analyses except those using only prisoners who received a Healthcheck, who were not included in any analyses requiring denominator data.

Sample size was estimated by assuming a range of prevalances for QRISK 2 of 10% and a precision of ±2% requiring 2185 individuals or for a precision of +-3%, 971 individals if prevalence was assumed

to be 35%. For a lower prevlance at 18%, then a sample of 908 participants would enable a precision of ±2.5% around this estimate. All analyses were performed using R version 3.5.3.

Patient and Public Involvement .

Prisoner involvement groups were used to development the consent form, qualitative aspects of the research and to check easy-read versions of printed material; Prisoners did not take part in recruitment. Results wil be disseminated via the prisoner participation groups in each establishment and on the public EM-CLAHRC website.

Results

Eligible and ineligible populations

Table 1 describes the characteristics of a sample of the whole population of prisoners aged 35-74 collected at August 2018 (n=2107) comparing the eligible (n=1648) and ineligible populations (n=459) across all prisons at that point in time. Overall 21.8% of the prison population were ineligible for a Healthcheck due to existing comorbidity. The ineligible prisoners were older (mean age 53.5 (10.2) v 43.8 (7.6) years, P<0.001), had a higher BMI (30.5 (6.7) v 26.9 (5.2), P<0.001), had a higher QRISK2 score (median 13.4 (7.5-22.1)v 3.2 (1.8-6.2), p<0.001), and sentence length (3.45 years (1.5-7.0) v 2.5 (1.0-6.0) P<0.001). Ethnicity was significantly different (P=0.008) with the eligible group contining more white prisoners (79.1% v 76.6%). and fewer from Asian backgrounds (2.6% v 5.2%). The predominant reasons for ineligibility were established history of hypertension (12.9%) and diabetes (8.5%) (Table 2). The proportion ineligible due to comorbidities varied considerably by prison (between 14-37%), largely reflecting age structure differences between prisons . Among all participants aged 35-74, smokers totalled 1748/2107 (82.9%).

Recruitment of eligible prisoners.

Overall 1207 subjects completed Healthchecks from an *invited* eligible population of 1579, a response rate of 76.4%. In all the total eligible population during the course of the study was 3620 individuals, so 43.6% of the available eligible population were invited and 33.3% took part. The mean age (standard deviation) of the whole eligible population was 43.8 (7.6) years. Not all eligible prisoners were invited because of the capacity of the researchers and the volume of prisoner churn.

Characteristics of the eligible study population.

Ethnicity , smoking status, sentence length (P<0.001) and prison attended (P<0.001) were all significantly different between those eligible prisoners who were invited to receive a Healthcheck

and those eligible but who were not invited. Of those who were invited, ethnicity was significantly different (P=0.023) with the invited group contining more white prisoners (82.4% v 79.2%). Invited prisoners were also less likely to be smokers (83.6% v 86.3% P=0.024) and had a larger percentage serving a 2 year or longer sentence (29.8% v 26.1% P<0.001). Other baseline characteristics were not significantly different between the two groups (Supplementary Table s2).

Characteristics of those who declined a Healthcheck

From those invited (n=1579), those who took up a Healthcheck in this study (n=1191 plus 16 who took part but for whom baseline data was not available) differed from those who declined (n=388) in terms of ethnicity (P=0.008), with a smaller percentage of black prisoners receiving a Healthcheck than declining (3.4% v 6.7%). There was also significant variability by prison (Supplementary Table s3). The level of deprivation of the participants was estimated; 35% of participants were identified as of no fixed abode and a further 29% were in the lowest IMD quintile. (Supplementary Table s4)

QRISK2 profiles of eligible prisoners

The QRISK2 profile for all 3620 eligible individuals identified that the proportion of male prisoners above a 10% threshold of QRISK2 varied between 5.6% and 19.8% of the population in the age range 35-74 years in each prison; 10.2% (370/3620) across all six prisons during the study period. (Supplementary Table s5).

High QRSK2 (>=10) prisoner characteristics

Those prisoners who received a Healthcheck and were in the high QRISK2 group (n=125 , 10.3% of participants) were compared for variables not used in the QRISK2 scoring. The high-risk group had greater numbers with a positive family history (69.1% v 53.7%, P=0.002) and fewer with high anxiety (GAD 7) scores (8.0% v 19.1%, P=0.016) than the lower risk prisoners (n=1082). There was no difference in measured levels of depression (PHQ-9), or ethnicity between these groups (Table 3).

Cardiovascular comorbidites in the participants

Among the 1207 prisoners who received a Healthcheck, 146 (12.1%) were found to have at least one of high CVD risk (on QRISK2), renal impairment or diabetes / pre diabetes, with seven having two and one, all three risk factors. There were a substantial number of missing values for the comorbidities defined by blood-based testing (Supplementary Table s6). Prisoners with blood test results were younger (mean age 45.5, s.d.8.2) than those without (mean age 42.7, s.d.7.0; p<0.001); completeness of blood results also varied by prison. Of the 1207 participants, 56.5% (n=682) of

participants described themselves as active or moderately active, and 43.5% (n=525) inactive or moderately inactive.

Mental Health of participants

Overall, (as measured by PHQ-9 and GAD-7) 20.7% (n=249) of participants were classed as moderately severe to severely depressed and 18.0% (n=217) were suffering from severe anxiety (definite cases). These values rose to 37.6% (n=453) for moderate depression or worse and 31.5% (n=378) for moderate anxiety of worse (definite and probable cases) (Table 3).

Length of Sentence

Those prisoners who received a Healthcheck and were sentenced to less than 2 years, compared with longer sentences, did not show significant differences for diabetes or QRISK2 score but had significantly higher rates of possible cases of anxiety (34.9% v 23.8% P<0.001) and depression (41.1% v 31.4% P=0.009). (Supplementary Table s7).

Discussion

Main Findings

When offered a Healthcheck, uptake was high at 75.4 % of those invited. Clinically important cardiovascular risk, as measured by a QRISK2 score ≥10%, diabetes or pre-diabetes, or renal impairment, was present in 12.1% of those participating in the study. This study also identified that the prevalence of existing cardiovascular disease that limited eligibility for the NHS Healthchecks programme was 21.8% (range 13.8-37.3%) of the prison populations studied (as at August 2018), and appeared to be influenced strongly by the age profile of the prisons. 82.9% of all prisoners aged 35-74 were recorded as smokers. Observed levels of clinically important anxiety (18.0%) and depression (20.7%) were more than double the rates found in a similar aged general male population.[29]

What is known about CVD risk already and what the study adds

In community populations eligible for an NHS Healthcheck, uptake between 2009 and 2012 has been reported between 18.7% [6] and 21.4%. [30] The uptake of a Healthcheck in our prison populations who were invited was 76.4 %, much higher than attendance rates found in community samples and

represents a real opportunity to intervene positively in this highly mobile at-risk population. In community studies, around 30% of those in the age group 40-74 were already ineligible because of existing co-morbidity.[6] In our study, 21.8 % of those aged 35-74 were ineligible but from a substantially younger mean age population (mean age = 43.8 years compared with a mean age of 53.3 for the England population distribution for males between the ages of 35 and 74).[31]

Among the study population who received a Healthcheck we found important levels of comorbidity in 12.1%. The proportion of participants receiving a Healthcheck who are found to have new significant comorbidity (hypertension, type 2 diabetes or chronic kidney disease) nationally was 5%, rising to 37.3% if QRISK2 >= 10% was also included.[6] Comorbidity rates have been shown to vary substantially and in one large multi-ethnic population studied which including those with a high diabetes risk (4.6%) and QRISK2 >= 10%, 53.4% of males had one of these comorbidities newly identified as a result of the Healthcheck.[32] In this study, with its much younger male study participants, 12.1% of participants had at least one of these comorbidities newly identified.

In community studies, 19% of males aged 35-74 have a QRISK2 score of 10 or above.[24] Overall, 10.2% of the eligible prison population studied here had a QRISK2 score of 10 or more but the prison population was almost 10 years younger on average. The age-specific QRISK2 bands described here (Supplementary Tables s8) suggest the level of risk is at least comparable; for the age bands 60-74, 26.9% of our participants, and 29.7% of all eligible prisoners in this study had a QRISK2 score of 20 or more, compared with 30.7% nationally[6] and 39.0% in a high risk multi-ethnic population.[32] The respective values for QRISK2 of 10 or more were 98.1% of participants and 92.0% of all eligible prisoners in our study, and 86.6% in the high-risk population.[32] In our study population only six prisoners were over 70 (0.5%) compared with 8.7% in the general population of males aged 35-74.[31]

A larger percentage of prisoners from a non-white heritage were ineligible for a Healthcheck because of existing comorbidity compared to prisoners from a white heritage, and of those eligible, a smaller proportion were both invited to a healthcheck, and received a Healthcheck. This suggests it may be important to monitor Heathcheck uptake by ethnicity to assess any potential inequity in provision of care.

This study is the first in the UK to our knowledge to have described whole eligible denominator populations, rather than just those who actually undertook a Healthcheck, and so allows an estimate of cardiovascular risk across the whole population by institution.

High cardiovascular risk is commoner in more deprived communities with a 20% higher crude incident rate of CVD in the worst deprivation quntile compared with the least deprived. [24] If we

assume that those with no fixed abode in our study were likely to have characteristics similar to those in the highest deprivation quintile, then 65% of participants could be considered to come from the most disadvantaged fifth of society, with the associated higher risks of Cardiovascular disease.

With almost 83% of all prisoners aged 35-74 being recorded as smokers on the GP electronic records system, there appears to still be a very large unmet need for preventative interventions and advice, and further work required on standardising how lifestyle data is collected in prison settings

Public Health England adjusted the eligibility criteria for NHS Healthchecks in 2017 to include those aged 35-74 and who were incarcerated for 2 years or more.[33] We only identified one prisoner among the 3620 eligible (0.02%) under the age of 40 who had a QRISK2 score of 10 or above suggesting that the reduction in eligibility to age 35 may not be an efficient use of scare primary care resources. Similarly, prisoners with a sentence length of 2 years or more had similar proportions with QRISK2 score of 10 or above (12.8% v 9.7%, p=0.238) suggesting this eligibility change did not itself identify those with higher risk. For those serving less than 2 years, there remained a substantial number with adverse cardiovascular risk profiles (9.7% QRISK2>=10) and the shorter sentence prisoners also had significantly higher levels of anxiety and depression (Table s7). This may have been associated with more rapid transit of the prison system but does suggest there was substantial unmet healthcare need in this shorter sentence group. Extending Healthchecks to offenders irrespective of length of sentence would seem a positive policy step but may require additional resources to tackle unmet mental and physical status. Good primary care follow up may also be more challenging after discharge if prisoners are returning to primary care services in areas of highest need.

Conclusion

This study, the largest study of its kind to report cardiovascular risk in male prisoners, identified that 21.8% of the prison population aged 35-74 already had comorbities that precluded them from taking part in an NHS Healthcheck. Across the whole prison population aged 35-74, 82.9% were recorded as smokers. Of those that were eligible for an NHS Healthcheck and took part, a further 12.1% were found to have a significant clinical risk for future cardiovascular disease (QRISK2 ≥10) and 20.7% and 18.0% respecively had definitely clinically significant depression or anxiety. Prisoners from ethnic minorities were less likely to be invited (P=0.023) or to accept (P=0.008) a Healthcheck. Prisoners serving less than 2 years, who would not normally receive NHS Healthcheck through prison healthcare services, had much higher levels of anxiety or depression and an appreciable level of

high cardiovascular risk (9.7%). With two-thirds of this group likely to come from the most deprived fifth of society, ensuing good access to primary care services on discharge is vital to achieving equity of care in this patient group.

Authors Contributions

CP designed the study, wrote the proposal and led the research. MW initiated the data collection, trained healthcare staff, liaisied with the Ethics committee, and led the qualitative research. EB led the research teams collecting the data, completed the project management required by CLARHC, and developed the methods section. JM undertook the statistical analysis and commented on presentation. RM developed the PHQ-9 and GAD-7 analysis. KK helped wih refinements to the study design based on past community research. RM and KK commented extensively on the manuscript. All authors contributed individually to the report content.

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Main Tables

Table 1: Baseline characteristics of those prisoners Eligible and not eligible for healthchecks (information available at August 2018)

	Non-eligible (N = 459)	N missing	Eligible (N =1648)	N missing	P-value
Ethnicity N (%)		32		62	0.008
White	363 (85.0)		1262 (79.6)		
Black	27 (6.3)		86 (5.4)		
Asian (S & E)	12 (2.8)		86 (5.4)		
Mixed/ Other	25 (5.9)		152 (9.6)		
Age (Years)	53.5 (10.2)	0	43.8 (7.6)	0	<0.001
Weight (kg)	93.5 (20.7)	1	83.9 (16.9)	15	<0.001
BMI	30.5 (6.7)	2	26.9 (5.2)	20	<0.001
Smoking status N (%)		2		13	<0.001
Non-smoker	98 (21.4)		246 (15.1)		
Smoker	359 (78.6)		1389 (85.0)		
Sentence length (years) Median (IQR)	3.45 (1.5-7.0)	177	2.5 (1.0-6.0)	580	<0.001
QRISK2 score Median (IQR)	13.4 (7.5-22.1)	0	3.2 (1.8-6.2)	0	<0.001
Prevalent disease	454 (99.1)		-		-
On a Statin	4 (0.9)		-		

All values are mean (sd) unless otherwise stated.

Table 2. Prevalance of existing cardiovascular co-morbidity in the whole eligible prisoner population studied aged 35-74 as at August 2018 (n=2107)

Co-Morbidity	N (%)
Hypertension	**272 (12.9%)**
Diabetes	**180 (8.5%)**
Cardiovascular Disease	**117 (5.7%)**
High Cholesterol / statin	**17 (0.8%)**
Chronic Kidney Disease	**12 (0.6%)**
All comorbidities	***459 (21.8%)***

Table 3: Characteristics of prisoners who received a Healthcheck (n=1207) with high v low QRISK2 scores

Variable	QRISK2 < 10 (N=1082)	No. missing	QRISK2 ≥ 10 (N=125)	No. missing	P-value
Depression: PHQ-9 N (%)		**2**		0	0.058
None or mild	668 (61.7)		84 (67.2)		
Moderate	177 (16.4)		27 (21.6)		
Moderate/ Severe or Severe	235 (21.7)		14 (11.2)		
Anxiety: GAD-7 N (%)		2		0	0.016
None or mild	730 (67.5)		97 (77.6)		
Moderate	143 (13.2)		18 (14.4)		
Severe	207 (19.1)		10 (8.0)		
1st degree Family History[1]		82		5	0.002
Yes	537 (53.7)		83 (69.1)		
No	463 (46.3)		37 (30.8)		
Ethnicity		4		0	0.057
White	876 (81.0)		113 (90.4)		
Black	44 (4.1)		2 (1.6)		
Asian	62 (5.7)		6 (4.8)		
Mixed/Other	96 (8.9)		4 (3.2)		

1] Family history of at least one of the following: Hypercholesterolaemia, Ischaemic heart disease, Angina, Myocardial Infarction, Cardiovascular disease or diabetes.

Supplementary Tables

Table s1. Effect of actual values on QRISK2 estimates based on missing values.

	QRISK2 score (estimated cholesterol)	Non-estimated QRISK2 score (actual cholesterol)
Median (IQR)	3.2 (1.8-6.1)	4.3 (2.1-8.1)

P=0.043

Table s2 Characteristics of patients who were invited to a Healthcheck compared to those who were not.

	Invite to Healthcheck (N=1579)	No. missing	Not invited to Healthcheck (N=2041)	No. missing	P-value
Age (Years)	43.6 (7.4)	0	43.2 (7.3)	0	0.136
Ethnicity N(%)		127		180	0.023
White	1196 (82.4)		1473 (79.2)		
Black	66 (4.5)		127 (6.8)		
Asian	72 (5.0)		109 (5.9)		
Mixed/ Other	118 (8.1)		152 (8.2)		
Weight (kg)	81.5 (16.8)	7	81.9 (17.0)	18	0.492
BMI	26.2 (5.9)	14	26.3 (5.9)	23	0.668
Smoking status N(%)		33		42	0.024
Smoker	1292 (83.6)		1726 (86.3)		
Non-smoker	254 (16.4)		273 (13.7)		
QRISK2 score		1		0	0.703
<10	1416 (89.7)		1834 (89.9)		
10-<20	139 (8.8)		172 (8.3)		
20 or over	23 (1.5)		36 (1.8)		
Median (IQR)	3.3 (1.9-6.2)	1	3.2 (1.8-5.9)		
Alcohol consumption Median (IQR)	6.0 (3.0-12.0)	1038	6.0 (3.0-12.0)	1496	0.818
Sentence length (Years) N (%)		649		978	<0.001
Less than1	441 (47.4)		626 (58.9)		
1-<2	212 (22.8)		160 (15.1)		
2-<3	77 (8.3)		73 (6.9)		
3-<4	50 (5.4)		45 (4.2)		
4 or more	150 (16.1)		159 (15.0)		
Prison N (%)		0		0	<0.001
HMP A	304 (57.1)		228 (42.9)		
HMP B	276 (44.2)		348 (55.8)		
HMP C	535 (45.8)		633 (54.2)		
HMP D	131 (27.2)		351 (72.8)		
HMP E	297 (63.3)		172 (36.7)		
HMP F	36 (10.4)		309 (89.6)		

Percentages calculated vertically except for prison data

Table s3: Characteristics of patients who received a Healthcheck compared to those who declined.

	Received Healthcheck (N=1191)	No. missing	Declined Healthcheck (N=388)	No. missing	P-value
Age (Years)	43.58 (7.4)	0	43.51 (7.4)	0	0.864
Ethnicity N(%)		104		23	0.008
White	914 (76.7)		282 (72.7)		
Black	40 (3.4)		26 (6.7)		
Asian	53 (4.5)		19 (4.9)		
Mixed/ Other	80 (6.7)		38 (9.8)		
Weight (kg)	81.7 (17.0)	6	80.8 (16.33)	1	0.334
BMI	26.2 (6.1)	10	26.1 (5.1)	4	0.611
Smoking status N(%)		25		8	0.155
Smoker	965 (82.8)		327 (86.1)		
Non-smoker	201 (17.2)		53 (14.0)		
QRISK2 score		1		0	0.372
<10	1066 (89.6)		350 (90.2)		
10-<20	109 (9.2)		30 (7.7)		
20 or over	15 (1.3)		8 (2.1)		
Median (IQR)	3.3 (1.9-6.2)		3.4 (2.0-6.2)		
Alcohol consumption Median (IQR)	6.0 (3.0-12.0)	760	7.0 (3.0-12.0)	278	0.960
Sentence length (Years) N (%)		473		165	0.313
<1	222 (30.9)		75 (33.6)		
1-<2	144 (20.1)		50 (22.4)		
2-<3	76 (10.6)		28 (12.6)		
3-<4	55 (7.7)		18 (8.1)		
4 or more	221 (30.8)		52 (23.3)		
Prison					<0.001
HMP A	283 (93.1)		21 (6.9)		
HMP B	190 (68.8)		86 (31.2)		
HMP C	345 (64.5)		190 (35.5)		
HMP D	99 (75.6)		32 (24.4)		
HMP E	247 (83.2)		50 (16.8)		
HMP F	27 (75.0)		9 (25.0)		

Percentages calculated vertically except for prison data

16 prisoners received a Healthcheck but their baseline data was not available in full and so they did not contribute to the analysis in this Table

Table s4. Categories of deprivation score for prisoners who received Healthcheck (n=1207)

IMD score category	N (%)
1-2	**340 (28.9)**
3-4	**207 (17.6)**
5-6	**84 (7.2)**
7-8	**94 (8.0)**
9-10	**38 (3.2)**
No fixed address (No IMD score)	**412 (35.1)**

32 prisoners had missing information on IMD score

Table s5. QRISK2 score by prison for entire eligible population (n=3620)

QRISK 2 category N (%)	HMP A	HMP B	HMP C	HMP D	HMP E	HMP F
N	532	624	1167	482	469	345
Under 10	481 (90.4)	590 (94.6)	1073 (92.0)	451 (93.4)	376 (80.2)	278 (80.6)
10-<20	43 (8.1)	31 (5.07)	80 (6.9)	28 (5.8)	78 (16.6)	51 (14.8)
20 or more	8 (1.5)	3 (0.5)	14 (1.2)	3 (0.6)	15 (3.2)	16 (4.6)
Median (IQR)	3.1 (1.9-5.6)	3.0 (1.8-5.1)	3.1 (1.9-5.4)	2.8 (1.6-4.9)	5.2 (2.3-8.9)	4.5 (2.4-8.0)
Type of prison	Cat B R and S	Cat C S	Cat B R and S	Cat B T	Cat C Sx	Cat B S

All values are N (%) unless otherwise specified. One missing value

Prison: Cat=security Category and Type R= Remand, S=Sentenced, Sx=sexual offences, T= Training

Table s6. Number of prisoners in each QRISK2 category, HbA1c levels, Chronic Kidney Disease and Depression (PHQ-9) and Anxiety (GAD-7) categories

	N (%)
QRISK 2 Score (%)	
<10	1082 (89.6)
≥10	125 (10.4)
Missing	0
HbA1c (mmols/mol)	
<42 (normal)	365 (92.6)
42-47 (pre-diabetes)	24 (6.1)
48+ (diabetes)	5 (1.3)
Missing	813
eGFR	
<60	1 (0.2)
>60	507 (99.8)
Missing	699
Total PHQ-9 score	
<10	752 (62.4)
≥10	453 (37.6)
Missing	2
Total GAD-7 Score	
<10	827 (68.6)
≥10	378 (31.4)
Missing	2

Table s7. Prevalence of cardiovascular comorbidity by sentence length of less than 2 years and 2 years or greater, in patients who received a heathcheck

	Length of sentence < 2 years (N=371)	Missing	Length of sentence ≥ 2 years (N=353)	Missing	P-value
eGFR		282		142	-
<60	0 (0.00)		1 (0.5)		
>60	89 (100.0)		210 (99.5)		
HbA1c		313		184	0.270
<42 (normal)	54 (93.1)		160 (94.7)		
42-47 (pre-diabetes)	2 (3.5)		8 (4.7)		
48+ (diabetes)	2 (3.5)		1 (0.6)		
QRISK score (%)		0		0	0.238
<10	335 (90.3)		308 (87.3)		
≥10	36 (9.7)		45 (12.8)		
Total PHQ-9		1		0	0.009
<10	218 (58.9)		242 (68.6)		
≥10	152 (41.1)		111 (31.4)		
GAD-7		1		0	0.001
<10	241 (65.1)		269 (76.2)		
≥10	129 (34.9)		84 (23.8)		

483 people were missing sentence length

Table s8a. Number of prisoners in each age bracket with QRISK2 score for those that received a Healthcheck (n=1207)

	Age bands							
QRISK2 score	**<40**	**40-44**	**45-49**	**50-54**	**55-59**	**60-64**	**65-69**	**70+**
<10	430 (99.8)	312 (99.7)	203 (94.4)	106 (80.9)	30 (46.2)	1 (3.5)	0 (0.0)	0 (0.0)
10-20	0 (0.0)	1 (0.3)	12 (5.6)	25 (19.1)	35 (53.9)	28 (96.6)	9 (52.9)	0 (0.0)
20 or more	1 (0.2)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	8 (47.1)	6 (1.0)

P-value <0.001. No missing values

Table s8b Number of prisoners in each age bracket with QRISK2 score for those that were eligible for a Healthcheck (n=3620)

	Age bands							
QRISK2 score	**<40**	**40-44**	**45-49**	**50-54**	**55-59**	**60-64**	**65-69**	**70+**
<10	1398 (99.9)	901 (98.6)	582 (94.3)	289 (78.3)	68 (37.4)	11 (13.9)	0 (0.0)	0 (0.0)
10-20	1 (0.1)	11 (1.2)	31 (5.0)	76 (20.6)	106 (58.2)	62 (78.5)	22 (53.7)	2 (11.1)
20 or more	0 (0.0)	2 (0.2)	4 (0.7)	4 (1.1)	8 (4.4)	6 (7.6)	19 (46.3)	16 (88.9)

P-value <0.001. 165 missing values

Table s8c. Number (%) of prisoners from each age group who have QRISK2 score of 10% or above and 20% and above for participants (n=1207)

Age (years)	**QRISK2 score 10% or over n=125**	**QRISK2 score 20% or over**
35-39	1 (0.2%)	1 (0.2%)
40-49	13 (2.5%)	0 (0.0%)
50-59	60 (30.6%)	0 (0.0%)
60-69	45 (97.8%)	8 (17.4%)
70-74	6 (100.0%)	6 (100.0%)

The RECORD statement – checklist of items, extended from the STROBE statement, that should be reported in observational studies using routinely collected health data.

