

The effects of screening on health behaviour: a summary of the results of randomized controlled trials

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ABSTRACT

Background Screening aims to improve health by early detection of disease or risk factors for disease. It may also influence health behaviour, either by intention or as a side effect. The aim of this review was to summarize evidence of the effects of screening, either risk factor screening or screening for early detection of disease, on health behaviour: smoking habits, diet, exercise, alcohol consumption and adherence to guidelines for healthy living.

Methods This review included randomized controlled trials (RCTs) comparing the effects of screening on health behaviour in a screened group and an unscreened group. Systematic searches of Medline, CCTR and Embase between 1970 and May 2008 were conducted.

Results Seven trials were included, five on screening for risk factors (four cardiovascular; one ALDH2) and two on screening for early detection of disease (colorectal cancer and hearing loss). In trials of screening for risk factors, health behaviour was on average significantly more favourable in screened individuals. The number of trials on screening for early detection of disease was too small to allow for conclusions on effects on health behaviour.

Conclusion The number of trials studying the effect of population-based screening programmes on health behaviour is limited. The trials on screening for risk factors suggest a positive effect on health behaviour, while the number of trials on screening for early detection of disease was too low to draw conclusions on subsequent health behaviour. Future RCTs of screening interventions should systematically include health behaviour effects in their study design.

Keywords exercise, health behaviour, risk factors, screening, smoking

Background

Screening aims to improve health by detecting risk factors or early detection of disease. Risk factor screening is a strategy for primary prevention. Risk factor screening, such as serum cholesterol screening for the prevention of cardiovascular disease, is often accompanied by lifestyle advice and aims to encourage screenees to improve their health behaviour. Screening for early detection of disease, or secondary prevention, aims to detect disease early, in a preclinical phase, so that more effective treatments can be offered and hence prognosis is improved. In addition, it has been proposed that such forms of screening may influence health behaviour as well.^{1–3}

Not everyone is convinced that risk factor screening and screening for early detection of disease always affect health behaviour in a positive way. There is some evidence available indicating that risk factor screening and screening for early detection of disease could adversely influence health

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behaviour. A study performed in the 1990s concluded that screening strategies aimed at identifying persons with undiagnosed hypercholesterolemia may interfere with population strategies designed to reduce everyone's dietary intake of fat.⁴ This study found that adults with normal cholesterol concentrations were discouraged from changing their diet. It has also been proposed that screening programmes could negatively affect the extent to which individuals feel they have control over their own health. Individuals might get the impression that good health can be maintained by regular visits to physicians and health checks only, thereby minimizing the role of individual behaviour.^{5,6}

In general, reassurance of people with normal screening results may make them more resistant to general health recommendations and behaviour change because they may interpret the test result as confirming the good effects of their existing patterns of health behaviour: a phenomenon described as the 'certificate of health' effect.⁷ It has indeed been suggested that these health behavioural effects need to be studied in the evaluation of screening as well.^{5,8} Contrary to diagnostic testing, which is performed in patients with symptoms, screening involves testing healthy persons. Before introducing a screening programme to the general public, a thorough assessment of all favourable and unfavourable effects needs to be performed.⁹ A less healthy lifestyle after screening may be seen as a harmful effect of a screening programme, while an improvement in health behaviour as a benefit. Including the changes in health behaviour can thus potentially change the benefit–harm ratio of any screening strategy.

Explorations of the relations between screening and health behaviour have produced contradictory results.^{1,3,5,10,11} A systematic review of studies published up to 2000 previously summarized the effects on health behaviour of screening for cholesterol level, breast cancer and cervical cancer.⁸ All three screening programmes were found to be associated with high levels of favourable health behaviours and beliefs. However, the methodological quality of most studies included in the review was weak. Baseline measurements were rarely taken, and studies often failed to include a control group.⁸ It is therefore difficult to determine the impact of screening on health behaviour from this review.

The impact of screening on health behaviour must be assessed in proper randomized controlled trials (RCTs) in which health behaviour is compared between unscreened and screened individuals. The aim of this review was to summarize the evidence from such trials, investigating the effects of risk factor screening and early detection of disease screening on health behaviour.

Methods

Search strategy

This review included RCTs studying the effects of screening on health behaviour in a screened group and an unscreened group. Systematic searches of electronic databases were conducted, including National Library of Medicine (Medline; 1966 onwards), Cochrane Controlled Trial Register (CCTR) and Embase (1980 onwards). The searches were conducted in May 2008.

