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Changes in cardiovascular disease risk and behavioural risk factors before the introduction of a health check programme in England

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ABSTRACT

A population-based programme of health checks was introduced for adults in England in 2011 for the primary prevention of cardiovascular diseases (CVD) and risk factors management. The aim was to evaluate changes in cardiovascular risk and behavioural risk factors in a health check eligible population in England from 1994 to 2013, by using repeated cross-sectional design using seven surveys of the Health Survey for England. Measures included traditional CVD risk factors and behavioural risk factors. Linear trends were estimated allowing for sampling design. The surveys comprised 49,805 adults aged 45 to 74 years; 30,639 were free from cardiovascular comorbidity; 16,041 (52%) had complete data for quantitative risk factors. Between 1994 and 2013, systolic blood pressure decreased by 3.1 (95% confidence interval 2.5 to 3.6) mm Hg per decade in men and 5.0 (4.5 to 5.5) in women. Total cholesterol decreased by 0.20 (0.16 to 0.24) mmol/l per decade in men; 0.23 (0.19 to 0.26) in women. Smoking declined by 6% (5% to 8%) per decade in men; 7% (6% - 8%) in women. The proportion with CVD-risk ≥20% declined by 6.8% per decade in men; 2.4% in women. Multiple behavioural risk factors were strongly associated with estimated CVD-risk, but improving trends in traditional CVD risk factors were inconsistent with increasing indicators of adiposity. Long-term declines in traditional risk factors contributed to reductions in estimated CVD-risk prior to the introduction of a health check programme. Behaviour change interventions for multiple risk factor exposures remain a key area for future research.

1. Introduction

Cardiovascular diseases (CVD) are the leading cause of death worldwide (Alwan, 2011). In the United Kingdom, CVD causes almost 155,000 deaths annually, accounting for more than a quarter of all deaths (BHF, 2015). Traditional cardiovascular disease risk factors, including hypertension, hypercholesterolemia and cigarette smoking, have been a key focus of efforts to reduce cardiovascular disease. In the context of preventive medicine, individualised risk reduction interventions are often tailored to cardiovascular disease (CVD) risk assessments using CVD risk scores. The Framingham risk score represents the most widely recognised of these CVD risk assessment tools (Anderson et al., 1991) and it has been adapted for use in other settings (van Staa et al., 2013). The QRISK2 score is commonly used as a summary measure in the UK because the original Framingham score now over-estimates CVD risk for a UK population (Hippisley-Cox et al., 2008).

Behavioural risk factors, including low physical activity, poor diet, overweight and obesity, excessive alcohol consumption and smoking, are also receiving attention, not only because of their association with CVD, but also because of the increasing incidence and prevalence of other conditions with lifestyle antecedents, including diabetes and dementia. Behavioural risk factors tend to be correlated within individuals, rather than occurring independently (Cairney et al., 2014; Lawder et al., 2010; Poortinga, 2007). This co-occurrence of behavioural risk factors may make it difficult to evaluate their independent effects and there is growing emphasis in public health interventions on risk factor combinations. A recent systematic review found that people who do not smoke, consume alcohol moderately, physically active and have a healthy diet have 66% lower all-cause mortality compared to those who have none or only one of these healthy behaviours (Loef and Walach, 2012). In the EPIC-Norfolk cohort, people who were current smokers, were physically inactive, consumed excess alcohol, and consumed less than five servings a day of fruit and vegetables, had a more than four-fold increase in their risk of all-cause and cardiovascular mortality compared to individuals who do engage in all of the four risky behaviours (Khaw et al., 2008). Analyses from a U.S. cohort showed that individuals who do not smoke, eat a healthy diet and are physically active have a risk for cardiovascular diseases mortality that is 65% lower than people who do not engage in these risk-lowering behaviours (Ford et al., 2012).