	Item No.	STROBE items	Location in manuscript where items are reported	RECORD items	Location in manuscript where items are reported
Title and abstract					
	1	(a) Indicate the study's design with a commonly used term in the title or the abstract (b) Provide in the abstract an informative and balanced summary of what was done and what was found	3	RECORD 1.1: The type of data used should be specified in the title or abstract. When possible, the name of the databases used should be included. RECORD 1.2: If applicable, the geographic region and timeframe within which the study took place should be reported in the title or abstract. RECORD 1.3: If linkage between databases was conducted for the study, this should be clearly stated in the title or abstract.	3 3 1
Introduction					
Background rationale	2	Explain the scientific background and rationale for the investigation being reported	5		
Objectives	3	State specific objectives, including any prespecified hypotheses	5		
Methods					
Study Design	4	Present key elements of study design early in the paper	6		
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	6		
Participants	6	*(a) Cohort study* - Give the	1	RECORD 6.1: The methods of study	

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		eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study* - Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study* - Give the eligibility criteria, and the sources and methods of selection of participants *(b) Cohort study* - For matched studies, give matching criteria and number of exposed and unexposed *Case-control study* - For matched studies, give matching criteria and the number of controls per case	6	population selection (such as codes or algorithms used to identify subjects) should be listed in detail. If this is not possible, an explanation should be provided. RECORD 6.2: Any validation studies of the codes or algorithms used to select the population should be referenced. If validation was conducted for this study and not published elsewhere, detailed methods and results should be provided. RECORD 6.3: If the study involved linkage of databases, consider use of a flow diagram or other graphical display to demonstrate the data linkage process, including the number of individuals with linked data at each stage.	6 1 1	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria if applicable.	7	RECORD 7.1: A complete list of codes and algorithms used to classify exposures, outcomes, confounders, and effect modifiers should be provided. If these cannot be reported, an explanation should be provided.	embedded in GP. I.T. systems.
Data sources/ measurement	8	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	7/8		
Bias	9	Describe any efforts to address potential sources of bias	10		

Study size	10	Explain how the study size was arrived at	8		
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen, and why	8		
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding (b) Describe any methods used to examine subgroups and interactions (c) Explain how missing data were addressed (d) *Cohort study* - If applicable, explain how loss to follow-up was addressed *Case-control study* - If applicable, explain how matching of cases and controls was addressed *Cross-sectional study* - If applicable, describe analytical methods taking account of sampling strategy (e) Describe any sensitivity analyses	8 8 / 8 /		
Data access and cleaning methods	..			RECORD 12.1: Authors should describe the extent to which the investigators had access to the database population used to create the study population. RECORD 12.2: Authors should provide information on the data cleaning methods used in the study. RECORD 12.3: State whether the	6/8
Linkage	..				

				study included person-level, institutional-level, or other data linkage across two or more databases. The methods of linkage and methods of linkage quality evaluation should be provided.
Results				
Participants	13	(a) Report the numbers of individuals at each stage of the study (*eg.*, numbers potentially eligible examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed) (b) Give reasons for non-participation at each stage. (c) Consider use of a flow diagram	9, 10, 11	RECORD 13.1: Describe in detail the selection of the persons included in the study (*i.e.*, study population selection) including filtering based on data quality, data availability and linkage. The selection of included persons can be described in the text and/or by means of the study flow diagram.
Descriptive data	14	(a) Give characteristics of study participants (*e.g.*, demographic, clinical, social) and information on exposures and potential confounders (b) Indicate the number of participants with missing data for each variable of interest (c) *Cohort study* - summarise follow-up time (*e.g.*, average and total amount)	9, 10 Tables 1-3 and S1-8	
Outcome data	15	*Cohort study* - Report numbers of outcome events or summary measures over time *Case-control study* - Report numbers in each exposure category, or summary measures of exposure *Cross-sectional study* - Report numbers of outcome events or		

		summary measures	9, 10		
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (e.g., 95% confidence interval). Make clear which confounders were adjusted for and why they were included (b) Report category boundaries when continuous variables were categorized (c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	9, 10 9, 10, tables /		
Other analyses	17	Report other analyses done—e.g., analyses of subgroups and interactions, and sensitivity analyses	/		
Discussion					
Key results	18	Summarise key results with reference to study objectives	11		
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	11, 12, 13 4	RECORD 19.1: Discuss the implications of using data that were not created or collected to answer the specific research question(s). Include discussion of misclassification bias, unmeasured confounding, missing data, and changing eligibility over time, as they pertain to the study being reported.	
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	11		

Generalisability	21	Discuss the generalisability (external validity) of the study results	13		
Other Information					
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	IN SUBMISSION Information.		
Accessibility of protocol, raw data, and programming code	..		ALL IN SUPPLEMENTARY TABLES.	RECORD 22.1: Authors should provide information on how to access any supplemental information such as the study protocol, raw data, or programming code.	

*Reference: Benchimol EI, Smeeth L, Guttmann A, Harron K, Moher D, Petersen I, Sørensen HT, von Elm E, Langan SM, the RECORD Working Committee. The REporting of studies Conducted using Observational Routinely-collected health Data (RECORD) Statement. *PLoS Medicine* 2015; in press.

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Cardiovascular risk profiles and the uptake of the NHS Healthcheck Programme in male prisoners in six UK prisons: an observational cross-sectional survey.

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Title page

Cardiovascular risk profiles and the uptake of the NHS Healthcheck Programme in male prisoners in six UK prisons: an observational cross-sectional survey.

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Cardiovascular risk profiles and the uptake of the NHS Healthcheck Programme in male prisoners in six UK prisons: an observational cross-sectional survey.

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Abstract

Introduction

Half of all deaths in custody are due to natural causes, the commonest being cardiovascular disease (CVD). NHS Healthchecks should be available to all eligible prisoners; it is not clear who receives them. Mental health issues are common in prisoners and may affect how healthcare interventions should be delivered. Current policy is to offer Healthchecks to those serving over 2 years in prison.

Objectives, Methods, Setting and Design

An observational cross-sectional survey in six male prisons in England between September 2017 and January 2019 in prisoners aged 35-74 to identify who was eligible for a Healthcheck and compare CVD risk data with those that were not, and factors associated with uptake.

Outcome measures

Characteristics of those accepting a Healthcheck were compared with those declining. Assessments of anxiety and depression and results compared with CVD risk factors.

Results

1207 prisoners completed a Healthcheck. 21.8% of prisoners were ineligble due to existing comorbidities. 76.4% of those invited took up a Healthcheck, and of those, 12.1% were found to have new significant CVD comorbidity. CVD risk was similar to community levels but this population was 10 years younger. Definite case-level depression or anxiety was present in 20.7% and 18.0% respectively of participants. Prisoners from ethnic minorities were less likely to be invited (P=0.023) or to accept (P=0.008) a Healthcheck. 9.7% of Prisoners serving less than 2 years had CVD risk scores of 10% or more, and had similar CVD risk profiles but much higher levels of anxiety (P<0.001) or depression (P=0.009) than those serving 2 years or more

Conclusion

Cardiovascular risk was comparable with community rates and in some prisons, much higher. Rates of anxiety and depression were high. The national policy for selecting prisoners for Healthchecks may leave many high-risk prisoners without appropriate cardiovascular preventative assessments.

ARTICLE SUMMARY : **Strengths and Limitations of the study**

- This study is the largest study of its kind to report cardiovascular risk in male prisoners, and allowed measurement of CVD risk across the whole eligible prison population not only those who took up a Healthcheck
- Estimation of QRISK2 by SystmOne is guided by an internal algorithm for missing values; we were unable to adjust for possible differences in prison population risk profiles although we compared estimated QRISK2 scores assuming missing lipid values with scores based on actual results and showed that QRISK2 scores were statistically worse (greater CVD risk) when using actual scores (Supplementary Table s1) suggesting that any bias introduced as a result of missing blood values may have been to under-estimate CVD risks in this population.
- The self-rating measures used to assess anxiety and depression are not the same as clinical diagnosis although scores recorded implied high levels of definite or probable depression and anxiety cases in this population.
- The logistics of conducting research in prison settings were challenging with throughput, security, staffing and clinic capacity issues all impacting on the ability to deliver Healthchecks and to engage participants in research so the research team were unable to invite all eligible participants and there was substantial variability of recruitment between establishments.
- Smoking, alcohol use and activity status appeared to be subject to error as both prisoners and health care staff interpreted current status differently; some recording their behaviour before coming into prison, and others describing literally since being in custody, at reception screen or subsequently with some prisoners also classed themselves as 'smokers' if they used e-cigarettes.

Introduction

The NHS Healthchecks programme[1] is designed to identify individuals between the ages of 40 and 75 with a high risk of future cardiovascular disease, people with diabetes, and those with chronic renal disease, and then offer interventions to help reduce that risk. Although its effectiveness has attracted controversy [2,3,4,5] it remains government policy and and appears to be an important public health intervention with benefits especially for more disadvantaged communities.[6] Uptake of Healthchecks is variable but there is evidence it has improved between 2009 and 2013.[6] A particular feature of the delivery of NHS Healthchecks is that they appear to successfully target higher risk patients in more deprived areas.[4,6,7]

In prison, around 56% of deaths are due to natural causes[8] and of those it is estimated that 35% are due to cardiovascular disease.[9] The prison population is aging with a rise in the proportion over 50 from 7% in 2002 to 16% in 2018,[8] so the burden of cardiovascular disease Is likely to rise. The Chief Medical Officer for England has previously identified prisoner health as a priority[10] and there is growing awareness of the need to improve services and offer parity of care with community settings.[11]

Studies of cardiovascular risk factor profiles in prisoners within the last 15-20 years are rare in the UK[12] but more common in the US and Australia.[13,14,15,16] Reports describing the results of Healthchecks in prisoners generally summarise only those prisoners who undertake a Healthcheck. There are good data comparing the characteristics of those that do or don't take up Healthchecks in community settings,[6] but such data have not been published in prisoner populations.

There is an established relationship between cardiovascular risk and mental health with depression and anxiety symptoms and disorders both arising from, and a possible causative agent for, cardiovascular disease.[17,18,19] There is a high prevalence of mental disorder in prisoner populations,[4] but patterns of anxiety or depression in those taking up a healthcheck in this setting are unknown. Designing interventions to reduce cardiovascular risk requires a good understanding of the pattern of risk factors present in the target population.

Recent national advice from Public Health England[20] has restated the value and need for a high uptake of Healthchecks in prisoners. It has lowered the age of first invitation (from 40 to 35) because prisoners are perceived to be at higher risk of cardiovascular ill-health than the general population. The advice also specifies targeting prisoners with expected incarceration of two years or more.[20] This study was designed to describe the burden of cardiovascular risk of male prisoners whatever their length of incarceration, and measure indicators of mental illness in study participants.

Methods

Ethics

Ethical approval was obtained from North-East York Research Ethics Committee (16/NE/0133). NHS England Health Research Authority (HRA) approval was also obtained. As with all prison research, Her Majesty's Prison and Probation Service approval was obtained and individual prison governors' permission sought to conduct the research on their site. All participating prisoners in the research study provided written informed consent.

Study Design

An observational cross-sectional survey was conducted in prison healthcare services in the East Midlands. In the period of data collection from September 2017 to January 2019, there were 13 male prisons in the region. Healthcare services at six prisons were approached and all agreed to contribute to the research. The prisons were chosen to cover a broad spectrum of remand through to longer stay. They held NHS (n=4) or private (n=2) contracts for prison healthcare The total number of potential eligible participants from these prisons was approximately 3600 over a 12 month period, calculated by utilising 'churn' (turnover) of the eligible prison population and the actual recorded population. This identified the annual churn of prisoners between 5-35%, depending upon the prison site, with a month by month churn of between 15-100 eligible new prisoners by prison.

The outcomes variables were the physical measures from the NHS Healthcheck and mental health measures of depression and anxiety.

Sampling procedure

All prisoners (regardless of sentence length or time served) who were deemed eligible for the NHS Healthcheck Programme adapted for prison settings[20] were scheduled to be invited to participate (aged between 35-74 years old with no exclusion diagnosis as per NHS Healthcheck criteria). Eligibility was sought using clinic reports from SystmOne, an NHS clinical record system, where those ineligible were subsequently filtered. As per the NHS Healthcheck programme guidance, those excluded were prisoners with established cardiovascular disease: coronary heart disease; strokes; transient ischaemic attacks; diabetes; atrial fibrillation; heart failure; peripheral artery disease and chronic kidney disease and those prisoners already taking statins.

Each prison had a new report run every 2-3 weeks to allow for new prisoner receptions and to discount released or transferred prisoners from being invited.

Variables collected and outcomes measured

Physical Measures:

All variables as per NHS Healthcheck guidance were collected; age, ethnicity (census categories), height, weight, body mass index (BMI), waist circumference, systolic and diastolic blood pressure (BP), smoking status (current, ex- and never smoked), family history of cardiovascular disease, alcohol intake using the Alcohol Use Disorders Identification Test (AUDIT). The AUDIT-C is a shortened version of the 10 question AUDIT tool used to help identify individuals who may have active hazardous drinking habits or have alcohol drinking disorders.[21] The full 10 question AUDIT was undertaken if prisoners scored 5 or above on the AUDIT-C. Physical activity was recorded using the General Practice Physical Activity Questionnaire (GPPAQ), a validated screening tool used in physical health.[22] This is a simple 4-level Physical Activity Index categorising patients as: Active, Moderately Active, Moderately Inactive, and Inactive. The questions were phrased so they gathered information about each prisoner's lifestyle habits prior to their current detainment in the criminal justice system and how active they were in prison.

Blood tests for creatinine, plasma glucose, lipids and HbA1c were requested. If participants had blood tests within 15 months, such results were utilised. Last known postcodes were recorded and Index Multiple Deprivation (IMD) codes applied;[23] IMD 1 being the most deprived area. 35.1% of prisoners were of no fixed abode (NFA) prior to incarceration which does not have a standardised IMD code. For this analysis, these postcodes were given NFA as a discreet categorical value.

As stated in the PHE Programme Guidance, the physical healthcheck in prison risk assessment requires the use of a risk engine to calculate the individual's risk of developing CVD in the next 10 years. As advised by national guidance,[1] this study used QRISK2. [24]

Mental Health Measures:

Two mental health screens were utilised: the Patient Health Questionnaire (PHQ-9)[25,26] and the Generalised Anxiety Disorder Assessment (GAD-7).[27] The PHQ-9 is a self-rated tool consisting of 9 items which has been found to have good sensitivity (88%) and specificity (88%) to detect major depressive disorder. [25,26]

The GAD-7 is a 7-item self-reported anxiety scale which has been found to have sensitivity of 89% and specificity of 82% for generalised anxiety disorder.[27] Both screens require the individuals to rate

their symptoms and feelings related to the previous 2 week period, with items measuring the frequency of symptoms on a scale of 0 (not at all), to 3 (nearly every day). The screens both have cut-off scores ≥ 10. The thresholds mild=0-5, moderate=6-10, moderate/severe=11-14 and severe ≥15 are used in this study. The PHQ-9 and GAD-7 are used nationally within services Improving Access to Psychological Therapies (IAPT) therefore allowing potential continuity in referrals and benchmarking against established scoring patterns.

SystmOne was also used to collect monthly anonymised denominator reports at each prison site to compare the whole population characteristics with those eligible to have an NHS Healthcheck and those eligible but declined active participation so differences in the CVD risk profiles between eligible, ineligible, responders and non-responders could be described.

The descriptive analysis compared: those invited for an NHS Healthcheck with those who were invited but did not attend; the eligible population invited with the eligible population uninvited; and the whole prison population (age 35-74) with the eligible prison population.

Statistical Analysis

Summary measures were described using mean (standard deviation) or median (interquartile range) for continuous variables, categorical data were given as count (percentage). Means were compared using a two-sample t-test and medians with a two-sample Wilcoxon test. Count data were compared using a Chi-squared test, or in the case of small counts, Fisher's exact test. A multivariate logistic regression was fitted on the population offered a healthcheck with accepted healthcheck as the outcome variable, fitted with age, BMI, smoking status, prison, IMD, ethnicity, and sentence length. Variables were then omitted if they were non-significant.

Baseline characteristics were taken from the first month a prisoner was recorded in the denominator data for all analyses except those using only prisoners who received a Healthcheck, who were not included in any analyses requiring denominator data.

Sample size was estimated by assuming a range of prevalances for QRISK 2 of 10% and a precision of ±2% requiring 2185 individuals or for a precision of +-3%, 971 individals if prevalence was assumed to be 35%. For a lower prevlance at 18%, then a sample of 908 participants would enable a precision of ±2.5% around this estimate. All analyses were performed using R version 3.5.3.

Patient and Public Involvement .

Prisoner involvement groups were used to development the consent form, qualitative aspects of the research and to check easy-read versions of printed material; Prisoners did not take part in recruitment. Results wil be disseminated via the prisoner participation groups in each establishment and on the public EM-CLAHRC website.

Results

Eligible and ineligible populations

Table 1 describes the characteristics of a sample of the whole population of prisoners aged 35-74 collected at August 2018 (n=2107) comparing the eligible (n=1648) and ineligible populations (n=459) across all prisons at that point in time. Overall 21.8% of the prison population were ineligible for a Healthcheck due to existing comorbidity. The ineligible prisoners were older (mean age 53.5 (10.2) v 43.8 (7.6) years, P<0.001), had a higher BMI (30.5 (6.7) v 26.9 (5.2), P<0.001), had a higher QRISK2 score (median 13.4 (7.5-22.1)v 3.2 (1.8-6.2), p<0.001), and sentence length (3.45 years (1.5-7.0) v 2.5 (1.0-6.0) P<0.001). Ethnicity was significantly different (P=0.008) with the eligible group contining more white prisoners (85.0% v 79.6%). and fewer from Asian backgrounds (2.8% v 5.4%). The predominant reasons for ineligibility were established history of hypertension (12.9%) and diabetes (8.5%) (Table 2). The proportion ineligible due to comorbidities varied considerably by prison (between 14-37%), largely reflecting age structure differences between prisons . Among all participants aged 35-74, smokers totalled 1748 (82.9%).

Recruitment of eligible prisoners.

Overall 1207 subjects completed Healthchecks from an *invited* eligible population of 1579, a response rate of 76.4%. In all the total eligible population during the course of the study was 3620 individuals, so 43.6% of the available eligible population were invited and 33.3% took part. The mean age (standard deviation) of the whole eligible population was 43.8 (7.6) years. Not all eligible prisoners were invited because of the capacity of the researchers and the volume of prisoner churn.

Characteristics of the eligible study population.

Ethnicity , smoking status, sentence length (P<0.001) and prison attended (P<0.001) were all significantly different between those eligible prisoners who were invited to receive a Healthcheck and those eligible but who were not invited. Of those who were invited, ethnicity was significantly different (P=0.023) with the invited group contining more white prisoners (82.4% v 79.2%). Invited prisoners were also less likely to be smokers (83.6% v 86.3% P=0.024) and had a larger percentage

serving a 2 year or longer sentence (29.8% v 26.1% P<0.001). Other baseline characteristics were not significantly different between the two groups (Supplementary Table s2).

Characteristics of those who took up compared with those who declined a Healthcheck

From those invited (n=1579), those who took up a Healthcheck in this study (n=1191 plus 16 who took part but for whom baseline data was not available) differed from those who declined (n=388) in terms of ethnicity (P=0.008), with a smaller percentage of black prisoners receiving a Healthcheck than declining (3.7% v 7.0%). There was also significant variability by prison (Supplementary Table s3). The level of deprivation of the participants was estimated; 35% of participants were identified as of no fixed abode and a further 29% were in the lowest IMD quintile. (Supplementary Table s4)

QRISK2 profiles of eligible prisoners

The QRISK2 profile for all 3620 eligible individuals identified that the proportion of male prisoners above a 10% threshold of QRISK2 varied between 5.6% and 19.8% of the population in the age range 35-74 years in each prison; 10.2% 370 across all six prisons during the study period. (Supplementary Table s5).

High QRSK2 (>=10) prisoner characteristics

Those prisoners who received a Healthcheck and were in the high QRISK2 group (n=125 , 10.3% of participants) were compared for variables not used in the QRISK2 scoring. The high-risk group had greater numbers with a positive family history (69.2% v 53.7%, P=0.002) and fewer with high anxiety (GAD 7) scores (8.0% v 19.2%, P=0.016) than the lower risk prisoners (n=1082). There was no difference in measured levels of depression (PHQ-9), or ethnicity between these groups (Table 3).

Cardiovascular comorbidites in the participants

Among the 1207 prisoners who received a Healthcheck, 146 (12.1%) were found to have at least one of high CVD risk (on QRISK2), renal impairment or diabetes / pre diabetes, with seven having two, and one all three risk factors. There were a substantial number of missing values for the comorbidities defined by blood-based testing (Supplementary Table s6). Prisoners with blood test results were younger (mean age 45.5, s.d.8.2) than those without (mean age 42.7, s.d.7.0; p<0.001); completeness of blood results also varied by prison. Of the 1207 participants, 56.5% (n=682) of participants described themselves as active or moderately active, and 43.5% (n=525) inactive or moderately inactive.

Mental Health of participants

Overall, (as measured by PHQ-9 and GAD-7) 20.7% (n=249) of participants were classed as moderately severe to severely depressed and 18.0% (n=217) were suffering from severe anxiety (definite cases). These values rose to 37.6% (n=453) for moderate depression or worse and 31.5% (n=378) for moderate anxiety of worse (definite and probable cases) (Table 3).

Length of Sentence

Those prisoners who received a Healthcheck and were sentenced to less than 2 years, compared with longer sentences, did not show significant differences for diabetes or QRISK2 score but had significantly higher rates of possible cases of anxiety (34.9% v 23.8% P<0.001) and depression (41.1% v 31.4% P=0.009). (Supplementary Table s7).

Relationship between Variables

After removing variables that were not significant from the multivariate logistic model only prison remained as a significant variable, with Prison D (OR: 0.59, CI: 0.37-0.90), Prison A (OR: 0.14, CI: 0.08-0.21) and Prison E (OR: 0.37, CI: 0.26-0.52) having significantly lower odds of consenting to a Healthcheck compared to the reference prison C.

Discussion

Main Findings

When offered a Healthcheck, uptake was high at 75.4 % of those invited. Clinically important cardiovascular risk, as measured by a QRISK2 score ≥10%, diabetes or pre-diabetes, or renal impairment, was present in 12.1% of those participating in the study. This study also identified that the prevalence of existing cardiovascular disease that limited eligibility for the NHS Healthchecks programme was 21.8% (range 13.8-37.3%) of the prison populations studied (as at August 2018), and appeared to be influenced strongly by the age profile of the prisons. 82.9% of all prisoners aged 35-74 were recorded as smokers. Observed levels of clinically important anxiety (18.0%) and depression (20.7%) were more than double the rates found in a similar aged general male population.[28] Not all eligible prisoners were recruited to the study so there is the potential for bias which we cannot exclude. The analysis may have been underpowered to detect signficant differences in some variables that may contribute to prisoners taking up a healthcheck.

What is known about CVD risk already and what the study adds

In community populations eligible for an NHS Healthcheck, uptake between 2009 and 2012 has been reported between 18.7% [6] and 21.4%.[29] The uptake of a Healthcheck in our prison populations who were invited was 76.4 %, much higher than attendance rates found in community samples and represented an opportunity to intervene positively; that 24.6% did not take up that offer from this at-risk population is a matter of concern especially as it appeared that a higher proportion of BME prisoners did not access a Healthcheck. In community studies, around 30% of those in the age group 40-74 were already ineligible because of existing co-morbidity.[6] In our study, 21.8 % of those aged 35-74 were ineligible but from a substantially younger mean age population (mean age = 43.8 years compared with a mean age of 53.3 for the England population distribution for males between the ages of 35 and 74).[30]

Among the study population who received a Healthcheck we found important levels of comorbidity in 12.1%. The proportion of participants receiving a Healthcheck who are found to have new significant comorbidity (hypertension, type 2 diabetes or chronic kidney disease) nationally was 5%, rising to 37.3% if QRISK2 >= 10% was also included.[6] Comorbidity rates have been shown to vary substantially and in one large multi-ethnic population studied which including those with a high diabetes risk (4.6%) and QRISK2 >= 10%, 53.4% of males had one of these comorbidities newly identified as a result of the Healthcheck.[31] In this study, with its much younger study participants, 12.1% of participants had at least one of these comorbidities newly identified.

In community studies, 19% of males aged 35-74 have a QRISK2 score of 10 or above.[24] Overall, 10.2% of the eligible prison population studied here had a QRISK2 score of 10 or more but the prison population was almost 10 years younger on average. The age-specific QRISK2 bands described here (Supplementary Tables s8) suggest the level of risk is at least comparable; for the age bands 60-74, 26.9% of our participants, and 29.7% of all eligible prisoners in this study had a QRISK2 score of 20 or more, compared with 30.7% nationally[6] and 39.0% in a high risk multi-ethnic population.[31] The respective values for QRISK2 of 10 or more were 98.1% of participants and 92.0% of all eligible prisoners in our study, and 86.6% in the high-risk population.[31] In our study population only six prisoners were over 70 (0.5%) compared with 8.7% in the general population of males aged 35-74.[30]

A larger percentage of prisoners from a non-white heritage were ineligible for a Healthcheck because of existing comorbidity compared to prisoners from a white heritage, and of those eligible, a smaller proportion were both invited to a healthcheck, and received a Healthcheck. This suggests

it may be important to monitor Heathcheck uptake by ethnicity to assess any potential inequity in provision of care.

Multivariate analysis showed prison itself was the only predictor of Healthcheck uptake and the variability by prison of CVD risk highlights the importance of ensuring every prison healthcare service is designed to be able to meet different profiles of need.

This study is the first in the UK to our knowledge to have described whole eligible denominator populations, rather than just those who actually undertook a Healthcheck, and so allows an estimate of cardiovascular risk across the whole population by institution.

High cardiovascular risk is common in more deprived communities with a 20% higher crude incident rate of CVD in the worst deprivation quintile compared with the least deprived. [24] If we assume that those with no fixed abode in our study were likely to have characteristics similar to those in the highest deprivation quintile, then 65% of participants could be considered to come from the most disadvantaged fifth of society, with the associated overall disease risks and healthcare access challenges.

With almost 83% of all prisoners aged 35-74 being recorded as smokers on the GP electronic records system, there appears to still be a very large unmet need for preventative interventions and advice, but further work is required on standardising how lifestyle data is collected in prison settings.

Public Health England adjusted the eligibility criteria for NHS Healthchecks in 2017 to include those aged 35-74 and who were incarcerated for 2 years or more.[32] We only identified one prisoner among the 3620 eligible (0.02%) under the age of 40 who had a QRISK2 score of 10 or above suggesting that the reduction in eligibility to age 35 may not be an efficient use of scarce primary care resources. Similarly, prisoners with a sentence length of 2 years or more had similar proportions with QRISK2 score of 10 or above (12.8% v 9.7%, p=0.238) suggesting this eligibility change did not itself identify those with higher risk. For those serving less than 2 years, there remained a substantial number with adverse cardiovascular risk profiles (9.7% QRISK2>=10) and the shorter sentence prisoners also had significantly higher levels of anxiety and depression (Table s7). This may have been associated with more rapid transit of the prison system but does suggest there was substantial unmet healthcare need in this shorter sentence group. Extending Healthchecks to offenders irrespective of length of sentence would seem a positive policy step but may require additional resources to tackle unmet mental and physical status. Good primary care follow up may also be more challenging after discharge if prisoners are returning to primary care services in areas of highest need.