The following search strategies were used: (health AND behaviour) OR lifestyle OR diet OR exercise OR smoking OR life style mesh OR risk reduction behaviour mesh OR health behaviour mesh AND mass screening mesh AND (Clinical trialpt OR randomizedtiab OR placebotiab OR clinical trialsmh OR randomlytiab OR trialti) NOT (animalsmh NOT (animalsmh AND humansmh)) (Medline) (diet or smoking or exercise or (health and behaviour) or lifestyle).mp AND mass screening/AND (Clinical tria\$ or randomized or randomized or placebo or control or randomly or trial).mp (Embase) and (health AND behaviour) OR lifestyle OR diet OR exercise OR smoking OR life style OR risk reduction behaviour) AND mass screening mesh in Clinical Trials (CCTR). No language restrictions were used. The reference sections of the obtained articles were also studied and requests for unpublished studies were circulated among colleagues. A methodological filter to identify RCTs was used.¹²

Possibly eligible papers were downloaded into Reference Manager.

Inclusion criteria were: randomized study on screening in healthy adults (aged 18 and above), measurement of health behaviour. Health behaviour was defined as any data on smoking habits, diet, exercise, alcohol consumption or adherence to guidelines of healthy living.

Studies were not included when they investigated health intentions only, when they focused solely on improving the uptake of screening, or reattendance at screening when next invited, or when they investigated the effect on families (significant others) and social environment.

When RCTs were found compared screened and unscreened individuals on clinical variables but did not mention any health behaviour variables, the corresponding author was contacted and asked whether he and his colleagues had collected such data. If so, these unpublished data were also included in the review.

Study selection

One reviewer (M.D.) assessed the title and abstract of references identified by the search strategy. The full reports of all

potentially eligible trial were then obtained for further assessment of eligibility by two authors (M.D. and F.V.). Any disagreements were resolved by discussion.

Data extraction

Data regarding inclusion criteria, study characteristics and results (study design, participants, interventions and outcomes) were extracted.

Data analysis

Due to the small number of included studies and marked heterogeneity in the type of screening, study population, length of follow-up and outcome assessment measures, we made no attempts at statistically pooling the data in a meta-analysis. Instead a qualitative synthesis of the results is presented. All dichotomous variables were analyzed, if possible, with Chi-square statistics to compare differences between the screened and unscreened groups. For all statistical tests P -values <0.05 were considered to represent statistical significance.

Results

Retrieval of papers

In total 1953 manuscripts were retrieved, of which 621 were duplicates. The remaining 1332 manuscripts were assessed for eligibility by reading title and abstract. This resulted in 107 potentially eligible trials. Based on the complete manuscripts 100 of these studies could not be included. In total, seven trials^{13–19} met our inclusion criteria (see Fig. 1).

General characteristics of the studies

Table 1 summarizes the characteristics of the seven included trials. Five studies dealt with risk factor screening, of which four dealt with cardiovascular disease,^{16–19} and one with genetic screening for aldehyde dehydrogenase 2, an enzyme that plays a role in the metabolism of acetaldehyde; patients with low enzyme activity who are heavy drinkers have a markedly increased risk for developing oesophageal cancer.¹⁴ Only two studies dealt with screening for early detection of disease; one concerned screening for hearing impairment¹⁵ and one colorectal cancer screening.¹³

Two studies were performed in the UK,^{17,18} two in Canada,^{16,19} one in Norway,¹³ one in Denmark¹⁵ and one in Japan.¹⁴ Six studies included men and women and one study included men only.¹⁴ The smallest study¹⁴ invited 329 patients and the largest over 18 000.¹⁸ In four studies patients from general practitioners^{15,17–19} were invited, in two studies participants were recruited in the working

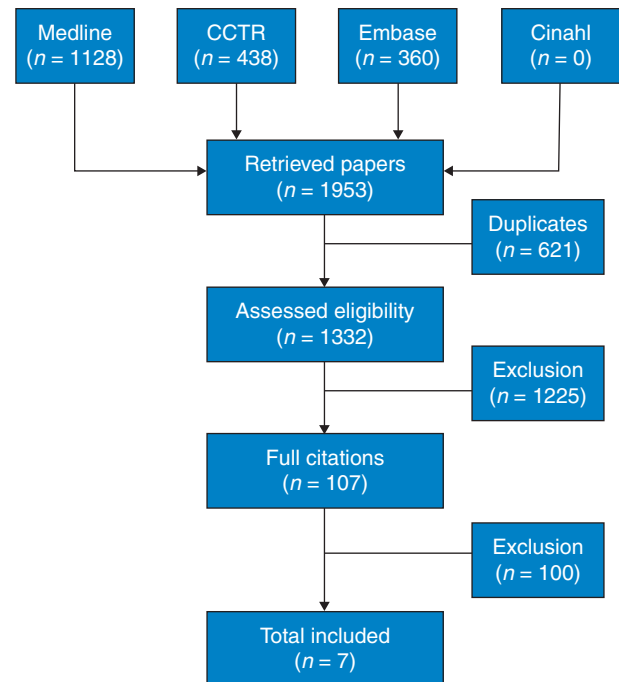


Fig. 1 Search strategy.