In England, the traditional cardiovascular risk assessment approach has informed the development of a population-wide cardiovascular risk assessment programme, known as 'NHS Health Checks'. The programme was first introduced in 2009 and fully rolled-out across

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England since 2011 (Department of Health, 2009). In the health check programme, patients registered in primary care, aged 40 to 74 years, free of CVD and are not already treated for elevated CVD-risk, are invited for a cardiovascular risk assessment and are offered lifestyle advice that is tailored to their estimated CVD risk level (Forster et al., 2015). This programme has proved to be controversial due to the lack of clear evidence for the clinical and cost-effectiveness of health checks (Krogsboll et al., 2012). There is also an important debate concerning the place of population-level, rather than individual patient-level, intervention in the prevention of chronic diseases (Capewell et al., 2015).

The present study aimed to situate the role of the Health Check programme in a wider epidemiological context by evaluating long term trends in both traditional cardiovascular risk factors and in multiple behavioural risk factors, in the population that is now eligible for health checks in England, over a 20-year period.

2. Methods

The research employed a repeated cross-sectional design using data from seven surveys of the Health Survey for England over a 20 year period. We evaluated three traditional CVD risk factors, blood pressure, serum cholesterol, and cigarette smoking in order to inform estimation of the QRISK2 cardiovascular risk score. We also evaluated six behavioural risk factors including low fruit and vegetable intake, cigarette smoking, physical inactivity, excessive alcohol consumption and elevated body mass index (BMI) or waist to hip ratio (WHR). Body mass index and waist-hip ratio are not behavioural risk factors but were viewed as being consequent on unhealthy behaviours.

2.1. Data source

The Health Survey for England (HSE) is a national survey carried out annually in England since 1994 to monitor population health in England with particular reference to cardiovascular disease (Colhoun, 1996; Mindell et al., 2012). The HSE employs a multi-stage cluster sampling design to provide a sample that is representative of the general population of England. The primary sampling units are post-code sectors, which are selected through stratified random sampling. A new sample is drawn in each year. Data collection for the HSE comprises an interview, a nurse-visit for anthropometric measures and a blood test. The response rate to interview has declined from 71% to 61% during the period, and there is further non-response at the measurement stage (Mindell et al., 2012). Key measures have been included in different years but the data collection procedures and data definitions have evolved over time (Mindell et al., 2012). For this study, data were analysed for the years 1994, 1998, 2003, 2006, 2008, 2011 and 2013 because these included a focus on cardiovascular disease and cardiovascular risk factors.

2.2. Participant selection

Participants were selected for analysis using the same criteria that are currently used for selection into the health check programme in England, which only includes those not already being managed for elevated cardiovascular risk (NHS, 2015a). Participants were included if they were aged 40 to 74 years but were excluded if they reported a previous diagnosis of CVD, hypertension or diabetes, as they would not be eligible for the health check. Participants taking anti-hypertensive drugs, statins or other lipid lowering drugs were also excluded.

2.3. Main measures

Traditional cardiovascular risk factors included blood pressure, serum cholesterol and cigarette smoking. Blood pressure measurements were taken using a Dinamap device in 1994 and 1998 and an Omron device in later years. Three measurements were taken and the mean of the second and third used for analysis. The Dinamap readings were translated into Omron readings using the equations reported by Falaschetti et al. (2014) to allow comparisons across years. Non-fasting blood samples were obtained from the participants to measure total serum cholesterol and HDL cholesterol. HDL cholesterol was measured in all years except 1994. Current cigarette smoking was evaluated using standard questions in all years.

Height was measured using a portable stadiometer. Weight was measured in light clothing using electronic scales. Body mass index was calculated and values >25 Kg/m^2 were coded as being at higher risk. Waist and hip measurements were taken using a tape measure, using the mean of two readings. The ratio of waist to hip circumference measurements was calculated. Values >1.0 for men, or >0.85 for women, were coded as being at higher risk (NHS, 2015b). Self-reported physical activity was evaluated by interview-administered questionnaire. Data for completion of 30 min of at least moderate activity on five days per week (150 min per week) was evaluated in all years except 2011 (DoH, 2011). Self-reported fruit and vegetable intake was evaluated by questionnaire and data for consuming five or more portions per day was available for analysis since 2003. Self-reported alcohol consumption was evaluated from questionnaire responses. The most consistently recorded measure, the number of units consumed on the day of heaviest consumption in the last week, was available in all years since 2003. Data were analysed for the proportion drinking more than four units on the day with highest consumption out of the last seven. In the UK, a unit of alcohol represents 8 g of pure alcohol.