Conclusion

This study, the largest study of its kind to report cardiovascular risk in male prisoners, identified that 21.8% of the prison population aged 35-74 already had comorbities that precluded them from taking part in an NHS Healthcheck. Across the whole prison population aged 35-74, 82.9% were recorded as smokers. Of those who were eligible for an NHS Healthcheck and took part, a further 12.1% were found to have a significant clinical risk for future cardiovascular disease (QRISK2 ≥10) and 20.7% and 18.0% respecively had definitely clinically significant depression or anxiety.Prisoners from ethnic minorities were less likely to be invited (P=0.023) or to accept (P=0.008) a Healthcheck. Prisoners serving less than 2 years, who would not normally receive NHS Healthcheck through prison healthcare services, had much higher levels of anxiety or depression and an appreciable level of high cardiovascular risk (9.7%). With two-thirds of this group likely to come from the most deprived fifth of society, ensuing good prison mental health services and access to primary care services on discharge is vital to achieving equity of care in this patient group.

Authors Contributions

CP designed the study, wrote the proposal and led the research. MW initiated the data collection, trained healthcare staff, liaisied with the Ethics committee, and led the qualitative research. EB led the research teams collecting the data, completed the project management required by CLARHC, and developed the methods section. JM undertook the statistical analysis and commented on presentation. RM developed the PHQ-9 and GAD-7 analysis. KK helped wih refinements to the study design based on past community research. RM and KK commented extensively on the manuscript. All authors contributed individually to the report content.

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Main Tables

Table 1: Baseline characteristics of those prisoners Eligible and not eligible for healthchecks (information available at August 2018)

	Non-eligible (N = 459)	N missing	Eligible (N =1648)	N missing	P-value
Ethnicity N (%)		32		62	0.008
White	363 (85.0)		1262 (79.6)		
Black	27 (6.3)		86 (5.4)		
Asian (S & E)	12 (2.8)		86 (5.4)		
Mixed/ Other	25 (5.9)		152 (9.6)		
Age (Years)	53.5 (10.2)	0	43.8 (7.6)	0	<0.001
Weight (kg)	93.5 (20.7)	1	83.9 (16.9)	15	<0.001
BMI	30.5 (6.7)	2	26.9 (5.2)	20	<0.001
Smoking status N (%)		2		13	<0.001
Non-smoker	98 (21.4)		246 (15.1)		
Smoker	359 (78.6)		1389 (85.0)		
Sentence length (years) Median (IQR)	3.45 (1.5-7.0)	177	2.5 (1.0-6.0)	580	<0.001
QRISK2 score Median (IQR)	13.4 (7.5-22.1)	0	3.2 (1.8-6.2)	0	<0.001
Prevalent disease	454 (99.1)				
On a Statin	4 (0.9)				

All values are mean (sd) unless otherwise stated

These 2107 prisoners were a subset of the whole prison population aged 35-74 available at August 2018 .

Table 2. Prevalance of existing cardiovascular co-morbidity in the whole prisoner population studied aged 35-74 as at August 2018 (n=2107)

Co-Morbidity	N (%)
Hypertension	**272 (12.9%)**
Diabetes	**180 (8.5%)**
Cardiovascular Disease	**117 (5.7%)**
High Cholesterol / statin	**17 (0.8%)**
Chronic Kidney Disease	**12 (0.6%)**
All comorbidities	***459 (21.8%)***

Table 3: Characteristics of prisoners who received a Healthcheck (n=1207) with high v low QRISK2 scores

Variable	QRISK2 < 10 (N=1082)	No. missing	QRISK2 ≥ 10 (N=125)	No. missing	P-value
Depression: PHQ-9 N (%)		**2**		0	0.058
None or mild	668 (61.7)		84 (67.2)		
Moderate	177 (16.4)		27 (21.6)		
Moderate/ Severe or Severe	235 (21.7)		14 (11.2)		
Anxiety: GAD-7 N (%)		2		0	0.016
None or mild	730 (67.5)		97 (77.6)		
Moderate	143 (13.2)		18 (14.4)		
Severe	207 (19.1)		10 (8.0)		
1st degree Family History[1]		82		5	0.002
Yes	537 (53.7)		83 (69.2)		
No	463 (46.3)		37 (30.8)		
Ethnicity		4		0	0.057
White	876 (81.3)		113 (90.4)		
Black	44 (4.1)		2 (1.6)		
Asian	62 (5.7)		6 (4.8)		
Mixed/Other	96 (8.9)		4 (3.2)		

1] Family history of at least one of the following: Hypercholesterolaemia, Ischaemic heart disease, Angina, Myocardial Infarction, Cardiovascular disease or diabetes.

Supplementary Tables

Table s1. Effect of actual values on QRISK2 estimates based on missing values.

	QRISK2 score (estimated cholesterol)	Non-estimated QRISK2 score (actual cholesterol)
Median (IQR)	3.2 (1.8-6.1)	4.3 (2.1-8.1)

P=0.043

Table s2 Characteristics of patients who were invited to a Healthcheck compared to those who were not.

	Invite to Healthcheck (N=1579)	No. missing	Not invited to Healthcheck (N=2041)	No. missing	P-value
Age (Years)	43.6 (7.4)	0	43.2 (7.3)	0	0.136
Ethnicity N(%)		127		180	0.023
White	1196 (82.4)		1473 (79.2)		
Black	66 (4.5)		127 (6.8)		
Asian	72 (5.0)		109 (5.9)		
Mixed/ Other	118 (8.1)		152 (8.2)		
Weight (kg)	81.5 (16.8)	7	81.9 (17.0)	18	0.492
BMI	26.2 (5.9)	14	26.3 (5.9)	23	0.668
Smoking status N(%)		33		42	0.024
Smoker	1292 (83.6)		1726 (86.3)		
Non-smoker	254 (16.4)		273 (13.7)		
QRISK2 score		1		0	0.703
<10	1416 (89.7)		1834 (89.9)		
10-<20	139 (8.8)		172 (8.3)		
20 or over	23 (1.5)		36 (1.8)		
Median (IQR)	3.3 (1.9-6.2)	1	3.2 (1.8-5.9)		
Alcohol consumption Median (IQR)	6.0 (3.0-12.0)	1038	6.0 (3.0-12.0)	1496	0.818
Sentence length (Years) N (%)		649		978	<0.001
Less than1	441 (47.4)		626 (58.9)		
1-<2	212 (22.8)		160 (15.1)		
2-<3	77 (8.3)		73 (6.9)		
3-<4	50 (5.4)		45 (4.2)		
4 or more	150 (16.1)		159 (15.0)		
Prison N (%)		0		0	<0.001
HMP A	304 (57.1)		228 (42.9)		
HMP B	276 (44.2)		348 (55.8)		
HMP C	535 (45.8)		633 (54.2)		
HMP D	131 (27.2)		351 (72.8)		
HMP E	297 (63.3)		172 (36.7)		
HMP F	36 (10.4)		309 (89.6)		

Percentages calculated vertically except for prison data

Table s3: Characteristics of patients who received a Healthcheck compared to those who declined.

	Received Healthcheck (N=1191)	No. missing	Declined Healthcheck (N=388)	No. missing	P-value
Age (Years)	43.58 (7.4)	0	43.51 (7.4)	0	0.864
Ethnicity N(%)		104		23	0.008
White	914 (84.1)		282 (77.3)		
Black	40 (3.7)		26 (7.0)		
Asian	53 (5.0)		19 (5.2)		
Mixed/ Other	80 (7.4)		38 (10.4)		
Weight (kg)	81.7 (17.0)	6	80.8 (16.33)	1	0.334
BMI	26.2 (6.1)	10	26.1 (5.1)	4	0.611
Smoking status N(%)		25		8	0.155
Smoker	965 (82.8)		327 (86.1)		
Non-smoker	201 (17.2)		53 (14.0)		
QRISK2 score		1		0	0.372
<10	1066 (89.6)		350 (90.2)		
10-<20	109 (9.2)		30 (7.7)		
20 or over	15 (1.3)		8 (2.1)		
Median (IQR)	3.3 (1.9-6.2)		3.4 (2.0-6.2)		
Alcohol consumption Median (IQR)	6.0 (3.0-12.0)	760	7.0 (3.0-12.0)	278	0.960
Sentence length (Years) N (%)		473		165	0.313
<1	222 (30.9)		75 (33.6)		
1-<2	144 (20.1)		50 (22.4)		
2-<3	76 (10.6)		28 (12.6)		
3-<4	55 (7.7)		18 (8.1)		
4 or more	221 (30.8)		52 (23.3)		
Prison					<0.001
HMP A	283 (93.1)		21 (6.9)		
HMP B	190 (68.8)		86 (31.2)		
HMP C	345 (64.5)		190 (35.5)		
HMP D	99 (75.6)		32 (24.4)		
HMP E	247 (83.2)		50 (16.8)		
HMP F	27 (75.0)		9 (25.0)		

Percentages calculated vertically except for prison data

16 prisoners received a Healthcheck but their baseline data was not available in full and so they did not contribute to the analysis in this Table

Table s4. Categories of deprivation score for prisoners who received Healthcheck (n=1207)

IMD score category	N (%)
1-2	**340 (28.9)**
3-4	**207 (17.6)**
5-6	**84 (7.2)**
7-8	**94 (8.0)**
9-10	**38 (3.2)**
No fixed address (No IMD score)	**412 (35.1)**

32 prisoners had missing information on IMD score

Table s5. QRISK2 score by prison for entire eligible population (n=3620)

QRISK 2 category N (%)	HMP A	HMP B	HMP C	HMP D	HMP E	HMP F
N	532	624	1167	482	469	345
Under 10	481 (90.4)	590 (94.6)	1073 (92.0)	451 (93.4)	376 (80.2)	278 (80.6)
10-<20	43 (8.1)	31 (5.1)	80 (6.9)	28 (5.8)	78 (16.6)	51 (14.8)
20 or more	8 (1.5)	3 (0.5)	14 (1.2)	3 (0.6)	15 (3.2)	16 (4.6)
Median (IQR)	3.1 (1.9-5.6)	3.0 (1.8-5.1)	3.1 (1.9-5.4)	2.8 (1.6-4.9)	5.2 (2.3-8.9)	4.5 (2.4-8.0)
Type of prison	Cat B R and S	Cat C S	Cat B R and S	Cat B T	Cat C Sx	Cat B S

All values are N (%) unless otherwise specified. One missing value

Prison: Cat=security Category and Type R= Remand, S=Sentenced, Sx=sexual offences, T= Training

Table s6. Number of prisoners in each QRISK2 category, HbA1c levels, Chronic Kidney Disease and Depression (PHQ-9) and Anxiety (GAD-7) categories

	N (%)
QRISK 2 Score (%)	
<10	1082 (89.6)
≥10	125 (10.4)
Missing	0
HbA1c (mmols/mol)	
<42 (normal)	365 (92.6)
42-47 (pre-diabetes)	24 (6.1)
48+ (diabetes)	5 (1.3)
Missing	813
eGFR	
<60	1 (0.2)
>60	507 (99.8)
Missing	699
Total PHQ-9 score	
<10	752 (62.4)
≥10	453 (37.6)
Missing	2
Total GAD-7 Score	
<10	827 (68.6)
≥10	378 (31.4)
Missing	2

Table s7. Prevalence of cardiovascular comorbidity by sentence length of less than 2 years and 2 years or greater, in patients who received a heathcheck

	Length of sentence < 2 years (N=371)	Missing	Length of sentence ≥ 2 years (N=353)	Missing	P-value
eGFR		282		142	-
<60	0 (0.00)		1 (0.5)		
>60	89 (100.0)		210 (99.5)		
HbA1c		313		184	0.270
<42 (normal)	54 (93.1)		160 (94.7)		
42-47 (pre-diabetes)	2 (3.5)		8 (4.7)		
48+ (diabetes)	2 (3.5)		1 (0.6)		
QRISK score (%)		0		0	0.238
<10	335 (90.3)		308 (87.3)		
≥10	36 (9.7)		45 (12.8)		
Total PHQ-9		1		0	0.009
<10	218 (58.9)		242 (68.6)		
≥10	152 (41.1)		111 (31.4)		
GAD-7		1		0	0.001
<10	241 (65.1)		269 (76.2)		
≥10	129 (34.9)		84 (23.8)		

483 people were missing sentence length

Table s8a. Number of prisoners in each age bracket with QRISK2 score for those that received a Healthcheck (n=1207)

	Age bands							
QRISK2 score	**<40**	**40-44**	**45-49**	**50-54**	**55-59**	**60-64**	**65-69**	**70+**
<10	430 (99.8)	312 (99.7)	203 (94.4)	106 (80.9)	30 (46.2)	1 (3.5)	0 (0.0)	0 (0.0)
10-20	0 (0.0)	1 (0.3)	12 (5.6)	25 (19.1)	35 (53.9)	28 (96.6)	9 (52.9)	0 (0.0)
20 or more	1 (0.2)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	8 (47.1)	6 (100.0)

P-value <0.001. No missing values

Table s8b Number of prisoners in each age bracket with QRISK2 score for those that were eligible for a Healthcheck (n=3620)

	Age bands							
QRISK2 score	**<40**	**40-44**	**45-49**	**50-54**	**55-59**	**60-64**	**65-69**	**70+**
<10	1398 (99.9)	901 (98.6)	582 (94.3)	289 (78.3)	68 (37.4)	11 (13.9)	0 (0.0)	0 (0.0)
10-20	1 (0.1)	11 (1.2)	31 (5.0)	76 (20.6)	106 (58.2)	62 (78.5)	22 (53.7)	2 (11.1)
20 or more	0 (0.0)	2 (0.2)	4 (0.7)	4 (1.1)	8 (4.4)	6 (7.6)	19 (46.3)	16 (88.9)

P-value <0.001. 165 missing values

Table s8c. Number (%) of prisoners from each age group who have QRISK2 score of 10% or above and 20% and above for participants (n=1207)

Age (years)	**QRISK2 score 10% or over n=125**	**QRISK2 score 20% or over**
35-39	1 (0.2%)	1 (0.2%)
40-49	13 (2.5%)	0 (0.0%)
50-59	60 (30.6%)	0 (0.0%)
60-69	45 (97.8%)	8 (17.4%)
70-74	6 (100.0%)	6 (100.0%)

The RECORD statement – checklist of items, extended from the STROBE statement, that should be reported in observational studies using routinely collected health data.

	Item No.	STROBE items	Location in manuscript where items are reported	RECORD items	Location in manuscript where items are reported
Title and abstract					
	1	(a) Indicate the study's design with a commonly used term in the title or the abstract (b) Provide in the abstract an informative and balanced summary of what was done and what was found	3	RECORD 1.1: The type of data used should be specified in the title or abstract. When possible, the name of the databases used should be included. RECORD 1.2: If applicable, the geographic region and timeframe within which the study took place should be reported in the title or abstract. RECORD 1.3: If linkage between databases was conducted for the study, this should be clearly stated in the title or abstract.	3 3 1
Introduction					
Background rationale	2	Explain the scientific background and rationale for the investigation being reported	5		
Objectives	3	State specific objectives, including any prespecified hypotheses	5		
Methods					
Study Design	4	Present key elements of study design early in the paper	6		
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	6		
Participants	6	*(a) Cohort study* - Give the	1	RECORD 6.1: The methods of study	

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		eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study* - Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study* - Give the eligibility criteria, and the sources and methods of selection of participants *(b) Cohort study* - For matched studies, give matching criteria and number of exposed and unexposed *Case-control study* - For matched studies, give matching criteria and the number of controls per case	6	population selection (such as codes or algorithms used to identify subjects) should be listed in detail. If this is not possible, an explanation should be provided. RECORD 6.2: Any validation studies of the codes or algorithms used to select the population should be referenced. If validation was conducted for this study and not published elsewhere, detailed methods and results should be provided. RECORD 6.3: If the study involved linkage of databases, consider use of a flow diagram or other graphical display to demonstrate the data linkage process, including the number of individuals with linked data at each stage.	6 1 1	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria if applicable.	7	RECORD 7.1: A complete list of codes and algorithms used to classify exposures, outcomes, confounders, and effect modifiers should be provided. If these cannot be reported, an explanation should be provided.	embedded in GP. I.T. systems.
Data sources/ measurement	8	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	7/8		
Bias	9	Describe any efforts to address potential sources of bias	10		

Study size	10	Explain how the study size was arrived at	8		
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen, and why	8		
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding (b) Describe any methods used to examine subgroups and interactions (c) Explain how missing data were addressed (d) *Cohort study* - If applicable, explain how loss to follow-up was addressed *Case-control study* - If applicable, explain how matching of cases and controls was addressed *Cross-sectional study* - If applicable, describe analytical methods taking account of sampling strategy (e) Describe any sensitivity analyses	8 8 / 8 /		
Data access and cleaning methods	..			RECORD 12.1: Authors should describe the extent to which the investigators had access to the database population used to create the study population. RECORD 12.2: Authors should provide information on the data cleaning methods used in the study. RECORD 12.3: State whether the	6/8
Linkage	..				

				study included person-level, institutional-level, or other data linkage across two or more databases. The methods of linkage and methods of linkage quality evaluation should be provided.
Results				
Participants	13	(a) Report the numbers of individuals at each stage of the study (*eg.*, numbers potentially eligible examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed) (b) Give reasons for non-participation at each stage. (c) Consider use of a flow diagram	9, 10, 11	RECORD 13.1: Describe in detail the selection of the persons included in the study (*i.e.*, study population selection) including filtering based on data quality, data availability and linkage. The selection of included persons can be described in the text and/or by means of the study flow diagram.
Descriptive data	14	(a) Give characteristics of study participants (*e.g.*, demographic, clinical, social) and information on exposures and potential confounders (b) Indicate the number of participants with missing data for each variable of interest (c) *Cohort study* - summarise follow-up time (*e.g.*, average and total amount)	9, 10 Tables 1-3 and S1-8	
Outcome data	15	*Cohort study* - Report numbers of outcome events or summary measures over time *Case-control study* - Report numbers in each exposure category, or summary measures of exposure *Cross-sectional study* - Report numbers of outcome events or		

		summary measures	9, 10		
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (e.g., 95% confidence interval). Make clear which confounders were adjusted for and why they were included (b) Report category boundaries when continuous variables were categorized (c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	9, 10 9, 10, tables /		
Other analyses	17	Report other analyses done—e.g., analyses of subgroups and interactions, and sensitivity analyses	/		
Discussion					
Key results	18	Summarise key results with reference to study objectives	11		
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	11, 12, 13 4	RECORD 19.1: Discuss the implications of using data that were not created or collected to answer the specific research question(s). Include discussion of misclassification bias, unmeasured confounding, missing data, and changing eligibility over time, as they pertain to the study being reported.	
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	11		

Generalisability	21	Discuss the generalisability (external validity) of the study results	13		
Other Information					
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	IN SUBMISSION Information.		
Accessibility of protocol, raw data, and programming code	..		ALL IN SUPPLEMENTARY TABLES.	RECORD 22.1: Authors should provide information on how to access any supplemental information such as the study protocol, raw data, or programming code.	

*Reference: Benchimol EI, Smeeth L, Guttmann A, Harron K, Moher D, Petersen I, Sørensen HT, von Elm E, Langan SM, the RECORD Working Committee. The REporting of studies Conducted using Observational Routinely-collected health Data (RECORD) Statement. *PLoS Medicine* 2015; in press.

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Title page

Cardiovascular risk profiles and the uptake of the NHS Healthcheck Programme in male prisoners in six UK prisons: an observational cross-sectional survey.

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Cardiovascular risk profiles and the uptake of the NHS Healthcheck Programme in male prisoners in six UK prisons: an observational cross-sectional survey.

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Abstract

Introduction

Half of all deaths in custody are due to natural causes, the commonest being cardiovascular disease (CVD). NHS Healthchecks should be available to all eligible prisoners; it is not clear who receives them. Mental health issues are common in prisoners and may affect how healthcare interventions should be delivered. Current policy is to offer Healthchecks to those serving over 2 years in prison.

Objectives, Methods, Setting and Design

An observational cross-sectional survey in six male prisons in England between September 2017 and January 2019 in prisoners aged 35-74 to identify who was eligible for a Healthcheck and compare CVD risk data with those that were not, and factors associated with uptake.

Outcome measures

Characteristics of those accepting a Healthcheck were compared with those declining. Assessments of anxiety and depression were compared with CVD risk factors.

Results

1207 prisoners completed a Healthcheck. 21.8% of prisoners were ineligble due to existing comorbidities. 76.4% of those invited took up a Healthcheck, and of those, 12.1% were found to have new significant CVD comorbidity. CVD risk was similar to community levels but this population was 10 years younger. Definite case-level depression or anxiety was present in 20.7% and 18.0% respectively of participants. An association was found between ethnicity and those invited (p=0.023) and accepting (p=0.008) a Healthcheck. 9.7% of Prisoners serving less than 2 years had CVD risk scores of 10% or more, and had similar CVD risk profiles but much higher levels of anxiety (p<0.001) or depression (p=0.009) than those serving 2 years or more

Conclusion

Cardiovascular risk was comparable with community rates and in some prisons, much higher. Rates of anxiety and depression were high. The national policy for selecting prisoners for Healthchecks may leave many high-risk prisoners without appropriate cardiovascular preventative assessments.

ARTICLE SUMMARY : **Strengths and Limitations of the study**

- This study is the largest study of its kind to report cardiovascular risk in male prisoners, and allowed measurement of CVD risk across the whole eligible prison population not only those who took up a Healthcheck
- Estimation of QRISK2 by SystmOne is guided by an algorithm for missing values; we were unable to adjust for possible differences in prison population risk profiles although we compared estimated QRISK2 scores assuming missing lipid values with scores based on actual results and showed that QRISK2 scores were statistically worse (greater CVD risk) when using actual scores (Supplementary Table s1) suggesting that any bias introduced as a result of missing blood values may have been to under-estimate CVD risks in this population.
- The self-rating measures used to assess anxiety and depression are not the same as clinical diagnosis although scores recorded implied high levels of definite or probable depression and anxiety cases in this population.
- Smoking, alcohol use and activity status appeared to be subject to error as both prisoners and health care staff interpreted current status differently; variably recording their behaviour before coming into prison, since being in custody, at reception screen or subsequently; some prisoners classed themselves as 'smokers' if they used e-cigarettes.
- Due to logistical problems of collecting, the dataset contained substantial missing values for variables such as sentence length, so the study may be underpowered to detect differences for these variables and for information only available for those who underwent a Healthcheck (anxiety and depression) so it was not possible to test for associations between these and Healthcheck uptake.

Introduction

The NHS Healthchecks programme[1] is designed to identify individuals between the ages of 40 and 75 with a high risk of future cardiovascular disease, people with diabetes, and those with chronic renal disease, and then offer interventions to help reduce that risk. Although its effectiveness has attracted controversy [2,3,4,5] it remains government policy and and appears to be an important public health intervention with benefits especially for more disadvantaged communities.[6] Uptake of Healthchecks is variable but there is evidence it has improved between 2009 and 2013.[6] A particular feature of NHS Healthchecks is that they appear to successfully target higher risk patients in more deprived areas.[4,6,7]

The prison population is aging with a rise in the proportion over 50 from 7% in 2002 to 16% in 2018,[8] so the burden of cardiovascular disease Is likely to rise. In prison, 54% of deaths are currently due to natural causes[9] and of those, 35% have been estimated to be due to cardiovascular disease.[10] The Chief Medical Officer for England has identified prisoner health as a priority and there is growing awareness of the need to improve services and offer parity of care with community settings.[11]

Studies of cardiovascular risk factor profiles in prisoners within the last 15-20 years are rare in the UK[12] but more common in the US and Australia.[13,14,15,16] Reports describing the results of Healthchecks in prisoners generally summarise only those prisoners who undertake a Healthcheck. There are good data comparing the characteristics of those that do or don't take up Healthchecks in community settings,[6] but such data have not been published in prisoner populations.

There is an established relationship between cardiovascular risk and mental health with depression and anxiety both arising from, and a possible causative agent for, cardiovascular disease.[17,18,19] There is a high prevalence of mental disorder in prisoner populations,[4] but patterns of anxiety or depression in those taking up a healthcheck in this setting are unknown. Designing interventions to reduce cardiovascular risk requires an understanding of the pattern of risk factors present in the target population.

Recent national advice from Public Health England[20] has restated the need for a high uptake of Healthchecks in prisoners. It has lowered the age of first invitation (from 40 to 35) because prisoners are perceived to be at higher risk of cardiovascular ill-health than the general population. The advice also specifies targeting prisoners with expected incarceration of two years or more.[20] This study was designed to describe the burden of cardiovascular risk of male prisoners whatever their length of incarceration, and measure indicators of mental illness in study participants.

Methods

Ethics

Ethical approval was obtained from North-East York Research Ethics Committee (16/NE/0133) and the NHS England Health Research Authority (HRA). As with all prison research, Her Majesty's Prison and Probation Service approval was obtained and individual prison governors' permissions sought to conduct research on their sites. All participating prisoners in the research study provided written informed consent.

Study Design

An observational cross-sectional survey was conducted in prison healthcare services in the East Midlands. In the period of data collection from September 2017 to January 2019, there were 13 male prisons in the region. Healthcare services at six prisons were approached and all agreed to contribute to the research. The prisons were chosen to cover a broad spectrum of remand through to longer stay. They held NHS (n=4) or private (n=2) contracts for prison healthcare The total number of potential eligible participants from these prisons was approximately 3600 over a 12 month period, calculated by utilising 'churn' (turnover) of the eligible prison population and the actual recorded population. This identified the annual churn of prisoners between 5-35%, depending upon the prison site, with a month by month churn of between 15-100 eligible new prisoners by prison. The outcomes variables were the physical measures from the NHS Healthcheck and mental health measures of depression and anxiety.

Sampling procedure

All prisoners (regardless of sentence length or time served) who were deemed eligible for the NHS Healthcheck Programme adapted for prison settings[20] were scheduled to be invited to participate (aged between 35-74 years old with no exclusion diagnosis as per NHS Healthcheck criteria). Eligibility was sought using clinic reports from SystmOne, an NHS clinical record system, where those ineligible were subsequently filtered. As per the NHS Healthcheck programme guidance, those excluded were prisoners with established cardiovascular disease; coronary heart disease; strokes; transient ischaemic attacks; diabetes; atrial fibrillation; heart failure; peripheral artery disease and chronic kidney disease, and those prisoners already taking statins.

Each prison had a new report run every 2-3 weeks to allow for new prisoner receptions and to discount released or transferred prisoners from being invited.

Variables collected and outcomes measured

Physical Measures:

All variables as per NHS Healthcheck guidance were collected; age, ethnicity (census categories), height, weight, body mass index (BMI), waist circumference, systolic and diastolic blood pressure, smoking status (current, ex- and never smoked), family history of cardiovascular disease, and alcohol intake using the Alcohol Use Disorders Identification Test (AUDIT). AUDIT-C is a shortened version of the 10 question AUDIT tool used to identify individuals who may have hazardous drinking or alcohol drinking disorders.[21] The full 10 question AUDIT was undertaken if prisoners scored 5 or above on AUDIT-C. Physical activity was recorded using the General Practice Physical Activity Questionnaire (GPPAQ), a validated screening tool,[22] categorising patients as Active, Moderately Active, Moderately Inactive, or Inactive.

Blood tests for creatinine, plasma glucose, lipids and HbA1c were requested. If participants had blood tests within 15 months, such results were utilised. Last known postcodes were recorded and Index of Multiple Deprivation (IMD) codes applied;[23] IMD 1 being the most deprived area. 35.1% of prisoners were of no fixed abode (NFA) prior to incarceration which does not have a standardised IMD code so these postcodes were given NFA as a discreet categorical value.

As stated in the PHE Programme Guidance, the physical healthcheck in prison risk assessment required the use of a risk engine to calculate the individual's risk of developing CVD in the next 10 years. As advised by national guidance,[1] this study used QRISK2. [24]

Mental Health Measures:

Two mental health screens were utilised: the Patient Health Questionnaire (PHQ-9)[25,26] and the Generalised Anxiety Disorder Assessment (GAD-7).[27] The PHQ-9 is a self-rated tool consisting of 9 items with a good sensitivity (88%) and specificity (88%) to detect major depressive disorder. [25,26] The GAD-7 is a 7-item self-reported anxiety scale with a sensitivity of 89% and specificity of 82% for generalised anxiety disorder.[27] Both screens require the individuals to rate their symptoms and feelings related to the previous 2 week period, with items measuring the frequency of symptoms on a scale of 0 (not at all), to 3 (nearly every day). The screens have cut-off scores $\geq$ 10. The thresholds mild=0-5, moderate=6-10, moderate/severe=11-14 and severe $\geq$15 were used in this study. The PHQ-9 and GAD-7 are used nationally in the Improving Access to Psychological Therapies services, allowing the potential to benchmark against community scoring patterns.

SystmOne was also used to collect monthly anonymised denominator reports at each prison site to compare the whole population characteristics with those eligible to have an NHS Healthcheck and those eligible but declining active participation, so differences in the CVD risk profiles between eligible, ineligible, responders and non-responders could be described.

The descriptive analysis compared: those invited for an NHS Healthcheck with those who were invited but did not attend; the eligible population invited with the eligible population uninvited; and the whole prison population (age 35-74) with the eligible prison population.

Statistical Analysis

Summary measures were described using mean (standard deviation) or median (interquartile range) for continuous variables, categorical data were given as a count (percentage). Means were compared using a two-sample t-test and medians with a two-sample Wilcoxon test. Count data were compared using a Chi-squared test, or in the case of small counts, Fisher's exact test. Cohens d statistic was calculated using a pooled estimate of standard deviations to estimate effect size. The assumptions of normality, independence, sample size and homogeneity of variance were checked as appropriate.

A multiple logistic regression was fitted on the population offered a healthcheck with declined healthcheck as the outcome variable, fitted with age, BMI, smoking status, prison, IMD, ethnicity, and sentence length.

Baseline characteristics were taken from the first month a prisoner was recorded in the denominator data for all analyses except those using only prisoners who received a Healthcheck, who were not included in any analyses requiring denominator data.

Sample size was estimated by assuming a range of prevalances for QRISK 2 of 10% and a precision of ±2% requiring 2185 individuals or for a precision of +-3%, 971 individals if prevalence was assumed to be 35%. For a lower prevlance at 18%, then a sample of 908 participants would enable a precision of ±2.5% around this estimate. All analyses were performed using R version 3.5.3.

Patient and Public Involvement .

Prisoner involvement groups were used to development the consent form, qualitative aspects of the research and to check easy-read versions of printed material; prisoners did not take part in recruitment. Results were disseminated via prisoner participation groups in each establishment and on the EM-CLAHRC website.

Results

Eligible and ineligible populations

Table 1 describes the characteristics of a sample of the whole population of prisoners aged 35-74 collected at August 2018 (n=2107) comparing the eligible (n=1648) and ineligible populations (n=459) across all prisons at that point in time. Overall 21.8% of the prison population were ineligible for a Healthcheck due to existing comorbidity. The ineligible prisoners were older (mean age 53.5 (10.2) v 43.8 (7.6) years, P<0.001), had a higher BMI (30.5 (6.7) v 26.9 (5.2), P<0.001), had a higher QRISK2 score (median 13.4 (7.5-22.1)v 3.2 (1.8-6.2), p<0.001), and sentence length (3.45 years (1.5-7.0) v 2.5 (1.0-6.0) P<0.001). Ethnicity was significantly different (P=0.008) with the eligible group contining more white prisoners (85.0% v 79.6%). and fewer from Asian backgrounds (2.8% v 5.4%). The predominant reasons for ineligibility were established history of hypertension (12.9%) and diabetes (8.5%) (Table 2). The proportion ineligible due to comorbidities varied considerably by prison (between 14-37%), largely reflecting age structure differences between prisons. Among all participants aged 35-74, smokers totalled 1748 (82.9%).

Recruitment of eligible prisoners.

Overall 1207 subjects completed Healthchecks from an *invited* eligible population of 1579, a response rate of 76.4%. In all the total eligible population during the course of the study was 3620 individuals, so 43.6% of the available eligible population were invited and 33.3% took part. The mean age (standard deviation) of the whole eligible population was 43.8 (7.6) years. Not all eligible prisoners were invited because of the capacity of the researchers and the volume of prisoner churn.

Characteristics of the eligible study population.

Ethnicity , smoking status, sentence length (P<0.001) and prison attended (P<0.001) were all significantly different between those eligible prisoners who were invited to receive a Healthcheck and those eligible but who were not invited. Of those who were invited, there were significant differences in ethnicity (p=0.023) and length of sentence (p<0.001, with the invited group contining more white prisoners (82.4% v 79.2%). and prisoners serving a 2 year or longer sentence (29.8% v 26.1%). Invited prisoners were also less likely to be smokers (83.6% v 86.3% P=0.024). Other baseline characteristics were not significantly different between the two groups (Supplementary Table s2).

Characteristics of those who took up compared with those who declined a Healthcheck

From those invited (n=1579), those who took up a Healthcheck in this study (n=1191 plus 16 who took part but for whom baseline data was not available) differed from those who declined (n=388) in terms of ethnicity (P=0.008), with a smaller percentage of black prisoners receiving a Healthcheck than declining (3.7% v 7.0%). There was also significant variability by prison (Supplementary Table s3). The level of deprivation of the participants was estimated; 35% of participants were identified as of no fixed abode and a further 29% were in the lowest IMD quintile. (Supplementary Table s4)

The multiple logistic regression showed a significantly higher odds of declining a health check for Prison C (OR: 6.4, CI: 3.4-13.4) and Prison B (OR: 5.3, CI: 2.8-11.0) when compared to the reference Prison A, while Prison E showed no significant difference. Prisons D and F were missing from the analysis due to these prisoners having missing data on other variables. BMI and smoking status were not significant. Having a length of sentence of four years or more significantly decreased the odds of declining the heathcheck (OR: 0.5, CI: 0.2-0.9), but the other categories of sentence length were not significant. For ethnicity black prisoners had significantly higher odds of declining a health check (OR: 2.7, CI: 1.3-5.9) compared to the reference category of white prisoners, Asian and mixed / other ethnicity were not significant (Supplementary Table s5).

QRISK2 profiles of eligible prisoners

The QRISK2 profile for all 3620 eligible individuals identified that the proportion of male prisoners above a 10% threshold of QRISK2 varied between 5.6% and 19.8% of the population in the age range 35-74 years in each prison; 10.2% (370) across all six prisons during the study period. (Supplementary Table s6).

High QRSK2 (>=10) prisoner characteristics

Those prisoners who received a Healthcheck and were in the high QRISK2 group (n=125 , 10.3% of participants) were compared for variables not used in the QRISK2 scoring. The high-risk group had greater numbers with a positive family history (69.2% v 53.7%, P=0.002). There was a significant association between QRISK2 score and anxiety with the high risk group containing fewer prisoners with high anxiety scores (8.0% v 19.2%,) than the lower risk prisoners. There was no significant difference in measured levels of depression (PHQ-9), or ethnicity between these groups (Table 3).

Cardiovascular comorbidites in the participants

Among the 1207 prisoners who received a Healthcheck, 146 (12.1%) were found to have at least one of high CVD risk (on QRISK2), renal impairment or diabetes / prediabetes, with seven having

two, and one all three, risk factors. There were substantial missing values for the comorbidities defined by blood-based testing (Supplementary Table s7). Prisoners with blood test results were younger (mean age 45.5, s.d.8.2) than those without (mean age 42.7, s.d.7.0; p<0.001); completeness of blood results also varied by prison. Of the 1207 participants, 56.5% (n=682) of participants described themselves as active or moderately active, and 43.5% (n=525) inactive or moderately inactive.

Mental Health of participants

Overall, (as measured by PHQ-9 and GAD-7) 20.7% (n=249) of participants were classed as moderately severe to severely depressed and 18.0% (n=217) were suffering from severe anxiety (definite cases). These values rose to 37.6% (n=453) for moderate depression or worse and 31.5% (n=378) for moderate anxiety of worse (definite and probable cases) (Table 3).

Length of Sentence

Those prisoners who received a Healthcheck and were sentenced to less than 2 years, compared with longer sentences, did not show significant differences for diabetes or QRISK2 score but had significantly higher rates of possible cases of anxiety (34.9% v 23.8% P<0.001) and depression (41.1% v 31.4% P=0.009). (Supplementary Table s8).

Discussion

Main Findings

When offered a Healthcheck, uptake was high at 75.4 % of those invited. Clinically important cardiovascular risk, as measured by a QRISK2 score ≥10%, diabetes or pre-diabetes, or renal impairment, was present in 12.1% of those participating in the study. This study also identified that the prevalence of existing CVD limiting eligibility for the NHS Healthchecks programme was 21.8% (range 13.8-37.3%) of the prison populations studied (as at August 2018), and appeared to be influenced strongly by the age profile of the prisons. 82.9% of all prisoners aged 35-74 were recorded as smokers. Observed levels of clinically important anxiety (18.0%) and depression (20.7%) were more than double the rates found in a similar aged general male population.[28]

What is known about CVD risk already and what the study adds

In community populations eligible for an NHS Healthcheck, uptake between 2009 and 2012 has been reported between 18.7% [6] and 21.4%.[29] The uptake of a Healthcheck in our prison populations who

were invited was 76.4 %, much higher than attendance rates found in community samples. This represented an opportunity to intervene positively; that 24.6% did not take up that offer from this at-risk population is a matter of concern especially as it appeared that a higher proportion of BME prisoners did not access a Healthcheck. In community studies, around 30% of those in the age group 40-74 were already ineligible because of existing co-morbidity.[6] In our study, 21.8 % of those aged 35-74 were ineligible but from a substantially younger mean age population (mean age = 43.8 years compared with a mean age of 53.3 for the England population distribution for males between the ages of 35 and 74).[30]

Among the study population who received a Healthcheck we found important levels of comorbidity in 12.1%. The proportion of Healthcheck participants who are found to have new significant comorbidity (hypertension, type 2 diabetes or chronic kidney disease) nationally was 5%, rising to 37.3% if QRISK2 >= 10% was also included.[6] Comorbidity rates vary substantially and in one large multi-ethnic population studied which including those with a high diabetes risk (4.6%) and QRISK2 >= 10%, 53.4% of males had one of these comorbidities newly identified in the Healthcheck.[31] In this study, with its much younger study participants, 12.1% of participants had at least one of these comorbidities newly identified.

In community studies, 19% of males aged 35-74 have a QRISK2 score of 10 or above.[24] Overall, 10.2% of the eligible prison population studied here had a QRISK2 score of 10 or more but the prison population was almost 10 years younger on average. The age-specific QRISK2 bands described here (Supplementary Tables s9) suggest the level of risk is at least comparable; for the age bands 60-74, 26.9% of our participants, and 29.7% of all eligible prisoners in this study had a QRISK2 score of 20 or more, compared with 30.7% nationally[6] and 39.0% in a high risk multi-ethnic population.[31] The respective values for QRISK2 of 10 or more were 98.1% of participants and 92.0% of all eligible prisoners in our study, and 86.6% in the high-risk population.[31] In our study population only six prisoners were over 70 (0.5%) compared with 8.7% in the general population of males aged 35-74.[30]

A larger percentage of prisoners from a non-white heritage were ineligible for a Healthcheck because of existing comorbidity compared to prisoners from a white heritage, and of those eligible, a smaller proportion were both invited to a healthcheck, and received a Healthcheck. with black prisoners having 2.74 times the odds of declining a Healthcheck compared to white prisoners. It may be important to monitor Heathcheck uptake by ethnicity to assess potential inequity in provision of care.

Multiple logistic regression showed evidence of an association between prison, black ethnicity and a sentence length of four years or more to be associated with prisoners declining a health check. Due to missing data, the analysis is likely to be underpowered to detect differences for the smaller categories of variables and only four prisons were included in the analysis due to missing data on other variables. There may have been other significant differences that we were underpowered to detect.

This study is the first in the UK to describe whole eligible denominator populations, rather than just those who actually undertook a Healthcheck, and so allows an estimate of cardiovascular risk across the eligible population by institution.

High cardiovascular risk is commoner in deprived communities with a 20% higher crude incident rate of CVD in the most deprived quintile compared with the least deprived. [24] If we assume that those with no fixed abode in our study were likely to have characteristics similar to the highest deprivation quintile, 65% of participants could be considered to come from the most disadvantaged fifth of society, with associated overall disease risks and healthcare access challenges.

With 83% of all prisoners aged 35-74 being recorded as smokers on the GP records system, there appears to be a very large unmet need for preventative interventions and advice, although further work is required on standardising how lifestyle data is collected in prison settings.

Public Health England adjusted the eligibility criteria for NHS Healthchecks in 2017 to those aged 35-74 and incarcerated for 2 years or more.[32] We identified one prisoner among the 3620 eligible (0.02%) under the age of 40 who had a QRISK2 score of 10 or above, suggesting that the reduction in eligibility to age 35 may not be an efficient use of scare primary care resources. Similarly, prisoners with a sentence length of 2 years or more had similar proportions with QRISK2 score of 10 or above (12.8% v 9.7%, p=0.238) suggesting this eligibility change did not itself identify those with higher risk. For those serving less than 2 years, there remained a substantial number with adverse cardiovascular risk profiles and high levels of anxiety and depression (Table s7). This may have been associated with more rapid transit through the system but suggests unmet healthcare need. Extending Healthchecks irrespective of length of sentence would seem a positive policy step but may require additional resources to tackle unmet mental and physical health need. Good primary care follow up may also be more challenging after discharge if prisoners are returning to primary care services in areas of highest need.

Conclusion

This study identified that 21.8% of the prison population aged 35-74 already had comorbities that precluded them from taking part in an NHS Healthcheck. Across the whole prison population aged 35-74, 82.9% were recorded as smokers. Of those that were eligible for an NHS Healthcheck and took part, a further 12.1% were found to have a significant clinical risk for future CVD (QRISK2 ≥10) and 20.7% and 18.0% respecively had clinically significant depression or anxiety, further strengthening the case of need for good mental health services in prison. Ethnicity was associated with invitation to attend (p=0.023) and accept a health check, with higher odds of black prisoners declining (OR: 2.7, CI: 1.3-5.9) compared to white prisoners. Prisoners serving less than 2 years, who would not normally receive NHS Healthcheck through prison healthcare services, had much higher levels of anxiety or depression and appreciable high CVD risk (9.7%). With two-thirds of this group likely to come from the most deprived fifth of society, ensuing good prison mental health services and access to primary care services on discharge is vital to achieving equity of care in this patient group.

Authors Contributions

CP designed the study, wrote the proposal and led the research. MW initiated the data collection, trained healthcare staff, liaisied with the Ethics committee, and led the qualitative research. EB led the research teams collecting the data, completed the project management required by CLARHC, and developed the methods section. JM undertook the statistical analysis and commented on presentation. RM developed the PHQ-9 and GAD-7 analysis. KK helped wih refinements to the study design based on past community research. RM and KK commented extensively on the manuscript. All authors contributed individually to the report content.

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Main Tables

Table 1: Baseline characteristics of those prisoners Eligible and not eligible for healthchecks .

	Non-eligible (N = 459)	N missing	Eligible (N =1648)	N missing	P-value	Cohen's d statistic
Ethnicity N (%)		32		62	0.008	-
White	363 (85.0 CI: 82.0–88.2)		1262 (79.6, CI: 77.7-81.5)			-
Black	27 (6.3, CI: 3.3-9.5)		86 (5.4, CI: 3.6-7.4)			-
Asian (S & E)	12 (2.8, CI: 0.0-6.0)		86 (5.4, CI: 3.6-7.4)			-
Mixed/ Other	25 (5.9, CI:2.8-9.0)		152 (9.6, CI: 7.8-11.5)			-
Age (Years)	53.5 (10.2) CI: 33.9-73.2	0	43.8 (7.6) CI: 28.9-58.7	0	<0.001	1.6 (CI: 1.5-1.8)
Weight (kg)	93.5 (20.7) CI: 52.9-134.1	1	83.9 (16.9) CI: 50.7-117.0	15	<0.001	0.8 (CI: 0.7-0.9)
BMI	30.5 (6.7) CI: 17.3-43.6	2	26.9 (5.2) CI: 16.7-37.1	20	<0.001	0.9 (CI: 0.8—1.0)
Smoking status N (%)		2		13	<0.001	
Non-smoker	98 (21.4, CI: 17.9-25.4)		246 (15.1, CI: 13.4-16.8)			-
Smoker	359 (78.6, CI: 75.1-82.5)		1389 (85.0, CI: 83.3-86.7)			-
Sentence length (years) Median (IQR)	3.45 (1.50–6.99)	177	2.5 (1.0-6.00)	580	<0.001	-
QRISK2 score Median (IQR)	13.4 (7.5-22.1)	0	3.2 (1.8-6.2)	0	<0.001	-
Prevalent disease	454 (99.1, CI: 98.5-99.9)		-			-
On a Statin	4 (0.9, CI: 0.2-1.6)		-			-

All values are mean (sd) unless otherwise stated

These 2107 prisoners were a subset of the whole prison population aged 35-74 available at August 2018 .

Table 2. Prevalance of existing cardiovascular co-morbidity in the whole prisoner population studied aged 35-74 as at August 2018 (n=2107)

Co-Morbidity	N (%)
Hypertension	272 (12.9, CI: 11.5-14.4)
Diabetes	180 (8.5, CI: 7.4-9.8)
Cardiovascular Disease	117 (5.6, CI: 4.6-6.6)
High Cholesterol / statin	17 (0.8, CI: 0.5-1.3)
Chronic Kidney Disease	12 (0.6, CI: 0.3-1.0)
All co-morbidities	459 (21.8, CI: 20.0-23.6)

Table 3: Characteristics of prisoners who received a Healthcheck (n=1207) with high v low QRISK2 scores

Variable	QRISK2 < 10 (N=1082)	No. missing	QRISK2 ≥ 10 (N=125)	No. missing	P-value
Depression: PHQ-9 N (%)		2		0	0.058
None or mild	668 (61.7, CI: 58.9-64.8)		84 (67.2, CI: 59.2-75.2)		
Moderate	177 (16.4, CI: 13.4-19.4)		27 (21.6, CI: 13.6-29.6)		
Moderate/ Severe or Severe	235 (21.7, CI: 18.8)		14 (11.2, CI: 3.2-19.2)		
Anxiety: GAD-7 N (%)		2		0	0.016
None or mild	730 (67.6, CI: 64.8-70.4)		97 (77.6, CI: 71.2-85.0)		
Moderate	143 (13.2, CI: 10.5-16.1)		18 (14.4, CI: 8.0-21.8)		
Severe	207 (19.2, CI: 16.4-22.0)		10 (8.0, 1.6-15.4)		
1st Degree family history[1]	82			5	0.002
Yes	537 (53.7, CI: 50.5-56.9)		83 (69.2, CI: 61.7-78.0)		
No	463 (46.3, CI: 43.1-49.5)		37 (30.8, CI: 23.3-39.7)		
Ethnicity		4		0	0.057
White	876 (81.3, CI: 79.1-83.5)		113 (90.4, CI: 86.4-95.4)		
Black	44 (4.1, CI: 1.9-6.3)		2 (1.6, CI: 0.0-6.6)		
Asian	62 (5.8, CI: 3.6-8.0)		6 (4.8, CI: 0.8-9.8)		
Mixed/Other	96 (8.9, CI: 6.8-11.2)		4 (3.2, CI: 0.0-8.2)		

1] Family history of at least one of the following: Hypercholesterolaemia, Ischaemic heart disease, Angina, Myocardial Infarction, Cardiovascular disease or diabetes.

Supplementary Tables

Table s1. Effect of actual values on QRISK2 estimates based on missing values.

	QRISK2 score (Estimated cholesterol)	Non-estimated QRISK2 score (actual Cholesterol)
Median (IQR)	3.2 (1.84-6.14)	4.3 (2.11-8.13)

P=0.043

Table s2 Characteristics of patients who were invited to a Healthcheck compared to those who were not.

	Invite to health check (N=1579)	No. missing	Not invited to health check (N=2041)	No. missing	P-value	Cohen's d statistic
Age (Years)	43.6 (7.4) CI: 29.1-58.1	0	43.2 (7.3) CI: 28.9-57.5	0	0.136	0.1 (CI: -0.0-0.1)
Ethnicity N(%)		127		180	0.023	
White	1196 (82.4, CI: 80.6-84.3)		1473 (79.2, CI: 77.4-80.9)			-
Black	66 (4.5, CI: 2.8-6.4)		127 (6.8, CI: 5.1-8.6)			-
Asian	72 (5.0, CI: 3.2-6.9)		109 (5.9, 4.1-7.6)			-
Mixed/ Other	118 (8.1, CI: 6.3-10.0)		152 (8.2, CI: 6.4-9.9)			-
Weight (kg)	81.5 (16.8) CI: 48.6-114.4	7	81.9 (17.0) CI: 48.6-115.2	18	0.492	-0.0 (CI: -0.0-0.0)
BMI	26.2 (5.9) CI: 14.6-37.7	14	26.3 (5.9) CI: 14.7-37.8	23	0.668	-0.0(CI: -0.1-0.0)
Smoking status N(%)		33		42	0.024	
Smoker	1292 (83.6, CI: 81.8-85.4)		1726 (86.3, CI: 84.9-87.8)			-
Non-smoker	254 (16.4, CI: 14.6-18.3)		273 (13.7, CI: 12.2-15.2)			-
QRISK2 score N(%)		1		0	0.703	
<10	1416 (89.7, CI: 88.3-91.2)		1834 (89.9, CI: 88.6-91.1)			-
10-<20	139 (8.8, CI: 7.4-10.3)		172 (8.3, CI: 7.2-9.7)			-
20 or over	23 (1.5, CI: 0.1-2.9)		36 (1.8, CI: 0.5-3.0)			-
Median (IQR)	3.32 (1.92-6.19)		3.22 (1.83-5.91)			-
Alcohol consumption Median (IQR)	6.00 (3.00-12.00)	1038	6.00 (3.00-12.00)	1496	0.818	-
Sentence length (Years) N (%)		649		978	<0.001	-
Less than1	441 (47.4, CI: 44.1-50.8)		626 (58.9, CI: 56.0-61.9)			-
1-<2	212 (22.8, CI: 19.5-26.1)		160 (15.1, CI: 21.1-18.0)			-
2-<3	77 (8.3, CI: 4.9-11.6)		73 (6.9, CI: 4.0-9.9)			-
3-<4	50 (5.4. CI:		45 (4.2, 1.3-			-

	2.0-8.7)		7.2)			
4 or more	150 (16.1, CI: 12.8-19.5)		159 (15.0, CI: 12.0-17.9)			-
Prison N (%)		0		0	<0.001	
HMP A	304 (57.1, CI: 52.8-61.5)		228 (42.9, CI: 38.5-47.2)			-
HMP B	276 (44.2, CI: 40.2-48.3)		348 (55.8, CI: 51.8-59.8)			-
HMP C	535 (45.8, CI: 42.9-48.9)		633 (54.2, CI: 51.3-57.2)			-
HMP D	131 (27.2, CI: 23.2-31.2)		351 (72.8, CI: 68.9-76.9)			-
HMP E	297 (63.3, CI: 59.1-68.0)		172 (36.7, CI: 32.4-41.3)			-
HMP F	36 (10.4, CI: 7.5-13.6)		309 (89.6, 86.7-92.8)			-

Percentages calculated vertically except for prison data

Table s3: Characteristics of patients who received a Healthcheck compared to those who declined.