2.4. Statistical analysis

Traditional cardiovascular risk factors were combined using the QRISK2 score. QRISK2 is a score that estimates 10-years CVD risk by looking into several variables that affects cardiovascular risk, including: age, sex, ethnicity, family history, smoking, blood pressure, total cholesterol/HDL cholesterol ratio, BMI and comorbidities (diabetes, atrial fibrillation, chronic kidney disease and rheumatoid arthritis) (Hippisley-Cox et al., 2008). QRISK2 is considered a preferred tool for CVD risk assessment in the United Kingdom (Collins and Altman, 2009; Jackson et al., 2009; NICE, 2014). A risk score of <10% is considered low risk, while 10–20% CVD risk is categorised as intermediate risk and 20% or more is classified as high-risk of CVD.

A co-occurrence analysis approach was employed to investigate the relationship of multiple risk factors and obesity indicators to CVD risk. This approach focuses on summing the number of behavioural risk factors, giving each a value of one, giving an ordinal score ranging from zero (no behavioural risks) to five (five or more behavioural risk factors present) (McAloney et al., 2013). The limitation of such an approach is that it assumes that different behavioural combinations are associated with the same risk level. It is the sum of the number of risks rather than a description of behavioural combinations (McAloney et al., 2013).

A complete case analysis was conducted, omitting cases with missing values for quantitative variables. As a sensitivity analysis, we compared estimates obtained using all data available for each variable. Linear trends were evaluated using the method of generalised estimating equations to allow for the effect of primary sampling unit. An identity link, with the binomial family option, was employed to estimate risk differences for proportions (Ukoumunne et al., 2008). Analyses were conducted for each sex separately, adjusting for the effect of age and ethnicity. Changes in alcohol consumption behaviour and smoking (in women) were not adjusted for ethnicity as convergence was not achieved. This could be due to certain ethnic groups have very low alcohol consumption and women from certain ethnicity rarely report smoking behaviour. Estimates are presented as changes per decade. Data were analysed using STATA statistical software version 13.1 (StataCorp, 2013).

Table 1
Participant selection by study year. Figures are frequencies except where indicated.

	1994	1998	2003	2006	2008	2011[a]	2013
Total number in survey	15,809	19,654	18,553	21,399	22,619	10,617	10,980
Aged 40 to 74 years	7786	8037	7954	7856	8400	4823	4949
Eligible: free from comorbidity and not treated for elevated CVD risk	5032	5078	4568	4543	5809	2629	2980
Included with data on all quantitative risk factors (percent of eligible)	3556 (71)	3120 (61)	2281 (50)	2224 (49)	2491 (43)	1028 (39)	1341 (45)

[a] The NHS Health Checks programme began its first full year in 2011.

3. Results

In the years selected for study, 119,631 individuals participated in the Health Survey for England, with 49,805 being aged 40 to 74 years (Table 1). Of these, 30,639 (62%) were free of cardiovascular disease and diabetes, were not treated with antihypertensive or lipid-lowering drugs and would have met the eligibility criteria of the health check programme. After excluding cases with missing values for BMI, waist-hip ratio, blood pressure and serum cholesterol, data were analysed for 16,041 (52%) of those eligible.

Table 2 shows changes in crude and estimated traditional cardiovascular risk factors and estimated CVD-risk scores in the health check eligible population from 1994 to 2013. The results of linear regression analysis, adjusting for age and ethnicity, showed reductions in blood pressure, total cholesterol and smoking during the study period. Systolic blood pressure declined by 3.0 (95% confidence interval 2.5 to 3.6) mm Hg per decade in men and by 5.0 (4.5 to 5.5) mm Hg per decade in women. Diastolic blood pressure declined by 1.5 (1.1 to 1.8) mm Hg per decade in men but there was no decrease in women. Total cholesterol declined by 0.20 (0.16 to 0.24) mmol/l per decade in men and by 0.22 (0.19 to 0.26) mmol/l per decade in women. HDL cholesterol values showed a slight increase over time in men and women. There was an important decline in tobacco use in this population, with current cigarette smoking declining by 6.4% per decade in men and 7.0% per decade in women. Consequent on these changes there were substantial reductions in estimated CVD-risk, with the proportion with ≥20% risk declining by 6.8% per decade in men and 2.4% per decade in women. The proportion with ≥10% risk declined by 5.3% per decade in men and by 3.2% per decade in women.