	Received health check (N=1191)	No. missing	Declined health check (N=388)	No. missing	P-value	Cohen's d statistic
Age (Years)	43.58 (7.4) CI: 29.1-58.1	0	43.51 (7.4) CI: 29.0-58.0	0	0.864	0.0 (CI: -0.1-0.1)
Ethnicity N(%)		104		23	0.008	
White	914 (84.1, CI: 82.1-86.1)		282 (77.3, CI: 73.4-81.5)			-
Black	40 (3.7, CI: 1.7-5.7)		26 (7.0, CI: 3.3-11.4)			-
Asian	53 (5.0, 2.9-6.9)		19 (5.2, CI: 1.4-9.5)			-
Mixed/ Other	80 (7.4, CI: 5.3-9.4)		38 (10.4, CI: 6.6-14.7)			-
Weight (kg)	81.71 (17.0) CI: 48.4-115.0	6	80.79 (16.3) CI: 48.8-112.7	1	0.334	0.0 (CI: -0.1-0.2
BMI	26.22 (6.1) CI: 14.3-38.2	10	26.06 (5.1) CI: 16.1-36.1	4	0.611	0.0 (CI: -0.1-0.1)
Smoking status N(%)		25		8	0.155	
Smoker	965 (82.8, CI: 80.7-85.0)		327 (86.1, CI: 82.9-89.6)			-
Non-smoker	201 (17.2, CI: 15.2-19.5)		53 (14.0, CI: 10.8-17.5)			-
QRISK2 score					0.372	
<10	1066 (89.6, CI: 87.9-91.3)		350 (90.2, 87.6-93.1)			-
10-<20	109 (9.2, CI: 7.6-10.9)		30 (7.7, CI: 5.2-10.6)			-
20 or over	15 (1.3, CI: 0.0-3.0)		8 (2.1, CI: 0.0-5.0)			-
Median (IQR)	3.29 (1.91-6.19)	1	3.35 (2.02-6.17)	0		-
Alcohol consumption Median (IQR)	6.00 (3.00-12.00)	760	7.00 (3.00-12.00)	278	0.960	-
Sentence length (Years) N (%)		473		165	0.313	

<1	222 (30.9, CI: 27.2-34.9)		75 (33.6, CI: 26.9-40.4)			-
-1-<2	144 (20.1, CI: 16.3-24.0)		50 (22.4, CI: 15.7-29.2)			-
2-<3	76 (10.6, CI: 6.8-14.5)		28 (12.6, CI: 5.8-19.4)			-
3-<4	55 (7.7, CI: 3.9-11.6)		18 (8.1, CI: 1.3-14.9)			-
4 or more	221 (30.8, CI: 27.0-34.7)		52 (23.3, CI: 16.6-30.1)			-
Prison		0		0	<0.001	
HMP A	283 (93.1, CI: 90.8-96.0)		21 (6.9, CI: 4.6-9.8)			-
HMP B	190 (68.8, CI: 63.4-74.4)		86 (31.2, CI: 25.7-36.7)			-
HMP C	345 (64.5, CI: 60.4-68.7)		190 (35.5, CI: 31.4-39.7)			-
HMP D	99 (75.6, 68.7-83.0)		32 (24.4, 17.6-31.9)			-
HMP E	247 (83.2, CI: 79.1-87.3)		50 (16.8, CI: 12.8-21.0)			-
HMP F	27 (75.0, CI: 63.9-90.2)		9 (25.0, CI: 13.9-40.2)			-

Percentages calculated vertically except for prison data

16 prisoners received a Healthcheck but their baseline data was not available in full and so they did not contribute to the analysis in this Table

Table s4. Categories of deprivation score for prisoners who received Healthcheck (n=1207)

IMD score category	N(%)
1-2	340 (28.9, CI 26.0-32.0)
3-4	207 (17.6, CI: 14.6-20.7)
5-6	84 (7.2, CI: 4.2-10.2)
7-8	94 (8.0, CI: 5.0-11.0)
9-10	38 (3.2, CI: 0.3-6.3)
No fixed address (No IMD score)	412 (35.1, CI: 32.1-38.1)

32 prisoners had missing information on IMD score

Supplementary Table s5. Multiple logistic regression results with consented / declined healthcheck the outcome variable, with age, ethnicity, prison, length of sentence, smoking status and BMI included in the model.

	Odds ratio	P-value
Age (years)	0.99 (0.97-1.02)	0.719
Ethnicity		
Black	2.74 (1.27-5.88)	0.004
Asian	1.40 (0.56-3.22)	0.447
Mixed \ other	1.02 (0.49-2.01)	0.957
Prison		
Nottingham	6.41 (3.35-13.39)	<0.001
Ranby	5.27 (2.76-10.99)	<0.001
Whatton	2.53 (1.18-5.77)	0.021
Length of sentence (years)		
1-<2	0.90 (0.58-1.38)	0.626
2-<3	0.99 (0.51-1.87)	0.982
3-<4	0.58 (0.21-1.42)	0.265
4 or more	0.47 (0.21-0.94)	0.040
Smoking status		
Smoker	1.07 (0.65-1.79)	0.802
BMI	1.03 (0.99-1.06)	0.167

Note that due to the model being fitted only on those prisoners with complete data for all variables included, Prisons D and F do not feature in the model, as they were missing data on other variables. Prison A is the reference prison

Table s6. QRISK2 score by prison for entire eligible population (n=3620)

QRISK 2 category N (%)	HMP A	HMP B	HMP C	HMP D	HMP E	HMP F
N	532	624	1167	482	469	345
Under 10	481 (90.4, CI: 88.2-92.8)	590 (94.6, CI: 92.9-96.2)	1073 (92.0, CI: 90.5-93.4)	451 (93.4, CI: 91.7-95.7)	376 (80.2, CI: 76.8-83.8)	278 (80.6, CI: 76.8-84.8)
10-<20	43 (8.1, CI: 5.8-10.5)	31 (5.1, CI: 3.4-6.6)	80 (6.9, CI: 5.4-8.3)	28 (5.8, CI: 3.9-8.0)	78 (16.6, CI: 13.2-20.2)	51 (14.8, CI: 11.0-19.0)
20 or more	8 (1.5, CI: 0.0-3.9)	3 (0.5, CI: 0.0-2.2)	14 (1.2, CI: 0.0-2.7)	3 (0.6, 0.0-2.8)	15 (3.2, CI: 0.0-6.8)	16 (4.6, CI: 0.9-8.9)
Median (IQR)	3.1 (1.9-5.6)	3.0 (1.8-5.1)	3.1 (1.9-5.4)	2.8 (1.6-4.9)	5.2 (2.3-8.9)	4.5 (2.4-8.0)
Type of prison	Cat B R and S	Cat C S	Cat B R and S	Cat B T	Cat C Sx	Cat B S

All values are N (%) unless otherwise specified. One missing value

Prison: Cat=security Category and Type R= Remand, S=Sentenced, Sx=sexual offences, T= Training

Table s7. Number of prisoners in each QRISK2 category, HbA1c levels, Chronic Kidney Disease and Depression (PHQ-9) and Anxiety (GAD-7) categories

	N (%)
QRISK 2 Score (%)	
<10	1082 (89.6, CI: 89.6-88.1)
≥10	125 (10.4, CI: 8.8-12.1)
Missing	0
HbA1c (mmols/mol)	
<42 (normal)	365 (92.6, CI: 90.4-95.1)
42-47 (pre-diabetes)	24 (6.1, CI: 3.8-8.5)
48+ (diabetes)	5 (1.3, CI: 0.0-3.7)
Missing	813
eGFR	
<60	1 (0.2, CI: 0.0-0.5)
>60	507 (99.8, CI: 99.6-1.0)
Missing	699
Total PHQ-9 score	
<10	752 (62.4, CI: 59.6-65.2)
≥10	453 (37.6, CI: 34.8-40.4)
Missing	2
Total GAD-7 Score	
<10	827 (68.6, CI: 66.0-71.3)
≥10	378 (31.4, CI: 28.7-34.1)
Missing	2

Table s8. Prevalence of cardiovascular comorbidity by sentence length of less than 2 years and 2 years or greater, in patients who received a heathcheck

	Length of sentence < 2 years (N=371)	Missing	Length of sentence ≥ 2 years (N=353)	Missing	P-value
eGFR		282		142	-
<60	0 (0.00)		1 (0.5)		
>60	89 (100.0)		210 (99.5)		
HbA1c		313		184	0.270
<42 (normal)	54 (93.1, CI: 87.9-98.5)		160 (94.7, CI: 92.3-98.2)		
42-47 (pre-diabetes)	2 (3.5, CI: 0.00-8.8)		8 (4.7, CI: 2.4-8.2)		
48+ (diabetes)	2 (3.5, CI: 0.00-8.8)		1 (0.6, CI: 0.0-4.1)		
QRISK score (%)				0	0.238
<10	335 (90.3, CI: 87.6-93.4)		308 (87.3, CI: 84.1-90.8)		
≥10	36 (9.7, CI: 7.0-12.6)		45 (12.8, CI: 9.6-16.3)		
Total PHQ-9		1		0	0.009
<10	218 (58.9, CI: 53.8-64.1)		242 (68.6, CI: 63.7-73.5)		
≥10	152 (41.1, CI: 35.9-46.2)		111 (31.4, 26.6-36.4)		
GAD-7		1			0.001
<10	241 (65.1, 60.3-70.2)		269 (76.2, CI: 72.0-80.8)		
≥10	129 (34.9, 30.0-39.9)		84 (23.8, 19.5-28.4)		

Table s9a. Number of prisoners in each age bracket with QRISK2 score for those that received a Healthcheck (n=1207)

	Age bands							
QRISK2 score	<40	40-44	45-49	50-54	55-59	60-64	65-69	70+
<10	430 (99.8, CI: 99.5-100.0)	312 (99.7, CI: 99.4-100.0)	203 (94.4, CI: 92.1-97.6)	106 (80.9, CI: 74.8-87.7)	30 (46.2, CI: 35.4-59.5)	1 (3.5, CI: 0.0-9.3)	0 (0.0, CI: 0.0-26.8)	0 (0.0, CI: 0.0-27.4)
10-20	0 (0.0, CI: 0.0-0.0)	1 (0.3, CI: 0.0-0.9)	12 (5.6, CI: 3.3-8.7)	25 (19.1, CI: 13.0-25.8)	35 (53.9, CI: 43.1-67.2)	28 (96.6, CI: 93.1-100.0)	9 (52.9, CI: 35.3-79.7)	0 (0.0, CI: 0.0-27.4)
20 or more	1 (0.2, CI: 0.0-0.6)	0 (0.0, CI: 0.0-0.5)	0 (0.0, CI: 0.0-3.2)	0 (0.0, CI: 0.0-6.8)	0 (0.0, CI: 0.0-13.3)	0 (0.0, CI: 0.0-5.8)	8 (47.1, CI: 29.4-73.8)	6 (100.0, CI: 100.0-100.0)

P-value <0.001. No missing values

Table s9b Number of prisoners in each age bracket with QRISK2 score for those that were eligible for a Healthcheck (n=3620)

	Age bands							
QRISK2 score	<40	40-44	45-49	50-54	55-59	60-64	65-69	70+
<10	1398 (99.9, CI: 99.9-100.0)	901 (98.6, CI: 97.9-99.3)	582 (94.3, CI: 92.7-96.1)	289 (78.3, CI: 74.3-82.5)	68 (37.4, CI: 30.2-44.8)	11 (13.9, CI: 6.3-23.1)	0 (0.0, CI: 0.0-15.1)	0 (0.0, CI: 0.0-16.5)
10-20	1 (0.1, 0.0-0.2)	11 (1.2, CI: 0.5-1.9)	31 (5.0, CI: 3.4-6.8)	76 (20.6, CI: 16.5-24.8)	106 (58.2, CI: 51.1-65.7)	62 (78.5, CI: 70.9-87.7)	22 (53.7, CI: 39.0-68.8)	2 (11.1, 5.6-27.6)
20 or more	0 (0.0, 0.0-0.1)	2 (0.2, CI: 0.0-0.9)	4 (0.7, CI: 0.0-2.4)	4 (1.1, CI: 0.0-5.3)	8 (4.4, 0.0-11.9)	6 (7.6, CI: 0.0-16.8)	19 (46.3, CI: 31.7-61.4)	16 (88.9, CI: 83.3-100.0)

P-value <0.001. 165 missing values

Table s9c. Number (%) of prisoners from each age group who have QRISK2 score of 10% or above and 20% and above for participants (n=1207)

Age (years)	QRISK2 score 10% or over n=125 N(%)	QRISK2 score 20% or over N(%)
35-39	1 (0.2%)	1 (0.2%)
40-49	13 (2.5%)	0 (0.0%)
50-59	60 (30.6%)	0 (0.0%)
60-69	45 (97.8%)	8 (17.4%)
70-74	6 (100.0%)	6 (100.0%)

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Title page

Cardiovascular risk profiles and the uptake of the NHS Healthcheck Programme in male prisoners in six UK prisons: an observational cross-sectional survey.

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Cardiovascular risk profiles and the uptake of the NHS Healthcheck Programme in male prisoners in six UK prisons: an observational cross-sectional survey.

Packham C, Butcher E, Williams M, Miksza J, Morriss R, Khunti K

Abstract

Introduction

Half of all deaths in custody are due to natural causes, the commonest being cardiovascular disease (CVD). NHS Healthchecks should be available to all eligible prisoners; it is not clear who receives them. Mental health issues are common in prisoners and may affect how healthcare interventions should be delivered. Current policy is to offer Healthchecks to those serving over 2 years in prison.

Objectives, Methods, Setting and Design

An observational cross-sectional survey in six male prisons in England between September 2017 and January 2019 in prisoners aged 35-74 to identify who was eligible for a Healthcheck and compare CVD risk data with those that were not, and factors associated with uptake.

Outcome measures

Characteristics of those accepting a Healthcheck were compared with those declining. Assessments of anxiety and depression were compared with CVD risk factors.

Results

1207 prisoners completed a Healthcheck. 21.8% of prisoners were ineligble due to existing comorbidities. 76.4% of those invited took up a Healthcheck, and of those, 12.1% were found to have new significant CVD comorbidity. CVD risk was similar to community levels but this population was 10 years younger. Definite case-level depression or anxiety was present in 20.7% and 18.0% respectively of participants. An association was found between ethnicity and those invited ($p=0.023$, $\phi=0.1$) and accepting ($p=0.008$, $\phi=0.1$) a Healthcheck. 9.7% of Prisoners serving less than 2 years had CVD risk scores of 10% or more, and had similar CVD risk profiles but much higher levels of anxiety ($p<0.001$, $\phi=0.2$) or depression ($p=0.009$, $\phi=0.2$) than those serving 2 years or more

Conclusion

Cardiovascular risk was comparable with community rates and in some prisons, much higher. Rates of anxiety and depression were high. The national policy for selecting prisoners for Healthchecks may leave many high-risk prisoners without appropriate cardiovascular preventative assessments.

ARTICLE SUMMARY : **Strengths and Limitations of the study**

- This study is the largest study of its kind to report cardiovascular risk in male prisoners, and allowed measurement of CVD risk across the whole eligible prison population not only those who took up a Healthcheck
- Estimation of QRISK2 by SystmOne is guided by an algorithm for missing values; we were unable to adjust for possible differences in prison population risk profiles although we compared estimated QRISK2 scores assuming missing lipid values with scores based on actual results and showed that QRISK2 scores were statistically worse (greater CVD risk) when using actual scores (Supplementary Table s1) suggesting that any bias introduced as a result of missing blood values may have been to under-estimate CVD risks in this population.
- The self-rating measures used to assess anxiety and depression are not the same as clinical diagnosis although scores recorded implied high levels of definite or probable depression and anxiety cases in this population.
- Smoking, alcohol use and activity status were subject to error as both prisoners and health care staff interpreted current status differently; variably recording their behaviour before coming into prison, since being in custody, at reception screen or subsequently; some prisoners classed themselves as 'smokers' if they used e-cigarettes.
- Due to logistical problems, the dataset contained missing values for variables such as sentence length, so the study may be underpowered to detect differences for these variables and for information only available for those who underwent a Healthcheck (anxiety and depression) so it was not possible to test for associations between these and Healthcheck uptake.

Introduction

The NHS Healthchecks programme[1] is designed to identify individuals between the ages of 40 and 75 with a high risk of future cardiovascular disease and then offer interventions to help reduce that risk. Although its effectiveness has attracted controversy [2,3,4,5] it remains government policy and appears to be an important public health intervention with benefits especially for higher risk patients in more disadvantaged communities.[4,6,7]

The prison population is aging with a rise in the proportion over 50 from 7% in 2002 to 16% in 2018,[8] so the burden of cardiovascular disease Is likely to rise. In prison, 54% of deaths are currently due to natural causes[9] and of those, 35% have been estimated to be due to cardiovascular disease.[10] The Chief Medical Officer for England identifies prisoner health as a priority and there is growing awareness of the need to improve services and offer parity of care with community settings.[11]

Studies of cardiovascular risk factor profiles in prisoners within the last 15-20 years are rare in the UK[12] but commoner in the US and Australia.[13,14,15,16] Reports describing the results of Healthchecks in prisoners generally summarise only those prisoners who undertake a Healthcheck. There are good data comparing the characteristics of those that do or don't take up Healthchecks in community settings,[6] but such data have not been published for prisoners.

There is an established relationship between cardiovascular risk and mental health with depression and anxiety both arising from, and a possible causative agent for, cardiovascular disease.[17,18,19] There is a high prevalence of mental disorder in prisoner populations,[4] but patterns of anxiety or depression in those taking up a healthcheck in this setting are unknown. Designing interventions to reduce cardiovascular risk requires an understanding of the pattern of risk factors present in target populations.

Recent national advice from Public Health England[20] has restated the need for a high uptake of Healthchecks in prisoners. It has lowered the age of first invitation (from 40 to 35) because prisoners are perceived to be at higher risk of cardiovascular ill-health than the general population. The advice also specifies targeting prisoners with expected incarceration of two years or more.[20] This study was designed to describe the burden of cardiovascular risk of male prisoners whatever their length of incarceration, and measure indicators of mental illness in study participants.

Methods

Ethics

Ethical approval was obtained from North-East York Research Ethics Committee (16/NE/0133) and the NHS England Health Research Authority (HRA). Her Majesty's Prison and Probation Service approval was obtained and individual prison governors' permissions obtained. All participating prisoners in the research study provided written informed consent.

Study Design

An observational cross-sectional survey was conducted in prison healthcare services in the East Midlands. In the period of data collection from September 2017 to January 2019, there were 13 male prisons in the region. Healthcare services at six prisons were approached and all agreed to contribute. The prisons were chosen to cover a broad spectrum of remand through to longer stay. They held NHS (n=4) or private (n=2) contracts for healthcare The total number of potential eligible participants from these prisons was calculated by utilising turnover of the eligible prison population and the actual recorded population. This identified an annual turnover of prisoners between 5-35%, depending upon the prison site, with a month by month turnover of between 15-100 eligible new prisoners by prison. The outcomes variables were the physical measures from the NHS Healthcheck and mental health measures of depression and anxiety.

Sampling procedure

All prisoners (regardless of sentence length or time served) who were deemed eligible for the NHS Healthcheck Programme in prison settings[20] were scheduled to be invited to participate (aged between 35-74 years old with no exclusion diagnosis as per NHS Healthcheck criteria). Eligibility was sought using clinic reports from SystmOne, an NHS clinical record system, where those ineligible were subsequently filtered. As per NHS Healthceck guidance, those excluded were prisoners with established cardiovascular disease, and those on statins.

Each prison ran a new report every 3 weeks to identify the eligible population and allow for new prisoner receptions and to discount released or transferred prisoners from being invited. From the total eligible, those actually invited were determined by individual prison capacity and conditions, with no pre-determined selection criteria.

Variables collected and outcomes measured

Physical Measures:

All variables as per NHS Healthcheck guidance were collected; age, ethnicity (census categories), height, weight, body mass index (BMI), blood pressure, smoking status (current, ex- and never smoked), family history of cardiovascular disease, and alcohol intake using the Alcohol Use Disorders

Identification Test (AUDIT). AUDIT-C is a shortened version of the 10 question AUDIT tool which identifies individuals who may have hazardous drinking or alcohol drinking disorders.[21] The full 10 question AUDIT was undertaken if prisoners scored 5 or above on AUDIT-C. Physical activity was recorded using the General Practice Physical Activity Questionnaire (GPPAQ), a validated screening tool,[22] categorising patients as Active, Moderately Active, Moderately Inactive, or Inactive.

Blood tests for creatinine, plasma glucose, lipids and HbA1c were requested. If participants had blood tests within 15 months, such results were utilised. Last known postcodes were recorded and Index of Multiple Deprivation (IMD) codes applied;[23] IMD 1 being the most deprived area. 35.1% of prisoners were of no fixed abode (NFA) prior to incarceration which does not have an IMD code so NFA was handled as a discreet categorical value.

As stated in the Programme Guidance, the physical healthcheck in prison risk assessment required the use of a risk engine to calculate the individual's risk of developing CVD in the next 10 years. As advised by national guidance,[1] this study used QRISK2. [24]

Mental Health Measures:

Two mental health screens were utilised: the Patient Health Questionnaire (PHQ-9)[25,26] and the Generalised Anxiety Disorder Assessment (GAD-7).[27] The PHQ-9 is a self-rated tool consisting of 9 items with a good sensitivity (88%) and specificity (88%) to detect major depressive disorder. [25,26] The GAD-7 is a 7-item self-reported anxiety scale with a sensitivity of 89% and specificity of 82% for generalised anxiety disorder.[27] Both screens require the individuals to rate their symptoms and feelings related to the previous 2 week period, with items measuring the frequency of symptoms on a scale of 0 (not at all), to 3 (nearly every day). The screens have cut-off scores $\geq$ 10. The thresholds mild=0-5, moderate=6-10, moderate/severe=11-14 and severe $\geq$15 were used in this study. The PHQ-9 and GAD-7 are used nationally in the Improving Access to Psychological Therapies services, allowing the potential to benchmark against community scoring patterns.

SystmOne was also used to collect monthly anonymised denominator reports at each prison site to compare the whole population characteristics with those eligible to have an NHS Healthcheck and those eligible but declining active participation, so differences in the CVD risk profiles between eligible, ineligible, responders and non-responders could be described.

The descriptive analysis compared: those invited for an NHS Healthcheck with those who were invited but did not attend; the eligible population invited with the eligible population uninvited; and the whole prison population (age 35-74) with the eligible prison population.

Statistical Analysis

Summary measures were described using mean (standard deviation) or median (interquartile range) for continuous variables, categorical data were given as a count (percentage). Means were compared using a two-sample t-test and medians with a two-sample Wilcoxon test. Count data were compared using a Chi-squared test, or in the case of small counts, Fisher's exact test. Cohens d statistic (d) was calculated using a pooled estimate of standard deviations to estimate effect size[28] for normally distributed continuous variables, Phi coefficient (ϕ) and Cramér's V (V) for categorical variables with two or more than two levels respectively, and the formula:

$$r = \frac{z}{\sqrt{N}}$$

The assumptions of normality, independence, sample size and homogeneity of variance were checked as appropriate.

A multiple logistic regression was fitted on the population offered a healthcheck with declined healthcheck as the outcome variable, fitted with age, BMI, smoking status, prison, IMD, ethnicity, and sentence length.

Baseline characteristics were taken from the first month a prisoner was recorded in the denominator data for all analyses except those using only prisoners who received a Healthcheck, who were not included in any analyses requiring denominator data.

Sample size was estimated by assuming a range of prevalances for QRISK 2 of 10% and a precision of ±2% requiring 2185 individuals or for a precision of +-3%, 971 individals if prevalence was assumed to be 35%. For a lower prevlance at 18%, then a sample of 908 participants would enable a precision of ±2.5% around this estimate. All analyses were performed using R version 3.5.3.

Patient and Public Involvement .

Prisoner involvement was used to development the consent form, qualitative aspects of the research and to check easy-read versions of material; prisoners did not take part in recruitment. Results were disseminated via participation groups in each establishment and on the EM-CLAHRC website.

Results

Eligible and ineligible populations

Table 1 describes the characteristics of a point prevalence sample of the whole population of prisoners aged 35-74 collected at August 2018 (n=2107) comparing the eligible (n=1648) and ineligible populations (n=459) across all prisons at that point in time. Overall 21.8% of the prison population were ineligible for a Healthcheck due to existing comorbidity. The ineligible prisoners were older (mean age 53.5 (10.2) v 43.8 (7.6) years, P<0.001, d=1.6), had a higher BMI (30.5 (6.7) v 26.9 (5.2), P<0.001, d=0.9), had a higher QRISK2 score (median 13.4 (7.5-22.1)v 3.2 (1.8-6.2), p<0.001, r=0.5), and sentence length (3.45 years (1.5-7.0) v 2.5 (1.0-6.0) P<0.001, r=0.1). Ethnicity was significantly different (P=0.008, ϕ=0.1) with the eligible group contining more white prisoners (85.0% v 79.6%). and fewer from Asian backgrounds (2.8% v 5.4%). The predominant reasons for ineligibility were established history of hypertension (12.9%) and diabetes (8.5%) (Table 2). The proportion ineligible due to comorbidities varied considerably by prison (between 14-37%), largely reflecting age structure differences between prisons. Among all participants aged 35-74, smokers totalled 1748 (82.9%).

Recruitment of eligible prisoners.

Overall 1207 subjects completed Healthchecks from an *invited* eligible population of 1579, a response rate of 76.4%. In all the total eligible population during the course of the study was 3620 individuals, so 43.6% of the available eligible population were invited and 33.3% took part. The mean age (standard deviation) of the whole eligible population was 43.8 (7.6) years. Not all eligible prisoners were invited because of the capacity of the researchers and the volume of prisoner churn.

Characteristics of the eligible study population.

Ethnicity , smoking status, sentence length (P<0.001, ϕ<0.1) and prison attended (P<0.001, ϕ=0.3) were all significantly different between those eligible prisoners who were invited to receive a Healthcheck and those eligible but who were not invited. Of those who were invited, there were significant differences in ethnicity (p=0.023, ϕ=0.1) and length of sentence (p<0.001, ϕ <0.1), with the invited group contining more white prisoners (82.4% v 79.2%). and prisoners serving a 2 year or longer sentence (29.8% v 26.1%). Invited prisoners were also less likely to be smokers (83.6% v 86.3% P=0.024, ϕ<0.1). Other baseline characteristics were not significantly different between the two groups (Supplementary Table s2).

Characteristics of those who took up compared with those who declined a Healthcheck

From those invited (n=1579), those who took up a Healthcheck in this study (n=1191 plus 16 who took part but for whom baseline data was not available) differed from those who declined (n=388) in terms of ethnicity (P=0.008, ϕ=0.1), with a smaller percentage of black prisoners receiving a Healthcheck than declining (3.7% v 7.0%). There was also significant variability by prison (Supplementary Table s3). The level of deprivation of the participants was estimated; 35% of participants were identified as of no fixed abode and a further 29% were in the lowest IMD quintile. (Supplementary Table s4)

The multiple logistic regression showed a significantly higher odds of declining a health check for Prison C (OR: 6.4, CI: 3.4-13.4) and Prison B (OR: 5.3, CI: 2.8-11.0) when compared to the reference Prison A, while Prison E showed no significant difference. Prisons D and F were missing from the analysis due to these prisoners having missing data on other variables. BMI (p = 0.17) and smoking status (p = 0.80) were not significant. Having a length of sentence of four years or more significantly decreased the odds of declining the heathcheck (OR: 0.5, CI: 0.2-0.9), but the other categories of sentence length were not significant. For ethnicity black prisoners had significantly higher odds of declining a health check (OR: 2.7, CI: 1.3-5.9) compared to the reference category of white prisoners, Asian and mixed / other ethnicity were not significant (Supplementary Table s5).

QRISK2 profiles of eligible prisoners

The QRISK2 profile for all 3620 eligible individuals identified that the proportion of male prisoners above a 10% threshold of QRISK2 varied between 5.6% and 19.8% of the population in the age range 35-74 years in each prison; 10.2% (370) across all six prisons during the study period. (Supplementary Table s6).

High QRSK2 (>=10) prisoner characteristics

Those prisoners who received a Healthcheck and were in the high QRISK2 group (n=125 , 10.3% of participants) were compared for variables not used in the QRISK2 scoring. The high-risk group had greater numbers with a positive family history (69.2% v 53.7%, P=0.002, ϕ=0.1). There was a significant association between QRISK2 score and anxiety with the high risk group containing fewer prisoners with high anxiety scores (8.0% v 19.2%,) than the lower risk prisoners, linked to length of sentence (Supplementary Table s7). There was no significant difference in measured levels of depression (PHQ-9), or ethnicity between these groups (Table 3).

Cardiovascular comorbidites in the participants

Among the 1207 prisoners who received a Healthcheck, 146 (12.1%) were found to have at least one of high CVD risk (on QRISK2), renal impairment or diabetes / prediabetes, with seven having two, and one all three, risk factors. There were substantial missing values for the comorbidities defined by blood-based testing (Supplementary Table s8). Prisoners with blood test results were younger (mean age 42.7, s.d.7.0; p<0.001) than those without (mean age 45.5, s.d.8.2, d=0.4); completeness of blood results also varied by prison. Of the 1207 participants, 56.5% (n=682) of participants described themselves as active or moderately active, and 43.5% (n=525) inactive or moderately inactive.

Mental Health of participants

Overall, (as measured by PHQ-9 and GAD-7) 20.7% (n=249) of participants were classed as moderately severe to severely depressed and 18.0% (n=217) were suffering from severe anxiety (definite cases). These values rose to 37.6% (n=453) for moderate depression or worse and 31.5% (n=378) for moderate anxiety of worse (definite and probable cases) (Table 3).

Length of Sentence

Those prisoners who received a Healthcheck and were sentenced to less than 2 years, compared with longer sentences, did not show significant differences for diabetes or QRISK2 score but had significantly higher rates of possible cases of anxiety (34.9% v 23.8% P<0.001, ϕ=0.2) and depression (41.1% v 31.4% P=0.009, ϕ=0.2). (Supplementary Table s8).

Discussion

Main Findings

When offered a Healthcheck, uptake was high at 76.4 % of those invited. Clinically important cardiovascular risk, as measured by a QRISK2 score ≥10%, diabetes or pre-diabetes, or renal impairment, was present in 12.1% of those participating in the study. This study also identified that the prevalence of existing CVD limiting eligibility for the NHS Healthchecks programme was 21.8% (range 13.8-37.3%) of the prison populations studied (as at August 2018), and appeared to be influenced strongly by the age profile of the prisons. 82.9% of all prisoners aged 35-74 were recorded as smokers. Observed levels of clinically important anxiety (18.0%) and depression (20.7%) were more than double the rates found in a similar aged general male population.[29]

What is known about CVD risk already and what the study adds

In community populations eligible for an NHS Healthcheck, uptake between 2009 and 2012 has been reported between 18.7% [6] and 21.4%.[30] The uptake of a Healthcheck in our prison populations who were invited was 76.4 %, much higher than attendance rates found in community samples. This represented an opportunity to intervene positively; that 24.6% did not take up that offer from this at-risk population is a matter of concern especially as a higher proportion of BME prisoners did not access a Healthcheck. In community studies, 30% of those in the age group 40-74 were already ineligible because of existing co-morbidity.[6] In our study, 21.8 % of those aged 35-74 were ineligible but from a substantially younger mean age population (mean age = 43.8 years compared with a mean age of 53.3 for the England population distribution for males between the ages of 35 and 74).[31]

Among the study population who received a Healthcheck we found important levels of comorbidity in 12.1%. The proportion of Healthcheck participants who are found to have new significant comorbidity (hypertension, type 2 diabetes or chronic kidney disease) nationally was 5%, rising to 37.3% if QRISK2 >= 10% was also included.[6] Comorbidity rates vary substantially and in one large multi-ethnic population studied which including those with a high diabetes risk (4.6%) and QRISK2 >= 10%, 53.4% of males had one of these comorbidities newly identified in the Healthcheck.[32] In this study, with its much younger study participants, 12.1% of participants had at least one of these comorbidities newly identified.

In community studies, 19% of males aged 35-74 have a QRISK2 score of 10 or above.[24] Overall, 10.2% of the eligible prison population studied here had a QRISK2 score of 10 or more but the prison population was almost 10 years younger on average. The age-specific QRISK2 bands described here (Supplementary Tables s9) suggest the level of risk is at least comparable; for the age bands 60-74, 26.9% of our participants, and 29.7% of all eligible prisoners in this study had a QRISK2 score of 20 or more, compared with 30.7% nationally[6] and 39.0% in a high risk multi-ethnic population.[32] The respective values for QRISK2 of 10 or more were 98.1% of participants and 92.0% of all eligible prisoners in our study, and 86.6% in the high-risk population.[32] In our study population only six prisoners were over 70 (0.5%) compared with 8.7% in the general population of males aged 35-74.[31]

A larger percentage of prisoners from a non-white heritage were ineligible for a Healthcheck because of existing comorbidity compared to prisoners from a white heritage, and of those eligible, a smaller proportion were both invited to a healthcheck, and received a Healthcheck, with black prisoners having 2.74 times the odds of declining a Healthcheck compared to white prisoners. It may be important to monitor Heathcheck uptake by ethnicity to assess potential inequity in provision of care.

Multiple logistic regression showed evidence of an association between prison, black ethnicity and a sentence length of four years or more to be associated with prisoners declining a health check. Due to missing data and small numbers in certain categories, the analysis is likely to be underpowered to detect differences for the smaller categories of variables and only four prisons were included in the analysis due to missing data on other variables There may have been other significant differences that we were underpowered to detect.

This study is the first in the UK to describe whole eligible denominator populations, rather than just those who actually undertook a Healthcheck, and so allows an estimate of cardiovascular risk across the eligible population by institution. Differences in those eligible, invited and participants were a reflection of a variety of practical barriers to healthcare operating in this study but are likely to be relevant nationally.

High cardiovascular risk is commoner in deprived communities with a 20% higher crude incident rate of CVD in the most deprived quintile compared with the least deprived. [24] If we assume that those with no fixed abode in our study were likely to have characteristics similar to the highest deprivation quintile, 65% of participants could be considered to come from the most disadvantaged fifth of society, with associated overall disease risks and healthcare access challenges.

With 83% of all prisoners aged 35-74 being recorded as smokers on the GP records system, there appears to be a very large unmet need for preventative interventions and advice, although further work is required on standardising how lifestyle data is collected in prison settings.

Public Health England adjusted the eligibility criteria for NHS Healthchecks in 2017 to those aged 35-74 and incarcerated for 2 years or more.[33] We identified one prisoner among the 3620 eligible (0.02%) under the age of 40 who had a QRISK2 score of 10 or above, suggesting that the reduction in eligibility to age 35 may not be an efficient use of scare primary care resources. Similarly, prisoners with a sentence length of 2 years or more had similar proportions with QRISK2 score of 10 or above (12.8% v 9.7%, p=0.238) suggesting this eligibility change did not itself identify those with higher risk. For those serving less than 2 years, there remained a substantial number with adverse cardiovascular risk profiles and high levels of anxiety and depression (Table s7). This may have been associated with more rapid transit through the system but suggests unmet healthcare need. Extending Healthchecks irrespective of length of sentence would seem a positive policy step but may require additional resources to tackle unmet mental and physical health need. Good primary care follow up may also be more challenging after discharge if prisoners are returning to primary care services in areas of highest need.

Conclusion

This study identified that 21.8% of the prison population aged 35-74 already had comorbities that precluded them from taking part in a Healthcheck. Across the whole prison population aged 35-74, 82.9% were recorded as smokers. Of those that were eligible for an NHS Healthcheck and took part, a further 12.1% were found to have a significant clinical risk for future CVD (QRISK2 ≥10) and 20.7% and 18.0% respecively had clinically significant depression or anxiety, further strengthening the case of need for good mental health services in prison. Ethnicity was associated with invitation to attend ($p=0.023$, $\phi=0.1$) and accept a health check, with higher odds of black prisoners declining (OR: 2.7, CI: 1.3-5.9) compared to white prisoners. Prisoners serving less than 2 years, who would not normally receive NHS Healthcheck through prison healthcare services, had much higher levels of anxiety or depression and high CVD risk (9.7%). With two-thirds of this group likely to come from the most deprived fifth of society, ensuring good prison mental health services and access to primary care services on discharge is vital to achieving equity of care in this patient group.

Authors Contributions

CP designed the study, wrote the proposal and led the research. MW initiated the data collection, trained healthcare staff, liaisied with the Ethics committee, and led the qualitative research. EB led the research teams collecting the data, completed the project management required by CLARHC, and developed the methods section. JM undertook the statistical analysis and commented on presentation. RM developed the PHQ-9 and GAD-7 analysis. KK helped wih refinements to the study design based on past community research. RM and KK commented extensively on the manuscript. All authors contributed individually to the report content.

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Main Tables

Table 1: Baseline characteristics of those prisoners Eligible and not eligible for healthchecks .

	Non-eligible (N = 459)	N missing	Eligible (N =1648)	N missing	P-value	Effect size
Ethnicity N (%)		32		62	0.008	ϕ = 0.1
White	363 (85.0 CI: 82.0–88.2)		1262 (79.6, CI: 77.7-81.5)			
Black	27 (6.3, CI: 3.3-9.5)		86 (5.4, CI: 3.6-7.4)			
Asian (S & E)	12 (2.8, CI: 0.0-6.0)		86 (5.4, CI: 3.6-7.4)			
Mixed/ Other	25 (5.9, CI:2.8-9.0)		152 (9.6, CI: 7.8-11.5)			
Age (Years)	53.5 (10.2) CI: 33.9-73.2	0	43.8 (7.6) CI: 28.9-58.7	0	<0.001	d = 1.6
Weight (kg)	93.5 (20.7) CI: 52.9-134.1	1	83.9 (16.9) CI: 50.7-117.0	15	<0.001	d = 0.8
BMI	30.5 (6.7) CI: 17.3-43.6	2	26.9 (5.2) CI: 16.7-37.1	20	<0.001	d = 0.9
Smoking status N (%)		2		13	<0.001	ϕ = 0.07
Non-smoker	98 (21.4, CI: 17.9-25.4)		246 (15.1, CI: 13.4-16.8)			
Smoker	359 (78.6, CI: 75.1-82.5)		1389 (85.0, CI: 83.3-86.7)			
Sentence length (years) Median (IQR)	3.45 (1.50–6.99)	177	2.5 (1.0-6.00)	580	<0.001	r = 0.1
QRISK2 score Median (IQR)	13.4 (7.5-22.1)	0	3.2 (1.8-6.2)	0	<0.001	r = 0.5
Prevalent disease	454 (99.1, CI: 98.5-99.9)		-			
On a Statin	4 (0.9, CI: 0.2-1.6)		-			

All values are mean (sd) unless otherwise stated

These 2107 prisoners were a subset of the whole prison population aged 35-74 available at August 2018 .

Table 2. Prevalance of existing cardiovascular co-morbidity in the whole prisoner population studied aged 35-74 as at August 2018 (n=2107)

Co-Morbidity	N (%)
Hypertension	272 (12.9, CI: 11.5-14.4)
Diabetes	180 (8.5, CI: 7.4-9.8)
Cardiovascular Disease	117 (5.6, CI: 4.6-6.6)
High Cholesterol / statin	17 (0.8, CI: 0.5-1.3)
Chronic Kidney Disease	12 (0.6, CI: 0.3-1.0)
All co-morbidities	459 (21.8, CI: 20.0-23.6)

Table 3: Characteristics of prisoners who received a Healthcheck (n=1207) with high v low QRISK2 scores

Variable	QRISK2 < 10 (N=1082)	No. missing	QRISK2 ≥ 10 (N=125)	No. missing	P-value	Effect size
Depression: PHQ-9 N (%)		2		0	0.058	ϕ = 0.1
None or mild	668 (61.7, CI: 58.9-64.8)		84 (67.2, CI: 59.2-75.2)			
Moderate	177 (16.4, CI: 13.4-19.4)		27 (21.6, CI: 13.6-29.6)			
Moderate/ Severe or Severe	235 (21.7, CI: 18.8)		14 (11.2, CI: 3.2-19.2)			
Anxiety: GAD-7 N (%)		2		0	0.016	ϕ = 0.1
None or mild	730 (67.6, CI: 64.8-70.4)		97 (77.6, CI: 71.2-85.0)			
Moderate	143 (13.2, CI: 10.5-16.1)		18 (14.4, CI: 8.0-21.8)			
Severe	207 (19.2, CI: 16.4-22.0)		10 (8.0, 1.6-15.4)			
1st Degree family history[1]	82			5	0.002	ϕ = 0.1
Yes	537 (53.7, CI: 50.5-56.9)		83 (69.2, CI: 61.7-78.0)			
No	463 (46.3, CI: 43.1-49.5)		37 (30.8, CI: 23.3-39.7)			
Ethnicity		4		0	0.057	ϕ= 0.1
White	876 (81.3, CI: 79.1-83.5)		113 (90.4, CI: 86.4-95.4)			
Black	44 (4.1, CI: 1.9-6.3)		2 (1.6, CI: 0.0-6.6)			
Asian	62 (5.8, CI: 3.6-8.0)		6 (4.8, CI: 0.8-9.8)			
Mixed/Other	96 (8.9, CI: 6.8-11.2)		4 (3.2, CI: 0.0-8.2)			

1] Family history of at least one of the following: Hypercholesterolaemia, Ischaemic heart disease, Angina, Myocardial Infarction, Cardiovascular disease or diabetes.

-

Supplementary Tables

Table s1. Effect of actual values on QRISK2 estimates based on missing values.

	QRISK2 score (Estimated cholesterol)	Non-estimated QRISK2 score (actual Cholesterol)
Median (IQR)	3.2 (1.84-6.14)	4.3 (2.11-8.13)

P=0.043 r=0.1

Table s2 Characteristics of patients who were invited to a Healthcheck compared to those who were not.

	Invite to health check (N=1579)	No. missing	Not invited to health check (N=2041)	No. missing	P-value	Effect size
Age (Years)	43.6 (7.4) CI: 29.1-58.1	0	43.2 (7.3) CI: 28.9-57.5	0	0.136	d = 0.1
Ethnicity N(%)		127		180	0.023	ϕ = 0.1
White	1196 (82.4, CI: 80.6-84.3)		1473 (79.2, CI: 77.4-80.9)			
Black	66 (4.5, CI: 2.8-6.4)		127 (6.8, CI: 5.1-8.6)			
Asian	72 (5.0, CI: 3.2-6.9)		109 (5.9, 4.1-7.6)			
Mixed/ Other	118 (8.1, CI: 6.3-10.0)		152 (8.2, CI: 6.4-9.9)			
Weight (kg)	81.5 (16.8) CI: 48.6-114.4	7	81.9 (17.0) CI: 48.6-115.2	18	0.492	d = 0.0
BMI	26.2 (5.9) CI: 14.6-37.7	14	26.3 (5.9) CI: 14.7-37.8	23	0.668	d = 0.0
Smoking status N(%)		33		42	0.024	ϕ <0.1
Smoker	1292 (83.6, CI: 81.8-85.4)		1726 (86.3, CI: 84.9-87.8)			
Non-smoker	254 (16.4, CI: 14.6-18.3)		273 (13.7, CI: 12.2-15.2)			
QRISK2 score N(%)		1		0	0.703	ϕ <0.1
<10	1416 (89.7, CI: 88.3-91.2)		1834 (89.9, CI: 88.6-91.1)			
10-<20	139 (8.8, CI: 7.4-10.3)		172 (8.3, CI: 7.2-9.7)			
20 or over	23 (1.5, CI: 0.1-2.9)		36 (1.8, CI: 0.5-3.0)			
Median (IQR)	3.32 (1.92-6.19)		3.22 (1.83-5.91)			
Alcohol consumption Median (IQR)	6.00 (3.00-12.00)	1038	6.00 (3.00-12.00)	1496	0.818	r <0.1
Sentence length (Years) N (%)		649		978	<0.001	- ϕ <0.1
Less than1	441 (47.4, CI: 44.1-50.8)		626 (58.9, CI: 56.0-61.9)			-
1-<2	212 (22.8, CI: 19.5-26.1)		160 (15.1, CI: 21.1-18.0)			-
2-<3	77 (8.3, CI: 4.9-11.6)		73 (6.9, CI: 4.0-9.9)			-

3-<4	50 (5.4. CI: 2.0-8.7)		45 (4.2, 1.3-7.2)			-
4 or more	150 (16.1, CI: 12.8-19.5)		159 (15.0, CI: 12.0-17.9)			
Prison N (%)		0		0	<0.001	ϕ = 0.3
HMP A	304 (57.1, CI: 52.8-61.5)		228 (42.9, CI: 38.5-47.2)			
HMP B	276 (44.2, CI: 40.2-48.3)		348 (55.8, CI: 51.8-59.8)			
HMP C	535 (45.8, CI: 42.9-48.9)		633 (54.2, CI: 51.3-57.2)			
HMP D	131 (27.2, CI: 23.2-31.2)		351 (72.8, CI: 68.9-76.9)			
HMP E	297 (63.3, CI: 59.1-68.0)		172 (36.7, CI: 32.4-41.3)			
HMP F	36 (10.4, CI: 7.5-13.6)		309 (89.6, 86.7-92.8)			

Percentages calculated vertically except for prison data.

Table s3: Characteristics of patients who received a Healthcheck compared to those who declined.

	Received health check (N=1191)	No. missing	Declined health check (N=388)	No. missing	P-value	Cohen's d statistic
Age (Years)	43.58 (7.4) CI: 29.1-58.1	0	43.51 (7.4) CI: 29.0-58.0	0	0.864	d = 0.0
Ethnicity N(%)		104		23	0.008	ϕ = 0.1
White	914 (84.1, CI: 82.1-86.1)		282 (77.3, CI: 73.4-81.5)			
Black	40 (3.7, CI: 1.7-5.7)		26 (7.0, CI: 3.3-11.4)			
Asian	53 (5.0, 2.9-6.9)		19 (5.2, CI: 1.4-9.5)			
Mixed/ Other	80 (7.4, CI: 5.3-9.4)		38 (10.4, CI: 6.6-14.7)			
Weight (kg)	81.71 (17.0) CI: 48.4-115.0	6	80.79 (16.3) CI: 48.8-112.7	1	0.334	d = 0.0
BMI	26.22 (6.1) CI: 14.3-38.2	10	26.06 (5.1) CI: 16.1-36.1	4	0.611	d = 0.0
Smoking status N(%)		25		8	0.155	ϕ <0.1
Smoker	965 (82.8, CI: 80.7-85.0)		327 (86.1, CI: 82.9-89.6)			-
Non-smoker	201 (17.2, CI: 15.2-19.5)		53 (14.0, CI: 10.8-17.5)			-
QRISK2 score		0		0	0.372	ϕ <0.1
<10	1066 (89.6, CI: 87.9-91.3)		350 (90.2, 87.6-93.1)			
10-<20	109 (9.2, CI: 7.6-10.9)		30 (7.7, CI: 5.2-10.6)			
20 or over	15 (1.3, CI: 0.0-3.0)		8 (2.1, CI: 0.0-5.0)			
Median (IQR)	3.29 (1.91-6.19)	1	3.35 (2.02-6.17)	0		
Alcohol consumption Median (IQR)	6.00 (3.00-12.00)	760	7.00 (3.00-12.00)	278	0.960	r <0.1
Sentence length (Years) N (%)		473		165	0.313	ϕ = 0.1

<1	222 (30.9, CI: 27.2-34.9)		75 (33.6, CI: 26.9-40.4)			-
-1-<2	144 (20.1, CI: 16.3-24.0)		50 (22.4, CI: 15.7-29.2)			-
2-<3	76 (10.6, CI: 6.8-14.5)		28 (12.6, CI: 5.8-19.4)			-
3-<4	55 (7.7, CI: 3.9-11.6)		18 (8.1, CI: 1.3-14.9)			-
4 or more	221 (30.8, CI: 27.0-34.7)		52 (23.3, CI: 16.6-30.1)			-
Prison		0		0	<0.001	$\phi = 0.3$
HMP A	283 (93.1, CI: 90.8-96.0)		21 (6.9, CI: 4.6-9.8)			-
HMP B	190 (68.8, CI: 63.4-74.4)		86 (31.2, CI: 25.7-36.7)			-
HMP C	345 (64.5, CI: 60.4-68.7)		190 (35.5, CI: 31.4-39.7)			-
HMP D	99 (75.6, 68.7-83.0)		32 (24.4, 17.6-31.9)			-
HMP E	247 (83.2, CI: 79.1-87.3)		50 (16.8, CI: 12.8-21.0)			-
HMP F	27 (75.0, CI: 63.9-90.2)		9 (25.0, CI: 13.9-40.2)			-

Percentages calculated vertically except for prison data

16 prisoners received a Healthcheck but their baseline data was not available in full and so they did not contribute to the analysis in this Table

Table s4. Categories of deprivation score for prisoners who received Healthcheck (n=1207)

IMD score category	N(%)
1-2	340 (28.9, CI 26.0-32.0)
3-4	207 (17.6, CI: 14.6-20.7)
5-6	84 (7.2, CI: 4.2-10.2)
7-8	94 (8.0, CI: 5.0-11.0)
9-10	38 (3.2, CI: 0.3-6.3)
No fixed address (No IMD score)	412 (35.1, CI: 32.1-38.1)

32 prisoners had missing information on IMD score

Supplementary Table s5. Multiple logistic regression results with consented / declined healthcheck the outcome variable, with age, ethnicity, prison, length of sentence, smoking status and BMI included in the model.