Multiple behavioural risk factors were evaluated from 2003 to 2013, years for which consistent data definitions were available. Fig. 1 shows changes over time in the proportion of men and women with multiple behavioural risk factors. Throughout the period, nearly 60% of men had either two or three behavioural risk factors. However, the proportion with either zero or one behavioural risk factors increased from 8.4% to 16.5%, while the proportion with four or more risk factors declined from 32.7% to 23.8%. A similar distribution was observed in women in whom the proportion with zero or one risk factor increased from 12.8% to 20.4%, while the proportion with four or more risk factors decreased from 29.2% to 23.9%, as shown in Fig. 1. Table 3 present changes in individual risk related behaviour, showing improvement in alcohol consumption, physical activity and dietary behaviour but elevation in BMI and WHR. Despite these improvements, >80% of the population had two or more behavioural risk factors in 2013. Table 4 shows the association between behavioural risk factors and ≥20% estimated CVD-risk. It is clear that in men and women there is a strong graded association between increasing number of behavioural risk factors and estimated CVD-risk.

4. Discussion

4.1. Summary of main findings

This study employed a repeated cross-sectional study drawing on the Health Survey for England to assemble a large population-based sample of individuals that under present criteria are eligible for health checks. The results revealed a substantial decline in the proportion of men and women at high risk of cardiovascular disease even before the start date of the health check programme. This appeared to be accounted for by reductions in traditional CVD risk factors that contribute to risk score calculation, including declines in smoking prevalence, blood pressure and total cholesterol levels among people eligible for the health checks. Our analysis demonstrated a strong association between multiple behavioural risk factors and CVD risk. The majority of our sample had two or more behavioural risk factors and trends of individual behavioural risk factors showed divergent trends over time. Some improvement was apparent in diet quality and physical activity but obesity indicators have been increasing across years.

Table 2
Changes in crude and estimated values of traditional CVD risk factors and in rates of estimated CVD risk score in men and women aged 40 to 74 years in England from 1994 to 2013.

Risk factor	Gender	1994[a]	1998[a]	2003[a]	2006[a]	2008[a]	2011[a]	2013[a]	Estimated change per decade (95% CI)[b]	P value
Number	Men	1691	1424	1053	983	1138	403	571		
	Women	1865	1696	1228	1241	1353	625	770		
Systolic BP (mean, mm Hg)	Men	134.1	132.9	131.6	130.1	130.3	127.5	128.6	−3.0 (−3.6 to −2.5)	<0.001
	Women	130.5	128.6	124.7	123.9	124.5	121.6	121.1	−5.0 (−5.5 to −4.5)	<0.001
Diastolic BP (mean, mm Hg)	Men	78.1	77.8	77.1	76.2	76.5	75.1	75.6	−1.5 (−1.8 to −1.1)	<0.001
	Women	73.4	72.9	74.1	73.6	74.2	73.2	72.9	0.1 (−0.2 to 0.4)	0.403
Total cholesterol (mean, mmol/L)	Men	6.18	5.75	6.00	5.82	5.82	5.70	5.67	−0.20 (−0.24 to −0.16)	<0.001
	Women	6.27	5.76	5.96	5.87	5.84	5.71	5.71	−0.22 (−0.26 to −0.19)	<0.001
HDL cholesterol (mean, mmol/L)	Men	–	1.31	1.41	1.38	1.39	1.40	1.39	0.05 (0.04 to 0.07)	<0.001
	Women	–	1.61	1.74	1.71	1.70	1.70	1.78	0.08 (0.07 to 0.10)	<0.001
Cigarette smoking (%)	Men	455 (27)	298 (21)	190 (18)	151 (15)	199 (17)	59 (15)	79 (14)	−6.4 (−7.8 to −5.0)	<0.001
	Women	476 (26)	397 (23)	217 (18)	211 (17)	197 (15)	79 (13)	108 (14)	−7.0 (−8.3 to −5.7)	<0.001
Estimated CVD risk ≥ 10%	Men	662 (39)	532 (37)	341 (32)	315 (32)	354 (31)	110 (27)	180 (32)	−5.3 (−6.4 to −4.1)	<0.001
	Women	325 (17)	231 (14)	146 (12)	152 (12)	156 (12)	75 (12)	87 (11)	−3.2 (−4.1 to −2.3)	<0.001
Estimated CVD risk ≥ 20%	Men	277 (16)	205 (14)	86 (8)	64 (7)	65 (6)	18 (4)	37 (6)	−6.8 (−7.7 to −5.8)	<0.001
	Women	90 (5)	56 (3)	16 (1)	15 (1)	16 (1)	6 (1)	4 (0.5)	−2.4 (−2.9 to −1.9)	<0.001