	Odds ratio	P-value
Age (years)	0.99 (0.97-1.02)	0.719
Ethnicity		
Black	2.74 (1.27-5.88)	0.004
Asian	1.40 (0.56-3.22)	0.447
Mixed \ other	1.02 (0.49-2.01)	0.957
Prison		
Nottingham	6.41 (3.35-13.39)	<0.001
Ranby	5.27 (2.76-10.99)	<0.001
Whatton	2.53 (1.18-5.77)	0.021
Length of sentence (years)		
1-<2	0.90 (0.58-1.38)	0.626
2-<3	0.99 (0.51-1.87)	0.982
3-<4	0.58 (0.21-1.42)	0.265
4 or more	0.47 (0.21-0.94)	0.040
Smoking status		
Smoker	1.07 (0.65-1.79)	0.802
BMI	1.03 (0.99-1.06)	0.167

Note that due to the model being fitted only on those prisoners with complete data for all variables included, Prisons D and F do not feature in the model, as they were missing data on other variables. Prison A is the reference prison

Table s6. QRISK2 score by prison for entire eligible population (n=3620)

QRISK 2 category N (%)	HMP A	HMP B	HMP C	HMP D	HMP E	HMP F
N	532	624	1167	482	469	345
Under 10	481 (90.4, CI: 88.2-92.8)	590 (94.6, CI: 92.9-96.2)	1073 (92.0, CI: 90.5-93.4)	451 (93.4, CI: 91.7-95.7)	376 (80.2, CI: 76.8-83.8)	278 (80.6, CI: 76.8-84.8)
10-<20	43 (8.1, CI: 5.8-10.5)	31 (5.1, CI: 3.4-6.6)	80 (6.9, CI: 5.4-8.3)	28 (5.8, CI: 3.9-8.0)	78 (16.6, CI: 13.2-20.2)	51 (14.8, CI: 11.0-19.0)
20 or more	8 (1.5, CI: 0.0-3.9)	3 (0.5, CI: 0.0-2.2)	14 (1.2, CI: 0.0-2.7)	3 (0.6, 0.0-2.8)	15 (3.2, CI: 0.0-6.8)	16 (4.6, CI: 0.9-8.9)
Median (IQR)	3.1 (1.9-5.6)	3.0 (1.8-5.1)	3.1 (1.9-5.4)	2.8 (1.6-4.9)	5.2 (2.3-8.9)	4.5 (2.4-8.0)
Type of prison	Cat B R and S	Cat C S	Cat B R and S	Cat B T	Cat C Sx	Cat B S

All values are N (%) unless otherwise specified. One missing value

Prison: Cat=security Category and Type R= Remand, S=Sentenced, Sx=sexual offences, T= Training

Table s7. Prevalence of cardiovascular comorbidity by sentence length of less than 2 years and 2 years or greater, in patients who received a heathcheck

	Length of sentence < 2 years (N=371)	Missing	Length of sentence ≥ 2 years (N=353)	Missing	P-value	Effect size
eGFR		282		142	-	-
<60	0 (0.00)		1 (0.5)			
>60	89 (100.0)		210 (99.5)			
HbA1c		313		184	0.270	ϕ = 0.1
<42 (normal)	54 (93.1, CI: 87.9-98.5)		160 (94.7, CI: 92.3-98.2)			
42-47 (pre-diabetes)	2 (3.5, CI: 0.00-8.8)		8 (4.7, CI: 2.4-8.2)			
48+ (diabetes)	2 (3.5, CI: 0.00-8.8)		1 (0.6, CI: 0.0-4.1)			
QRISK score (%)				0	0.238	ϕ = 0.1
<10	335 (90.3, CI: 87.6-93.4)		308 (87.3, CI: 84.1-90.8)			
≥10	36 (9.7, CI: 7.0-12.6)		45 (12.8, CI: 9.6-16.3)			
Total PHQ-9		1		0	0.009	ϕ = 0.2
<10	218 (58.9, CI: 53.8-64.1)		242 (68.6, CI: 63.7-73.5)			
≥10	152 (41.1, CI: 35.9-46.2)		111 (31.4, 26.6-36.4)			
GAD-7		1			0.001	ϕ = 0.2
<10	241 (65.1, 60.3-70.2)		269 (76.2, CI: 72.0-80.8)			
≥10	129 (34.9, 30.0-39.9)		84 (23.8, 19.5-28.4)			

Table s8. Number of prisoners in each QRISK2 category, HbA1c levels, Chronic Kidney Disease and Depression (PHQ-9) and Anxiety (GAD-7) categories

	N (%)
QRISK 2 Score (%)	
<10	1082 (89.6, CI: 89.6-88.1)
≥10	125 (10.4, CI: 8.8-12.1)
Missing	0
HbA1c (mmols/mol)	
<42 (normal)	365 (92.6, CI: 90.4-95.1)
42-47 (pre-diabetes)	24 (6.1, CI: 3.8-8.5)
48+ (diabetes)	5 (1.3, CI: 0.0-3.7)
Missing	813
eGFR	
<60	1 (0.2, CI: 0.0-0.5)
>60	507 (99.8, CI: 99.6-1.0)
Missing	699
Total PHQ-9 score	
<10	752 (62.4, CI: 59.6-65.2)
≥10	453 (37.6, CI: 34.8-40.4)
Missing	2
Total GAD-7 Score	
<10	827 (68.6, CI: 66.0-71.3)
≥10	378 (31.4, CI: 28.7-34.1)
Missing	2

Table s9a. Number of prisoners in each age bracket with QRISK2 score for those that received a Healthcheck (n=1207)

	Age bands							
QRISK2 score	35 - 39	40-44	45-49	50-54	55-59	60-64	65-69	70-74
<10	430 (99.8, CI: 99.5-100.0)	312 (99.7, CI: 99.4-100.0)	203 (94.4, CI: 92.1-97.6)	106 (80.9, CI: 74.8-87.7)	30 (46.2, CI: 35.4-59.5)	1 (3.5, CI: 0.0-9.3)	0 (0.0, CI: 0.0-26.8)	0 (0.0, CI: 0.0-27.4)
10-20	0 (0.0, CI: 0.0-0.0)	1 (0.3, CI: 0.0-0.9)	12 (5.6, CI: 3.3-8.7)	25 (19.1, CI: 13.0-25.8)	35 (53.9, CI: 43.1-67.2)	28 (96.6, CI: 93.1-100.0)	9 (52.9, CI: 35.3-79.7)	0 (0.0, CI: 0.0-27.4)
20 or more	1 (0.2, CI: 0.0-0.6)	0 (0.0, CI: 0.0-0.5)	0 (0.0, CI: 0.0-3.2)	0 (0.0, CI: 0.0-6.8)	0 (0.0, CI: 0.0-13.3)	0 (0.0, CI: 0.0-5.8)	8 (47.1, CI: 29.4-73.8)	6 (100.0, CI: 100.0-100.0)

P-value <0.001. No missing values. V = 0.7

Table s9b Number of prisoners in each age bracket with QRISK2 score for those that were eligible for a Healthcheck (n=3620)

	Age bands							
QRISK2 score	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74
<10	1398 (99.9, CI: 99.9-100.0)	901 (98.6, CI: 97.9-99.3)	582 (94.3, CI: 92.7-96.1)	289 (78.3, CI: 74.3-82.5)	68 (37.4, CI: 30.2-44.8)	11 (13.9, CI: 6.3-23.1)	0 (0.0, CI: 0.0-15.1)	0 (0.0, CI: 0.0-16.5)
10-20	1 (0.1, 0.0-0.2)	11 (1.2, CI: 0.5-1.9)	31 (5.0, CI: 3.4-6.8)	76 (20.6, CI: 16.5-24.8)	106 (58.2, CI: 51.1-65.7)	62 (78.5, CI: 70.9-87.7)	22 (53.7, CI: 39.0-68.8)	2 (11.1, 5.6-27.6)
20 or more	0 (0.0, 0.0-0.1)	2 (0.2, CI: 0.0-0.9)	4 (0.7, CI: 0.0-2.4)	4 (1.1, CI: 0.0-5.3)	8 (4.4, 0.0-11.9)	6 (7.6, CI: 0.0-16.8)	19 (46.3, CI: 31.7-61.4)	16 (88.9, CI: 83.3-100.0)

P-value <0.001. 165 missing values. V=0.6

Table s9c. Number (%) of prisoners from each age group who have QRISK2 score of 10% or above and 20% and above for participants (n=1207)

Age (years)	QRISK2 score 10% or over n=125 N(%)	QRISK2 score 20% or over N(%)
35-39	1 (0.2%)	1 (0.2%)
40-49	13 (2.5%)	0 (0.0%)
50-59	60 (30.6%)	0 (0.0%)
60-69	45 (97.8%)	8 (17.4%)
70-74	6 (100.0%)	6 (100.0%)

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Title page

Cardiovascular risk profiles and the uptake of the NHS Healthcheck Programme in male prisoners in six UK prisons: an observational cross-sectional survey.

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Cardiovascular risk profiles and the uptake of the NHS Healthcheck Programme in male prisoners in six UK prisons: an observational cross-sectional survey.

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Abstract

Introduction

Half of all deaths in custody are due to natural causes, the commonest being cardiovascular disease (CVD). NHS Healthchecks should be available to all eligible prisoners; it is not clear who receives them. Mental health issues are common in prisoners and may affect how healthcare interventions should be delivered. Current policy is to offer Healthchecks to those serving over 2 years in prison.

Objectives, Methods, Setting and Design

An observational cross-sectional survey in six male prisons in England between September 2017 and January 2019 in prisoners aged 35-74 to identify who was eligible for a Healthcheck and compare CVD risk data with those that were not, and factors associated with uptake.

Outcome measures

Characteristics of those accepting a Healthcheck were compared with those declining. Assessments of anxiety and depression were compared with CVD risk factors.

Results

1207 prisoners completed a Healthcheck. 21.8% of prisoners were ineligble due to existing comorbidities. 76.4% of those invited took up a Healthcheck, and of those, 12.1% were found to have new significant CVD comorbidity. CVD risk was similar to community levels but this population was 10 years younger. Definite case-level depression or anxiety was present in 20.7% and 18.0% respectively of participants. An association was found between ethnicity and those invited ($p=0.023$, $\phi=0.1$) and accepting ($p=0.008$, $\phi=0.1$) a Healthcheck. 9.7% of Prisoners serving less than 2 years had CVD risk scores of 10% or more, and had similar CVD risk profiles but much higher levels of anxiety ($p<0.001$, $\phi=0.2$) or depression ($p=0.009$, $\phi=0.2$) than those serving 2 years or more

Conclusion

Cardiovascular risk was comparable with community rates and in some prisons, much higher. Rates of anxiety and depression were high. The national policy for selecting prisoners for Healthchecks may leave many high-risk prisoners without appropriate cardiovascular preventative assessments.

ARTICLE SUMMARY : **Strengths and Limitations of the study**

- This study is the largest study of its kind to report cardiovascular risk in male prisoners, and allowed measurement of CVD risk across the whole eligible prison population.
- We compared estimated QRISK2 scores assuming missing lipid values with scores based on actual results and showed that QRISK2 scores were statistically worse (greater CVD risk) when using actual scores suggesting that any bias introduced as a result of missing blood values may have been to under-estimate CVD risks in this population.
- The self-rating measures used to assess anxiety and depression are not the same as clinical diagnosis although scores recorded implied high levels of definite or probable depression and anxiety cases in this population.
- Smoking, alcohol use and activity status were subject to error as both prisoners and health care staff interpreted current status differently.
- Due to logistical problems, the dataset contained missing values so the study may be underpowered to detect differences for these, and for information only available for those who underwent a Healthcheck.

Introduction

The NHS Healthchecks programme[1] is designed to identify individuals between the ages of 40 and 75 with a high risk of future cardiovascular disease and then offer interventions to help reduce that risk. Although its effectiveness has attracted controversy [2,3,4,5] it remains government policy and appears to be an important public health intervention with benefits especially for higher risk patients in more disadvantaged communities.[4,6,7]

The prison population is aging with a rise in the proportion over 50 from 7% in 2002 to 16% in 2018,[8] so the burden of cardiovascular disease Is likely to rise. In prison, 54% of deaths are currently due to natural causes[9] and of those, 35% have been estimated to be due to cardiovascular disease.[10] The Chief Medical Officer for England identifies prisoner health as a priority and there is growing awareness of the need to improve services and offer parity of care with community settings.[11]

Studies of cardiovascular risk factor profiles in prisoners within the last 15-20 years are rare in the UK[12] but commoner in the US and Australia.[13,14,15,16] Reports describing the results of Healthchecks in prisoners generally summarise only those prisoners who undertake a Healthcheck. There are good data comparing the characteristics of those that do or don't take up Healthchecks in community settings,[6] but such data have not been published for prisoners.

There is an established relationship between cardiovascular risk and mental health with depression and anxiety both arising from, and a possible causative agent for, cardiovascular disease.[17,18,19] There is a high prevalence of mental disorder in prisoner populations,[4] but patterns of anxiety or depression in those taking up a healthcheck in this setting are unknown. Designing interventions to reduce cardiovascular risk requires an understanding of the pattern of risk factors present in target populations.

Recent national advice from Public Health England[20] has restated the need for a high uptake of Healthchecks in prisoners. It has lowered the age of first invitation (from 40 to 35) because prisoners are perceived to be at higher risk of cardiovascular ill-health than the general population. The advice also specifies targeting prisoners with expected incarceration of two years or more.[20] This study was designed to describe the burden of cardiovascular risk of male prisoners whatever their length of incarceration, and measure indicators of mental illness in study participants.

Methods

Ethics

Ethical approval was obtained from North-East York Research Ethics Committee (16/NE/0133) and the NHS England Health Research Authority (HRA). Her Majesty's Prison and Probation Service approval was obtained and individual prison governors' permissions obtained. All participating prisoners in the research study provided written informed consent.

Study Design

An observational cross-sectional survey was conducted in prison healthcare services in the East Midlands. In the period of data collection from September 2017 to January 2019, there were 13 male prisons in the region. Healthcare services at six prisons were approached and all agreed to contribute. The prisons were chosen to cover a broad spectrum of remand through to longer stay. They held NHS (n=4) or private (n=2) contracts for healthcare The total number of potential eligible participants from these prisons was calculated by utilising turnover of the eligible prison population and the actual recorded population. This identified an annual turnover of prisoners between 5-35%, depending upon the prison site, with a month by month turnover of between 15-100 eligible new prisoners by prison. The outcomes variables were the physical measures from the NHS Healthcheck and mental health measures of depression and anxiety.

Sampling procedure

All prisoners (regardless of sentence length or time served) who were deemed eligible for the NHS Healthcheck Programme in prison settings[20] were scheduled to be invited to participate (aged between 35-74 years old with no exclusion diagnosis as per NHS Healthcheck criteria). Eligibility was sought using clinic reports from SystmOne, an NHS clinical record system, where those ineligible were subsequently filtered. As per NHS Healthceck guidance, those excluded were prisoners with established cardiovascular disease, and those on statins.

Each prison ran a new report every 3 weeks to identify the eligible population and allow for new prisoner receptions and to discount released or transferred prisoners from being invited. From the total eligible, those actually invited were determined by individual prison capacity and conditions, with no pre-determined selection criteria.

Variables collected and outcomes measured

Physical Measures:

All variables as per NHS Healthcheck guidance were collected; age, ethnicity (census categories), height, weight, body mass index (BMI), blood pressure, smoking status (current, ex- and never smoked), family history of cardiovascular disease, and alcohol intake using the Alcohol Use Disorders

Identification Test (AUDIT). AUDIT-C is a shortened version of the 10 question AUDIT tool which identifies individuals who may have hazardous drinking or alcohol drinking disorders.[21] The full 10 question AUDIT was undertaken if prisoners scored 5 or above on AUDIT-C. Physical activity was recorded using the General Practice Physical Activity Questionnaire (GPPAQ), a validated screening tool,[22] categorising patients as Active, Moderately Active, Moderately Inactive, or Inactive.

Blood tests for creatinine, plasma glucose, lipids and HbA1c were requested. If participants had blood tests within 15 months, such results were utilised. Last known postcodes were recorded and Index of Multiple Deprivation (IMD) codes applied;[23] IMD 1 being the most deprived area. 35.1% of prisoners were of no fixed abode (NFA) prior to incarceration which does not have an IMD code so NFA was handled as a discreet categorical value.

As stated in the Programme Guidance, the physical healthcheck in prison risk assessment required the use of a risk engine to calculate the individual's risk of developing CVD in the next 10 years. As advised by national guidance,[1] this study used QRISK2. [24]

Mental Health Measures:

Two mental health screens were utilised: the Patient Health Questionnaire (PHQ-9)[25,26] and the Generalised Anxiety Disorder Assessment (GAD-7).[27] The PHQ-9 is a self-rated tool consisting of 9 items with a good sensitivity (88%) and specificity (88%) to detect major depressive disorder. [25,26] The GAD-7 is a 7-item self-reported anxiety scale with a sensitivity of 89% and specificity of 82% for generalised anxiety disorder.[27] Both screens require the individuals to rate their symptoms and feelings related to the previous 2 week period, with items measuring the frequency of symptoms on a scale of 0 (not at all), to 3 (nearly every day). The screens have cut-off scores $\geq$ 10. The thresholds mild=0-5, moderate=6-10, moderate/severe=11-14 and severe $\geq$15 were used in this study. The PHQ-9 and GAD-7 are used nationally in the Improving Access to Psychological Therapies services, allowing the potential to benchmark against community scoring patterns.

SystmOne was also used to collect monthly anonymised denominator reports at each prison site to compare the whole population characteristics with those eligible to have an NHS Healthcheck and those eligible but declining active participation, so differences in the CVD risk profiles between eligible, ineligible, responders and non-responders could be described.

The descriptive analysis compared: those invited for an NHS Healthcheck with those who were invited but did not attend; the eligible population invited with the eligible population uninvited; and the whole prison population (age 35-74) with the eligible prison population.

Statistical Analysis

Summary measures were described using mean (standard deviation) or median (interquartile range) for continuous variables, categorical data were given as a count (percentage). Means were compared using a two-sample t-test and medians with a two-sample Wilcoxon test. Count data were compared using a Chi-squared test, or in the case of small counts, Fisher's exact test. Cohens d statistic (d) was calculated using a pooled estimate of standard deviations to estimate effect size[28] for normally distributed continuous variables, Phi coefficient (ϕ) and Cramér's V (V) for categorical variables with two or more than two levels respectively, and the formula:

$$r = \frac{z}{\sqrt{N}}$$

The assumptions of normality, independence, sample size and homogeneity of variance were checked as appropriate.

A multiple logistic regression was fitted on the population offered a healthcheck with declined healthcheck as the outcome variable, fitted with age, BMI, smoking status, prison, IMD, ethnicity, and sentence length.

Baseline characteristics were taken from the first month a prisoner was recorded in the denominator data for all analyses except those using only prisoners who received a Healthcheck, who were not included in any analyses requiring denominator data.

Sample size was estimated by assuming a range of prevalances for QRISK 2 of 10% and a precision of ±2% requiring 2185 individuals or for a precision of +-3%, 971 individals if prevalence was assumed to be 35%. For a lower prevlance at 18%, then a sample of 908 participants would enable a precision of ±2.5% around this estimate. All analyses were performed using R version 3.5.3.

Patient and Public Involvement .

Prisoner involvement was used to development the consent form, qualitative aspects of the research and to check easy-read versions of material; prisoners did not take part in recruitment. Results were disseminated via participation groups in each establishment and on the EM-CLAHRC website.

Results

Eligible and ineligible populations

Table 1 describes the characteristics of a point prevalence sample of the whole population of prisoners aged 35-74 collected at August 2018 (n=2107) comparing the eligible (n=1648) and ineligible populations (n=459) across all prisons at that point in time. Overall 21.8% of the prison population were ineligible for a Healthcheck due to existing comorbidity. The ineligible prisoners were older (mean age 53.5 (10.2) v 43.8 (7.6) years, P<0.001, d=1.6), had a higher BMI (30.5 (6.7) v 26.9 (5.2), P<0.001, d=0.9), had a higher QRISK2 score (median 13.4 (7.5-22.1)v 3.2 (1.8-6.2), p<0.001, r=0.5), and sentence length (3.45 years (1.5-7.0) v 2.5 (1.0-6.0) P<0.001, r=0.1). Ethnicity was significantly different (P=0.008, ϕ=0.1) with the eligible group contining more white prisoners (85.0% v 79.6%). and fewer from Asian backgrounds (2.8% v 5.4%). The predominant reasons for ineligibility were established history of hypertension (12.9%) and diabetes (8.5%) (Table 2). The proportion ineligible due to comorbidities varied considerably by prison (between 14-37%), largely reflecting age structure differences between prisons. Among all participants aged 35-74, smokers totalled 1748 (82.9%).

Recruitment of eligible prisoners.

Overall 1207 subjects completed Healthchecks from an *invited* eligible population of 1579, a response rate of 76.4%. In all the total eligible population during the course of the study was 3620 individuals, so 43.6% of the available eligible population were invited and 33.3% took part. The mean age (standard deviation) of the whole eligible population was 43.8 (7.6) years. Not all eligible prisoners were invited because of the capacity of the researchers and the volume of prisoner churn.

Characteristics of the eligible study population.

Ethnicity , smoking status, sentence length (P<0.001, ϕ<0.1) and prison attended (P<0.001, ϕ=0.3) were all significantly different between those eligible prisoners who were invited to receive a Healthcheck and those eligible but who were not invited. Of those who were invited, there were significant differences in ethnicity (p=0.023, ϕ=0.1) and length of sentence (p<0.001, ϕ <0.1), with the invited group contining more white prisoners (82.4% v 79.2%). and prisoners serving a 2 year or longer sentence (29.8% v 26.1%). Invited prisoners were also less likely to be smokers (83.6% v 86.3% P=0.024, ϕ<0.1). Other baseline characteristics were not significantly different between the two groups (Supplementary Table s1).

Characteristics of those who took up compared with those who declined a Healthcheck

From those invited (n=1579), those who took up a Healthcheck in this study (n=1191 plus 16 who took part but for whom baseline data was not available) differed from those who declined (n=388) in terms of ethnicity (P=0.008, ϕ=0.1), with a smaller percentage of black prisoners receiving a Healthcheck than declining (3.7% v 7.0%). There was also significant variability by prison (Supplementary Table s2). The level of deprivation of the participants was estimated; 35% of participants were identified as of no fixed abode and a further 29% were in the lowest IMD quintile. (Supplementary Table s3)

The multiple logistic regression showed a significantly higher odds of declining a health check for Prison C (OR: 6.4, CI: 3.4-13.4) and Prison B (OR: 5.3, CI: 2.8-11.0) when compared to the reference Prison A, while Prison E showed no significant difference. Prisons D and F were missing from the analysis due to these prisoners having missing data on other variables. BMI (p = 0.17) and smoking status (p = 0.80) were not significant. Having a length of sentence of four years or more significantly decreased the odds of declining the heathcheck (OR: 0.5, CI: 0.2-0.9), but the other categories of sentence length were not significant. For ethnicity black prisoners had significantly higher odds of declining a health check (OR: 2.7, CI: 1.3-5.9) compared to the reference category of white prisoners, Asian and mixed / other ethnicity were not significant (Supplementary Table s4).

QRISK2 profiles of eligible prisoners

The QRISK2 profile for all 3620 eligible individuals identified that the proportion of male prisoners above a 10% threshold of QRISK2 varied between 5.6% and 19.8% of the population in the age range 35-74 years in each prison; 10.2% (370) across all six prisons during the study period. (Supplementary Table s5).

High QRSK2 (>=10) prisoner characteristics

Those prisoners who received a Healthcheck and were in the high QRISK2 group (n=125 , 10.3% of participants) were compared for variables not used in the QRISK2 scoring. The high-risk group had greater numbers with a positive family history (69.2% v 53.7%, P=0.002, ϕ=0.1). There was a significant association between QRISK2 score and anxiety with the high risk group containing fewer prisoners with high anxiety scores (8.0% v 19.2%,) than the lower risk prisoners, linked to length of sentence (Supplementary Table s6). There was no significant difference in measured levels of depression (PHQ-9), or ethnicity between these groups (Table 3).

Cardiovascular comorbidites in the participants

Among the 1207 prisoners who received a Healthcheck, 146 (12.1%) were found to have at least one of high CVD risk (on QRISK2), renal impairment or diabetes / prediabetes, with seven having two, and one all three, risk factors. There were substantial missing values for the comorbidities defined by blood-based testing (Supplementary Table s7). Prisoners with blood test results were younger (mean age 42.7, s.d.7.0; p<0.001) than those without (mean age 45.5, s.d.8.2, d=0.4); completeness of blood results also varied by prison. Of the 1207 participants, 56.5% (n=682) of participants described themselves as active or moderately active, and 43.5% (n=525) inactive or moderately inactive.

Mental Health of participants

Overall, (as measured by PHQ-9 and GAD-7) 20.7% (n=249) of participants were classed as moderately severe to severely depressed and 18.0% (n=217) were suffering from severe anxiety (definite cases). These values rose to 37.6% (n=453) for moderate depression or worse and 31.5% (n=378) for moderate anxiety of worse (definite and probable cases) (Table 3).

Length of Sentence

Those prisoners who received a Healthcheck and were sentenced to less than 2 years, compared with longer sentences, did not show significant differences for diabetes or QRISK2 score but had significantly higher rates of possible cases of anxiety (34.9% v 23.8% P<0.001, ϕ=0.2) and depression (41.1% v 31.4% P=0.009, ϕ=0.2). (Supplementary Table s7).

Discussion

Main Findings

When offered a Healthcheck, uptake was high at 76.4 % of those invited. Clinically important cardiovascular risk, as measured by a QRISK2 score ≥10%, diabetes or pre-diabetes, or renal impairment, was present in 12.1% of those participating in the study. This study also identified that the prevalence of existing CVD limiting eligibility for the NHS Healthchecks programme was 21.8% (range 13.8-37.3%) of the prison populations studied (as at August 2018), and appeared to be influenced strongly by the age profile of the prisons. 82.9% of all prisoners aged 35-74 were recorded as smokers. Observed levels of clinically important anxiety (18.0%) and depression (20.7%) were more than double the rates found in a similar aged general male population.[29]

What is known about CVD risk already and what the study adds

In community populations eligible for an NHS Healthcheck, uptake between 2009 and 2012 has been reported between 18.7% [6] and 21.4%.[30] The uptake of a Healthcheck in our prison populations who were invited was 76.4 %, much higher than attendance rates found in community samples. This represented an opportunity to intervene positively; that 24.6% did not take up that offer from this at-risk population is a matter of concern especially as a higher proportion of BME prisoners did not access a Healthcheck. In community studies, 30% of those in the age group 40-74 were already ineligible because of existing co-morbidity.[6] In our study, 21.8 % of those aged 35-74 were ineligible but from a substantially younger mean age population (mean age = 43.8 years compared with a mean age of 53.3 for the England population distribution for males between the ages of 35 and 74).[31]

Among the study population who received a Healthcheck we found important levels of comorbidity in 12.1%. The proportion of Healthcheck participants who are found to have new significant comorbidity (hypertension, type 2 diabetes or chronic kidney disease) nationally was 5%, rising to 37.3% if QRISK2 >= 10% was also included.[6] Comorbidity rates vary substantially and in one large multi-ethnic population studied which including those with a high diabetes risk (4.6%) and QRISK2 >= 10%, 53.4% of males had one of these comorbidities newly identified in the Healthcheck.[32] In this study, with its much younger study participants, 12.1% of participants had at least one of these comorbidities newly identified.

In community studies, 19% of males aged 35-74 have a QRISK2 score of 10 or above.[24] Overall, 10.2% of the eligible prison population studied here had a QRISK2 score of 10 or more but the prison population was almost 10 years younger on average. The age-specific QRISK2 bands described here (Supplementary Tables s8) suggest the level of risk is at least comparable; for the age bands 60-74, 26.9% of our participants, and 29.7% of all eligible prisoners in this study had a QRISK2 score of 20 or more, compared with 30.7% nationally[6] and 39.0% in a high risk multi-ethnic population.[32] The respective values for QRISK2 of 10 or more were 98.1% of participants and 92.0% of all eligible prisoners in our study, and 86.6% in the high-risk population.[32] In our study population only six prisoners were over 70 (0.5%) compared with 8.7% in the general population of males aged 35-74.[31]

A larger percentage of prisoners from a non-white heritage were ineligible for a Healthcheck because of existing comorbidity compared to prisoners from a white heritage, and of those eligible, a smaller proportion were both invited to a healthcheck, and received a Healthcheck, with black prisoners having 2.74 times the odds of declining a Healthcheck compared to white prisoners. It may be important to monitor Heathcheck uptake by ethnicity to assess potential inequity in provision of care.

Multiple logistic regression showed evidence of an association between prison, black ethnicity and a sentence length of four years or more to be associated with prisoners declining a health check. Due to missing data and small numbers in certain categories, the analysis is likely to be underpowered to detect differences for the smaller categories of variables and only four prisons were included in the analysis due to missing data on other variables There may have been other significant differences that we were underpowered to detect.

We compared estimated QRISK2 scores assuming missing lipid values with scores based on actual results and showed that QRISK2 scores were statistically worse (greater CVD risk) when using actual scores (Supplementary Table s9) suggesting that any bias introduced as a result of missing blood values may have been to under-estimate CVD risks in this population.

This study is the first in the UK to describe whole eligible denominator populations, rather than just those who actually undertook a Healthcheck, and so allows an estimate of cardiovascular risk across the eligible population by institution. Differences in those eligible, invited and participants were a reflection of a variety of practical barriers to healthcare operating in this study but are likely to be relevant nationally.