[a] Crude values of CVD risk factors and estimated CVD-risk n(%).
[b] Changes were estimated by linear regression adjusting for age and ethnicity.

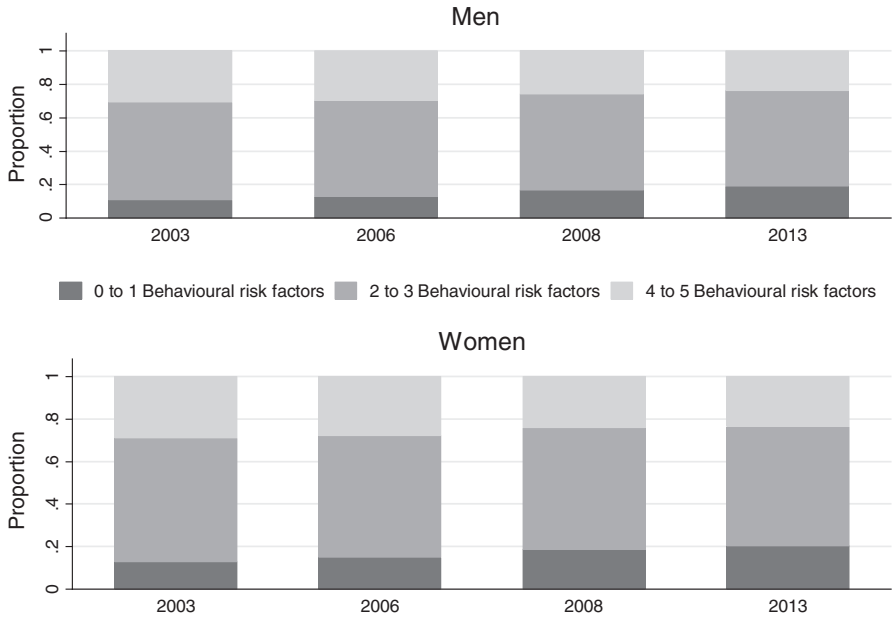

Fig. 1. Changes in proportion with multiple behavioural risk factors in men and women aged 40 to 74 years from 2003 to 2013 in England.

4.2. Comparison with existing literature

The analyses for this study provide new estimates CVD risk in people meeting eligibility criteria for health checks in England from 1994 up to 2013. The findings from the current study support the changes in CVD incidence and CVD risk factors. Favourable trends in risk factor prevalence are consistent with improving cardiovascular health outcomes. The South London Stroke Register showed a reduction of 39.5% in stroke incidence since 1995 (Wang et al., 2013). Representative data for England also demonstrate reductions in stroke and ischaemic heart disease in recent decades (Bajekal et al., 2012; He et al., 2014; Lee et al., 2011). The observed decline in cardiovascular risk is likely to be related to better control of CVD risk factors and population based interventions such as salt reductions (He and MacGregor, 2002; He et al., 2014) and smoking cessation policies (Critchley and Capewell, 2003). Changes in CVD risk factors have been reported for the general population in England with reported reductions in blood pressure, total cholesterol and smoking prevalence (Bajekal et al., 2012). Although our analyses have shown reductions in CVD risk and CVD risk factors, adiposity indicators are still increasing. Previous evidence confirms similar trends in England, where reductions in CVD risk factors were accompanied with adverse trends in body mass index levels (Bajekal et al., 2012). This

Table 3
Changes in crude and estimated rates of behavioural risk factors from 1994 to 2013 in men and women aged 40 to 74 years in England.

Risk factor	Gender	1994[a]	1998[a]	2003[a]	2006[a]	2008[a]	2011[a]	2013[a]	Estimated percent change per decade (95% CI)[b]	P value
Number	Men	1691	1424	1053	983	1138	403	571		
	Women	1865	1696	1228	1241	1353	625	770		
Elevated BMI (>25 Kg/m^2)	Men	1120 (66)	997 (70)	774 (74)	728 (74)	809 (71)	289 (72)	410 (72)	3.2 (1.5 to 4.8)	<0.001
	Women	979 (52)	993 (59)	701 (57)	681 (55)	804 (59)	364 (58)	440 (57)	2.1 (0.4 to 3.7)	0.013
WHR (>0.85 women; >1 men)	Men	136 (8)	131 (9)	139 (13)	143 (15)	180 (16)	56 (14)	90 (16)	4.6 (3.5 to 5.7)	<0.001
	Women	318 (17)	294 (17)	346 (28)	380 (31)	483 (36)	233 (37)	277 (36)	12.5 (11.1 to 13.8)	<0.001
Cigarette smoking	Men	455 (27)	298 (21)	190 (18)	151 (15)	199 (17)	59 (15)	79 (14)	−6.4 (−7.8 to −5.0)	<0.001
	Women	476 (26)	397 (23)	217 (18)	211 (17)	197 (15)	79 (13)	108 (14)	−7.0 (−8.3 to −5.7)	<0.001
Low physical activity (<150 mins/week)	Men	1040 (62)	883 (62)	675 (64)	594 (60)	636 (56)	–	303 (53)	−3.9 (−5.9 to −2.0)	<0.001
	Women	1432 (77)	1226 (72)	889 (72)	840 (68)	832 (61)	–	428 (56)	−10.1 (−11.7 to −8.4)	<0.001
Low fruit and vegetable intake (<5 portions/day)	Men	–	–	887 (84)	795 (81)	799 (70)	330 (82)	401 (70)	−12.6 (−16.3 to −8.8)	<0.001
	Women	–	–	972 (79)	941 (76)	884 (65)	507 (81)	527 (68)	−7.5 (−11.1 to −3.9)	<0.001
Alcohol excess (>4 units on highest day)	Men	–	–	504 (48)	510 (52)	524 (46)	174 (43)	234 (41)	−7.7 (−12.3 to −3.1)	0.001
	Women	–	–	381 (31)	399 (32)	380 (28)	154 (25)	204 (26)	−5.7 (−9.4 to −2.1)	0.002

[a] Crude rates of behavioural risk factors n(%).
[b] Changes have been estimated by linear regression adjusting for age and ethnicity.

Table 4
Multiple behavioural risk factors and ≥20% CVD risk in men and women aged 40 to 74 years from 2003 to 2013.[a]

Number of behavioural risk factors	Men			Women		
	n/N (%)	OR (95% CI)	P value	n/N (%)	OR (95% CI)	P value
0 or 1	14/437 (3)	Ref.		1/751 (0.1)	Ref.	
2	38/947 (4)	1.27 (0.66 to 2.42)	0.477	8/1225 (0.7)	4.78 (0.60 to 37.9)	0.138
3	91/1247 (7)	2.97 (1.61 to 5.48)	0.001	13/1397 (0.9)	6.32 (0.84 to 47.8)	0.074
4	72/847 (9)	5.26 (2.77 to 9.99)	<0.001	16/863 (1.8)	12.7 (1.68 to 96.5)	0.014
5	37/267 (14)	11.7 (5.53 to 24.7)	<0.001	13/356 (3.7)	57.4 (7.28 to 452.2)	<0.001

n: number of participants at high risk of cardiovascular diseases (QRISK ≥20%).
N: number of total participants.
[a] Results were adjusted for age and ethnicity.