High cardiovascular risk is commoner in deprived communities with a 20% higher crude incident rate of CVD in the most deprived quintile compared with the least deprived. [24] If we assume that those with no fixed abode in our study were likely to have characteristics similar to the highest deprivation quintile, 65% of participants could be considered to come from the most disadvantaged fifth of society, with associated overall disease risks and healthcare access challenges.

With 83% of all prisoners aged 35-74 being recorded as smokers, there appears to be a large unmet need for preventative interventions, although further work is required on standardising how lifestyle data is collected in prison settings.

Public Health England adjusted the eligibility criteria for NHS Healthchecks in 2017 to those aged 35-74 and incarcerated for 2 years or more.[33] We identified one prisoner among the 3620 eligible (0.02%) under the age of 40 who had a QRISK2 score of 10 or above, suggesting that the reduction in eligibility to age 35 may not be an efficient use of scare primary care resources. Similarly, prisoners with a sentence length of 2 years or more had similar proportions with QRISK2 score of 10 or above (12.8% v 9.7%, p=0.238) suggesting this eligibility change did not itself identify those with higher risk. For those serving less than 2 years, there remained a substantial number with adverse cardiovascular risk profiles; higher levels of anxiety and depression (Table s7) were possibly

associated with more rapid transit through the system rather than any association with CVD risk, but suggest unmet physical and mental healthcare need. Extending Healthchecks irrespective of length of sentence would seem a positive policy step but may require additional resources to tackle unmet mental and physical health need. Good primary care follow up may also be more challenging after discharge if prisoners are returning to primary care services in areas of highest need.

Conclusion

This study identified that 21.8% of the prison population aged 35-74 already had comorbities that precluded them from taking part in a Healthcheck. Across the whole prison population aged 35-74, 82.9% were recorded as smokers. Of those that were eligible for an NHS Healthcheck and took part, a further 12.1% were found to have a significant clinical risk for future CVD (QRISK2 ≥10) and 20.7% and 18.0% respecively had clinically significant depression or anxiety, further strengthening the case of need for good mental health services in prison. Ethnicity was associated with invitation to attend ($p=0.023$, $\phi=0.1$) and accept a health check, with higher odds of black prisoners declining (OR: 2.7, CI: 1.3-5.9) compared to white prisoners. Prisoners serving less than 2 years, who would not normally receive NHS Healthcheck through prison healthcare services, had much higher levels of anxiety or depression and high CVD risk (9.7%). With two-thirds of this group likely to come from the most deprived fifth of society, ensuring good prison mental health services and access to primary care services on discharge is vital to achieving equity of care in this patient group.

Authors Contributions

CP designed the study, wrote the proposal and led the research. MW initiated the data collection, trained healthcare staff, liaisied with the Ethics committee, and led the qualitative research. EB led the research teams collecting the data, completed the project management required by CLARHC, and developed the methods section. JM undertook the statistical analysis and commented on presentation. RM developed the PHQ-9 and GAD-7 analysis. KK helped wih refinements to the study design based on past community research. RM and KK commented extensively on the manuscript. All authors contributed individually to the report content.

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Main Tables

Table 1: Baseline characteristics of those prisoners Eligible and not eligible for healthchecks .

	Non-eligible (N = 459)	N missing	Eligible (N =1648)	N missing	P-value	Effect size
Ethnicity N (%)		32		62	0.008	ϕ = 0.1
White	363 (85.0 CI: 82.0–88.2)		1262 (79.6, CI: 77.7-81.5)			
Black	27 (6.3, CI: 3.3-9.5)		86 (5.4, CI: 3.6-7.4)			
Asian (S & E)	12 (2.8, CI: 0.0-6.0)		86 (5.4, CI: 3.6-7.4)			
Mixed/ Other	25 (5.9, CI:2.8-9.0)		152 (9.6, CI: 7.8-11.5)			
Age (Years)	53.5 (10.2) CI: 33.9-73.2	0	43.8 (7.6) CI: 28.9-58.7	0	<0.001	d = 1.6
Weight (kg)	93.5 (20.7) CI: 52.9-134.1	1	83.9 (16.9) CI: 50.7-117.0	15	<0.001	d = 0.8
BMI	30.5 (6.7) CI: 17.3-43.6	2	26.9 (5.2) CI: 16.7-37.1	20	<0.001	d = 0.9
Smoking status N (%)		2		13	<0.001	ϕ = 0.07
Non-smoker	98 (21.4, CI: 17.9-25.4)		246 (15.1, CI: 13.4-16.8)			
Smoker	359 (78.6, CI: 75.1-82.5)		1389 (85.0, CI: 83.3-86.7)			
Sentence length (years) Median (IQR)	3.45 (1.50–6.99)	177	2.5 (1.0-6.00)	580	<0.001	r = 0.1
QRISK2 score Median (IQR)	13.4 (7.5-22.1)	0	3.2 (1.8-6.2)	0	<0.001	r = 0.5
Prevalent disease	454 (99.1, CI: 98.5-99.9)		-			
On a Statin	4 (0.9, CI: 0.2-1.6)		-			

All values are mean (sd) unless otherwise stated

These 2107 prisoners were a subset of the whole prison population aged 35-74 available at August 2018 .

Table 2. Prevalance of existing cardiovascular co-morbidity in the whole prisoner population studied aged 35-74 as at August 2018 (n=2107)

Co-Morbidity	N (%)
Hypertension	272 (12.9, CI: 11.5-14.4)
Diabetes	180 (8.5, CI: 7.4-9.8)
Cardiovascular Disease	117 (5.6, CI: 4.6-6.6)
High Cholesterol / statin	17 (0.8, CI: 0.5-1.3)
Chronic Kidney Disease	12 (0.6, CI: 0.3-1.0)
All co-morbidities	459 (21.8, CI: 20.0-23.6)

Table 3: Characteristics of prisoners who received a Healthcheck (n=1207) with high v low QRISK2 scores

Variable	QRISK2 < 10 (N=1082)	No. missing	QRISK2 ≥ 10 (N=125)	No. missing	P-value	Effect size
Depression: PHQ-9 N (%)		2		0	0.058	ϕ = 0.1
None or mild	668 (61.7, CI: 58.9-64.8)		84 (67.2, CI: 59.2-75.2)			
Moderate	177 (16.4, CI: 13.4-19.4)		27 (21.6, CI: 13.6-29.6)			
Moderate/ Severe or Severe	235 (21.7, CI: 18.8)		14 (11.2, CI: 3.2-19.2)			
Anxiety: GAD-7 N (%)		2		0	0.016	ϕ = 0.1
None or mild	730 (67.6, CI: 64.8-70.4)		97 (77.6, CI: 71.2-85.0)			
Moderate	143 (13.2, CI: 10.5-16.1)		18 (14.4, CI: 8.0-21.8)			
Severe	207 (19.2, CI: 16.4-22.0)		10 (8.0, 1.6-15.4)			
1st Degree family history[1]	82			5	0.002	ϕ = 0.1
Yes	537 (53.7, CI: 50.5-56.9)		83 (69.2, CI: 61.7-78.0)			
No	463 (46.3, CI: 43.1-49.5)		37 (30.8, CI: 23.3-39.7)			
Ethnicity		4		0	0.057	ϕ= 0.1
White	876 (81.3, CI: 79.1-83.5)		113 (90.4, CI: 86.4-95.4)			
Black	44 (4.1, CI: 1.9-6.3)		2 (1.6, CI: 0.0-6.6)			
Asian	62 (5.8, CI: 3.6-8.0)		6 (4.8, CI: 0.8-9.8)			
Mixed/Other	96 (8.9, CI: 6.8-11.2)		4 (3.2, CI: 0.0-8.2)			

1] Family history of at least one of the following: Hypercholesterolaemia, Ischaemic heart disease, Angina, Myocardial Infarction, Cardiovascular disease or diabetes.

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Supplementary Tables

Table s1 Characteristics of patients who were invited to a Healthcheck compared to those who were not.

	Invite to health check (N=1579)	No. missing	Not invited to health check (N=2041)	No. missing	P-value	Effect size
Age (Years)	43.6 (7.4) CI: 29.1-58.1	0	43.2 (7.3) CI: 28.9-57.5	0	0.136	d = 0.1
Ethnicity N(%)		127		180	0.023	ϕ = 0.1
White	1196 (82.4, CI: 80.6-84.3)		1473 (79.2, CI: 77.4-80.9)			
Black	66 (4.5, CI: 2.8-6.4)		127 (6.8, CI: 5.1-8.6)			
Asian	72 (5.0, CI: 3.2-6.9)		109 (5.9, 4.1-7.6)			
Mixed/ Other	118 (8.1, CI: 6.3-10.0)		152 (8.2, CI: 6.4-9.9)			
Weight (kg)	81.5 (16.8) CI: 48.6-114.4	7	81.9 (17.0) CI: 48.6-115.2	18	0.492	d = 0.0
BMI	26.2 (5.9) CI: 14.6-37.7	14	26.3 (5.9) CI: 14.7-37.8	23	0.668	d = 0.0
Smoking status N(%)		33		42	0.024	ϕ <0.1
Smoker	1292 (83.6, CI: 81.8-85.4)		1726 (86.3, CI: 84.9-87.8)			
Non-smoker	254 (16.4, CI: 14.6-18.3)		273 (13.7, CI: 12.2-15.2)			
QRISK2 score N(%)		1		0	0.703	ϕ <0.1
<10	1416 (89.7, CI: 88.3-91.2)		1834 (89.9, CI: 88.6-91.1)			
10-<20	139 (8.8, CI: 7.4-10.3)		172 (8.3, CI: 7.2-9.7)			
20 or over	23 (1.5, CI: 0.1-2.9)		36 (1.8, CI: 0.5-3.0)			
Median (IQR)	3.32 (1.92-6.19)		3.22 (1.83-5.91)			
Alcohol consumption Median (IQR)	6.00 (3.00-12.00)	1038	6.00 (3.00-12.00)	1496	0.818	r <0.1
Sentence length (Years) N (%)		649		978	<0.001	- ϕ <0.1

Less than1	441 (47.4, CI: 44.1-50.8)		626 (58.9, CI: 56.0-61.9)			-
1-<2	212 (22.8, CI: 19.5-26.1)		160 (15.1, CI: 21.1-18.0)			-
2-<3	77 (8.3, CI: 4.9-11.6)		73 (6.9, CI: 4.0-9.9)			-
3-<4	50 (5.4. CI: 2.0-8.7)		45 (4.2, 1.3-7.2)			-
4 or more	150 (16.1, CI: 12.8-19.5)		159 (15.0, CI: 12.0-17.9)			
Prison N (%)		0		0	<0.001	$\phi = 0.3$
HMP A	304 (57.1, CI: 52.8-61.5)		228 (42.9, CI: 38.5-47.2)			
HMP B	276 (44.2, CI: 40.2-48.3)		348 (55.8, CI: 51.8-59.8)			
HMP C	535 (45.8, CI: 42.9-48.9)		633 (54.2, CI: 51.3-57.2)			
HMP D	131 (27.2, CI: 23.2-31.2)		351 (72.8, CI: 68.9-76.9)			
HMP E	297 (63.3, CI: 59.1-68.0)		172 (36.7, CI: 32.4-41.3)			
HMP F	36 (10.4, CI: 7.5-13.6)		309 (89.6, 86.7-92.8)			

Percentages calculated vertically except for prison data.

Table s2: Characteristics of patients who received a Healthcheck compared to those who declined.

	Received health check (N=1191)	No. missing	Declined health check (N=388)	No. missing	P-value	Cohen's d statistic
Age (Years)	43.58 (7.4) CI: 29.1-58.1	0	43.51 (7.4) CI: 29.0-58.0	0	0.864	d = 0.0
Ethnicity N(%)		104		23	0.008	ϕ = 0.1
White	914 (84.1, CI: 82.1-86.1)		282 (77.3, CI: 73.4-81.5)			
Black	40 (3.7, CI: 1.7-5.7)		26 (7.0, CI: 3.3-11.4)			
Asian	53 (5.0, 2.9-6.9)		19 (5.2, CI: 1.4-9.5)			
Mixed/ Other	80 (7.4, CI: 5.3-9.4)		38 (10.4, CI: 6.6-14.7)			
Weight (kg)	81.71 (17.0) CI: 48.4-115.0	6	80.79 (16.3) CI: 48.8-112.7	1	0.334	d = 0.0
BMI	26.22 (6.1) CI: 14.3-38.2	10	26.06 (5.1) CI: 16.1-36.1	4	0.611	d = 0.0
Smoking status N(%)		25		8	0.155	ϕ <0.1
Smoker	965 (82.8, CI: 80.7-85.0)		327 (86.1, CI: 82.9-89.6)			-
Non-smoker	201 (17.2, CI: 15.2-19.5)		53 (14.0, CI: 10.8-17.5)			-
QRISK2 score		0		0	0.372	ϕ <0.1
<10	1066 (89.6, CI: 87.9-91.3)		350 (90.2, 87.6-93.1)			
10-<20	109 (9.2, CI: 7.6-10.9)		30 (7.7, CI: 5.2-10.6)			
20 or over	15 (1.3, CI: 0.0-3.0)		8 (2.1, CI: 0.0-5.0)			
Median (IQR)	3.29 (1.91-6.19)	1	3.35 (2.02-6.17)	0		
Alcohol consumption Median (IQR)	6.00 (3.00-12.00)	760	7.00 (3.00-12.00)	278	0.960	r <0.1
Sentence length (Years) N (%)		473		165	0.313	ϕ = 0.1

<1	222 (30.9, CI: 27.2-34.9)		75 (33.6, CI: 26.9-40.4)			-
-1-<2	144 (20.1, CI: 16.3-24.0)		50 (22.4, CI: 15.7-29.2)			-
2-<3	76 (10.6, CI: 6.8-14.5)		28 (12.6, CI: 5.8-19.4)			-
3-<4	55 (7.7, CI: 3.9-11.6)		18 (8.1, CI: 1.3-14.9)			-
4 or more	221 (30.8, CI: 27.0-34.7)		52 (23.3, CI: 16.6-30.1)			-
Prison		0		0	<0.001	$\phi = 0.3$
HMP A	283 (93.1, CI: 90.8-96.0)		21 (6.9, CI: 4.6-9.8)			-
HMP B	190 (68.8, CI: 63.4-74.4)		86 (31.2, CI: 25.7-36.7)			-
HMP C	345 (64.5, CI: 60.4-68.7)		190 (35.5, CI: 31.4-39.7)			-
HMP D	99 (75.6, 68.7-83.0)		32 (24.4, 17.6-31.9)			-
HMP E	247 (83.2, CI: 79.1-87.3)		50 (16.8, CI: 12.8-21.0)			-
HMP F	27 (75.0, CI: 63.9-90.2)		9 (25.0, CI: 13.9-40.2)			-

Percentages calculated vertically except for prison data

16 prisoners received a Healthcheck but their baseline data was not available in full and so they did not contribute to the analysis in this Table

Table s3. Categories of deprivation score for prisoners who received Healthcheck (n=1207)

IMD score category	N(%)
1-2	340 (28.9, CI 26.0-32.0)
3-4	207 (17.6, CI: 14.6-20.7)
5-6	84 (7.2, CI: 4.2-10.2)
7-8	94 (8.0, CI: 5.0-11.0)
9-10	38 (3.2, CI: 0.3-6.3)
No fixed address (No IMD score)	412 (35.1, CI: 32.1-38.1)

32 prisoners had missing information on IMD score

Supplementary Table s4. Multiple logistic regression results with consented / declined healthcheck the outcome variable, with age, ethnicity, prison, length of sentence, smoking status and BMI included in the model.

	Odds ratio	P-value
Age (years)	0.99 (0.97-1.02)	0.719
Ethnicity		
Black	2.74 (1.27-5.88)	0.004
Asian	1.40 (0.56-3.22)	0.447
Mixed \ other	1.02 (0.49-2.01)	0.957
Prison		
Prison C	6.41 (3.35-13.39)	<0.001
Prison B	5.27 (2.76-10.99)	<0.001
Prison E	2.53 (1.18-5.77)	0.021
Length of sentence (years)		
1-<2	0.90 (0.58-1.38)	0.626
2-<3	0.99 (0.51-1.87)	0.982
3-<4	0.58 (0.21-1.42)	0.265
4 or more	0.47 (0.21-0.94)	0.040
Smoking status		
Smoker	1.07 (0.65-1.79)	0.802
BMI	1.03 (0.99-1.06)	0.167

Note that due to the model being fitted only on those prisoners with complete data for all variables included, Prisons D and F do not feature in the model, as they were missing data on other variables. Prison A is the reference prison

Table s5. QRISK2 score by prison for entire eligible population (n=3620)

QRISK 2 category N (%)	HMP A	HMP B	HMP C	HMP D	HMP E	HMP F
N	532	624	1167	482	469	345
Under 10	481 (90.4, CI: 88.2-92.8)	590 (94.6, CI: 92.9-96.2)	1073 (92.0, CI: 90.5-93.4)	451 (93.4, CI: 91.7-95.7)	376 (80.2, CI: 76.8-83.8)	278 (80.6, CI: 76.8-84.8)
10-<20	43 (8.1, CI: 5.8-10.5)	31 (5.1, CI: 3.4-6.6)	80 (6.9, CI: 5.4-8.3)	28 (5.8, CI: 3.9-8.0)	78 (16.6, CI: 13.2-20.2)	51 (14.8, CI: 11.0-19.0)
20 or more	8 (1.5, CI: 0.0-3.9)	3 (0.5, CI: 0.0-2.2)	14 (1.2, CI: 0.0-2.7)	3 (0.6, 0.0-2.8)	15 (3.2, CI: 0.0-6.8)	16 (4.6, CI: 0.9-8.9)
Median (IQR)	3.1 (1.9-5.6)	3.0 (1.8-5.1)	3.1 (1.9-5.4)	2.8 (1.6-4.9)	5.2 (2.3-8.9)	4.5 (2.4-8.0)
Type of prison	Cat B R and S	Cat C S	Cat B R and S	Cat B T	Cat C Sx	Cat B S

All values are N (%) unless otherwise specified. One missing value

Prison: Cat=security Category and Type R= Remand, S=Sentenced, Sx=sexual offences, T= Training

Table s6. Prevalence of cardiovascular comorbidity by sentence length of less than 2 years and 2 years or greater, in patients who received a heathcheck

	Length of sentence < 2 years (N=371)	Missing	Length of sentence ≥ 2 years (N=353)	Missing	P-value	Effect size
eGFR		282		142	-	-
<60	0 (0.00)		1 (0.5)			
>60	89 (100.0)		210 (99.5)			
HbA1c		313		184	0.270	ϕ = 0.1
<42 (normal)	54 (93.1, CI: 87.9-98.5)		160 (94.7, CI: 92.3-98.2)			
42-47 (pre-diabetes)	2 (3.5, CI: 0.00-8.8)		8 (4.7, CI: 2.4-8.2)			
48+ (diabetes)	2 (3.5, CI: 0.00-8.8)		1 (0.6, CI: 0.0-4.1)			
QRISK score (%)				0	0.238	ϕ = 0.1
<10	335 (90.3, CI: 87.6-93.4)		308 (87.3, CI: 84.1-90.8)			
≥10	36 (9.7, CI: 7.0-12.6)		45 (12.8, CI: 9.6-16.3)			
Total PHQ-9		1		0	0.009	ϕ = 0.2
<10	218 (58.9, CI: 53.8-64.1)		242 (68.6, CI: 63.7-73.5)			
≥10	152 (41.1, CI: 35.9-46.2)		111 (31.4, 26.6-36.4)			
GAD-7		1			0.001	ϕ = 0.2
<10	241 (65.1, 60.3-70.2)		269 (76.2, CI: 72.0-80.8)			
≥10	129 (34.9, 30.0-39.9)		84 (23.8, 19.5-28.4)			

Table s7. Number of prisoners in each QRISK2 category, HbA1c levels, Chronic Kidney Disease and Depression (PHQ-9) and Anxiety (GAD-7) categories

	N (%)
QRISK 2 Score (%)	
<10	1082 (89.6, CI: 89.6-88.1)
≥10	125 (10.4, CI: 8.8-12.1)
Missing	0
HbA1c (mmols/mol)	
<42 (normal)	365 (92.6, CI: 90.4-95.1)
42-47 (pre-diabetes)	24 (6.1, CI: 3.8-8.5)
48+ (diabetes)	5 (1.3, CI: 0.0-3.7)
Missing	813
eGFR	
<60	1 (0.2, CI: 0.0-0.5)
>60	507 (99.8, CI: 99.6-1.0)
Missing	699
Total PHQ-9 score	
<10	752 (62.4, CI: 59.6-65.2)
≥10	453 (37.6, CI: 34.8-40.4)
Missing	2
Total GAD-7 Score	
<10	827 (68.6, CI: 66.0-71.3)
≥10	378 (31.4, CI: 28.7-34.1)
Missing	2

Table s8a. Number of prisoners in each age bracket with QRISK2 score for those that received a Healthcheck (n=1207)

	Age bands							
QRISK2 score	35 - 39	40-44	45-49	50-54	55-59	60-64	65-69	70-74
<10	430 (99.8, CI: 99.5-100.0)	312 (99.7, CI: 99.4-100.0)	203 (94.4, CI: 92.1-97.6)	106 (80.9, CI: 74.8-87.7)	30 (46.2, CI: 35.4-59.5)	1 (3.5, CI: 0.0-9.3)	0 (0.0, CI: 0.0-26.8)	0 (0.0, CI: 0.0-27.4)
10-20	0 (0.0, CI: 0.0-0.0)	1 (0.3, CI: 0.0-0.9)	12 (5.6, CI: 3.3-8.7)	25 (19.1, CI: 13.0-25.8)	35 (53.9, CI: 43.1-67.2)	28 (96.6, CI: 93.1-100.0)	9 (52.9, CI: 35.3-79.7)	0 (0.0, CI: 0.0-27.4)
20 or more	1 (0.2, CI: 0.0-0.6)	0 (0.0, CI: 0.0-0.5)	0 (0.0, CI: 0.0-3.2)	0 (0.0, CI: 0.0-6.8)	0 (0.0, CI: 0.0-13.3)	0 (0.0, CI: 0.0-5.8)	8 (47.1, CI: 29.4-73.8)	6 (100.0, CI: 100.0-100.0)

P-value <0.001. No missing values. V = 0.7

Table s8b Number of prisoners in each age bracket with QRISK2 score for those that were eligible for a Healthcheck (n=3620)

	Age bands							
QRISK2 score	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74
<10	1398 (99.9, CI: 99.9-100.0)	901 (98.6, CI: 97.9-99.3)	582 (94.3, CI: 92.7-96.1)	289 (78.3, CI: 74.3-82.5)	68 (37.4, CI: 30.2-44.8)	11 (13.9, CI: 6.3-23.1)	0 (0.0, CI: 0.0-15.1)	0 (0.0, CI: 0.0-16.5)
10-20	1 (0.1, 0.0-0.2)	11 (1.2, CI: 0.5-1.9)	31 (5.0, CI: 3.4-6.8)	76 (20.6, CI: 16.5-24.8)	106 (58.2, CI: 51.1-65.7)	62 (78.5, CI: 70.9-87.7)	22 (53.7, CI: 39.0-68.8)	2 (11.1, 5.6-27.6)
20 or more	0 (0.0, 0.0-0.1)	2 (0.2, CI: 0.0-0.9)	4 (0.7, CI: 0.0-2.4)	4 (1.1, CI: 0.0-5.3)	8 (4.4, 0.0-11.9)	6 (7.6, CI: 0.0-16.8)	19 (46.3, CI: 31.7-61.4)	16 (88.9, CI: 83.3-100.0)

P-value <0.001. 165 missing values. V=0.6

Table s8c. Number (%) of prisoners from each age group who have QRISK2 score of 10% or above and 20% and above for participants (n=1207)

Age (years)	QRISK2 score 10% or over n=125 N(%)	QRISK2 score 20% or over N(%)
35-39	1 (0.2%)	1 (0.2%)
40-49	13 (2.5%)	0 (0.0%)
50-59	60 (30.6%)	0 (0.0%)
60-69	45 (97.8%)	8 (17.4%)
70-74	6 (100.0%)	6 (100.0%)

Table s9. Effect of actual values on QRISK2 estimates based on missing values.

	QRISK2 score (Estimated cholesterol)	Non-estimated QRISK2 score (actual Cholesterol)
Median (IQR)	3.2 (1.84-6.14)	4.3 (2.11-8.13)

P=0.043 r=0.1

STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found YES in Abstract
Introduction		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported YES in Introduction
Objectives	3	State specific objectives, including any prespecified hypotheses YES IN Abstract
Methods		
Study design	4	Present key elements of study design early in the paper YES in Abstract and page 6 Methods
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection YES in Abstract, Methods page 6
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants YES in methods page 6
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable YES in methods pages 6,7 and 8
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group YES page 6
Bias	9	Describe any efforts to address potential sources of bias YES Limitations and Supplementary table s1
Study size	10	Explain how the study size was arrived at YES methods page 8

Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why YES methods page 8
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding YES methods page 8
		(*b*) Describe any methods used to examine subgroups and interactions YES methods page 8
		(*c*) Explain how missing data were addressed YES methods page 8 and Discussion paragraph 6
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy YES methods page 6
		(*e*) Describe any sensitivity analyses

Continued on next page

Results		
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed YES Results page 9
		(b) Give reasons for non-participation at each stage Yes results page 9
		(c) Consider use of a flow diagram
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders YES Results table 1 and supplementary tables 1-s9c
		(b) Indicate number of participants with missing data for each variable of interest YES in results tables 1,3 and s1-s9c
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time
		Case-control study—Report numbers in each exposure category, or summary measures of exposure
		Cross-sectional study—Report numbers of outcome events or summary measures YES used uptake of healthchecks table 3
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included YES in all reported results
		(*b*) Report category boundaries when continuous variables were categorized YES in all reported results
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period Not relevant
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses
Discussion		
Key results	18	Summarise key results with reference to study objectives Yes discussion first paragraph
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias Yes strengths and limitation and discussion text paragraph 10
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity

		of analyses, results from similar studies, and other relevant evidence Yes discussion paragraphs 1, 2, 3,4
Generalisability	21	Discuss the generalisability (external validity) of the study results Yes strengths and conclusion page 14
Other information		
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based Yes page 2

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.