trend has been observed globally, where decreases in SBP (Danaei et al., 2011) have been reported alongside increasing BMI (Finucane et al., 2011). It has been suggested that smoking cessation could result in substantial weight gain (Campbell et al., 2008; Clair et al., 2013) and an increase in HDL cholesterol (Campbell et al., 2008). Chronic mental stress might be another mediating factor. It has also been suggested that mental stress might decrease blood pressure levels in lean people but to increase blood pressure levels in obese individuals (Toyoshima et al., 2014). Our analyses report data separately for a population that meets the eligibility criteria for health checks, and show that substantial decreases in risk factor levels were in progress before the start of the health check programme.

Previous evidence across different population have suggested the clustering of risk behaviours, parallel to this study, but covers much wider age range. Studies have shown that more than half of their populations engage in two or more risk behaviours (Coups et al., 2004; Lawder et al., 2010). However, when studying the clustering of behaviours, different studies use different definitions and varying combinations of behavioural risk factors. Our analysis have shown strong associations between multiple behavioural risk factors and increased risk of cardiovascular diseases. Several studies have investigated behavioural risk factors in relation to CVD incidence. Findings have suggested that adhering to a combination of healthy behaviours (non-smoking, moderate alcohol intake, physical activity and fruit vegetable consumption) was associated with lower risk of CVD morbidity and mortality (Eriksen et al., 2015; Khaw et al., 2008). However, in our study we used two additional factors (BMI and WHR) and a more limited self-reported diet measure in relation to the objective measure used in previous studies.

4.3. Strengths and limitations

Our study included data from a large and nationally representative random sample. In addition, similar questions and protocols were used across the surveys which allows for direct comparisons to be made. The main limitations of the data used were the low proportion of participants who participated in the nurse visit at which risk factor measurements were made. Furthermore, the HSE did not include data on some components of the QRISK2 score (chronic kidney disease, atrial fibrillation or rheumatoid arthritis), however, these are not core components and the score allows them to be assumed absent if data is missing. Second, the included risk behaviours were based on self-reports, therefore, participants might have gave answers that are consistent with socially desirable behaviour. Third, CVD risk score was transformed into a categorical variable because CVD risk scores are not normally distributed (the majority of the sample are below 20% risk of CVD in the next 10 years). In order to translate CVD risk score in practice, patients are categorised into low, intermediate and high risk. Finally, the results present estimated risk rather than CVD incidence and we did not include some risk factors (e.g. chronic mental stress) when estimating CVD risk. As this study only included participants who are eligible for the NHS Health Checks, people with diabetes were excluded from the study. Exclusion of this obesity-related comorbidity might have affected estimated trends in CVD-risk. Public health initiatives are required to address the worsening trends of adiposity indicators. Further research is needed to understand the consequences of increasing adiposity indicators despite the decrease in CVD risk factors and improvements in behavioural risk factors. Health outcomes including diabetes, chronic kidney disease and mental stress are relevant and constitute an area for future research.

5. Conclusion

This study shows that important reductions in CVD risk and CVD risk factors were in progress in the population eligible for health checks before the introduction of the programme. However, behavioural risk factors represent an ongoing concern with an increase in overweight and obesity and a high proportion exposed to multiple behavioural risks, with few participants having one or fewer behavioural risks. This draws attention to the need for population-wide in addition to individual level interventions delivered to those at high-risk to promote healthy lifestyle and prevent cardiovascular disease.

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Transparency document

The Transparency document associated with this article can be found, in online version.

Appendix A. Supplementary data

Supplementary data to this article can be found online at http://dx.doi.org/10.1016/j.ypmed.2016.08.025.

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