place,^{14,16} in one study¹⁴ individuals were randomly drawn from the population registry. The follow-up length varied from 3 months¹⁹ to 5 years.¹⁵

Different forms of health behaviour were studied: smoking in three studies,^{13,17,18} diet in three studies,^{13,16,18} exercise in two studies,^{13,18} alcohol consumption in two studies,^{14,18} and adherence to given advice (testing for cholesterol and avoidance of noise) in two studies.^{15,19}

Risk factor screening

Two studies investigated the effects of screening for cardiovascular screening on smoking.^{17,18} Screened individuals in the British Family Heart Study¹⁷ showed a significantly lower smoking prevalence than unscreened individuals (19 versus 23%, $P < 0.001$) after 1 year. No difference between screened and unscreened participants was found in the OXCHECK study.¹⁸ The smoking prevalence after 3 years was 25% in the screened group compared with 26% in the unscreened group ($P = 0.44$).¹⁹

The effect on diet was measured in two studies.^{16,18} The OXCHECK group¹⁸ studied the use of full cream milk and the use of butter or margarine. Both were significantly lower in the screened group (respectively 23% and 22%) after 3 years compared with the unscreened group (31 and 31%, respectively; $P < 0.01$). In the study of Strychar *et al.*,¹⁶ after 4 months no differences were detected in nutrient intake (e.g. total energy, % energy of (saturated) fat and dietary

Table 1 Descriptives of included studies

Study	Participants	Interventions	Outcomes	Notes
Risk factor screening				
Wood <i>et al.</i> ¹⁷	7460 men and 5012 women, aged 40–59 from 26 general practices in 13 towns in the UK identified by household	I: received cardiovascular screening and were offered risk-related lifestyle intervention and follow-up. They were re-screened after 1 year (men: $n = 1767$; women: $n = 1217$). C: received first screening after 1 year (at the same time I-group was re-screened) (men: $n = 2174$; women: $n = 1402$)	Smoking prevalence. I: 19%; C: 23%, $P < 0.001$	Two control groups used but internal control used in this review. Post results after 1 year.
Hutchison <i>et al.</i> ¹⁹	Patients from a capitation funded primary care practice in Canada ($n = 7785$) who did not have had a cholesterol test in the preceding 5 years	I: the health questionnaire and a questionnaire appraising risk of coronary heart disease that encouraged those meeting criteria for cholesterol measurement to have a cholesterol test ($n = 1549$) Positive test result: 27% C: received a health questionnaire that determined whether they were at risk of coronary heart disease without identifying the risk factors as related to coronary heart disease ($n = 1603$)	Meeting the Toronto Working Group for cholesterol testing requirements Of those needing a cholesterol test: I: 11%; C: 1.8% (had a test) ($P < 0.0001$).	Post-results after 3 months of follow-up
OXCHECK-group ¹⁸	Patients, aged 36–64 from five GP practices in the UK ($n = 11090$)	I: received a health check ($n = 2136$), 73% of those screened needed specific advice or follow-up for one or more risk factors C: received the check later ($n = 3988$)	Smoking prevalence at follow-up. I: 25%, C: 26% ($P = 0.44$). Exercise: I, 29%; C: 22% ($P = 0.01$). Diet: –Use of full cream milk; I: 23%, C: 31% ($P < 0.01$). –Use of butter or margarine. I: 22%, C: 31% ($P < 0.01$).	
Strychar <i>et al.</i> ¹⁶	Maintenance workers in six hospitals in Canada ($n = 789$).	I: received blood cholesterol test results at pretest ($n = 216$), 51% had an elevated cholesterol level (>5.2 mmol) C: received test results at post-test ($n = 213$)	Diet (mean change baseline-follow-up): total energy (kcal): I: -147 (95% CI: -302 to 9) C: -166 (95% CI: -332 to -1) % Energy of total fat: I: -1.8 (95% CI: -3.4 to -0.2) C: -0.8 (95% CI: -2.3 to 0.6) Dietary cholesterol (g/1000 kcal): I: -8.9 (95% CI: -27.3 to 9.6) C: 2.1 (95% CI: -11.4 to 15.5)	Post-results after 16–20 weeks

Komiya <i>et al.</i> ¹⁴	Male employees of a manufacturing factory in Japan ($n = 329$)	I: received disclosure of ALDH2 genotype ($n = 85$)	Alcohol consumption per week (g)	
		36% high-risk genotype	Low risk:	
			I: 269 baseline to 291 follow-up	
			C: 288 baseline to 307 follow-up	
		C: did not receive disclosure ($n = 130$)	High risk:	
			I: 211 baseline to 190 follow-up	
			C: 218 baseline to 252 follow-up	
			<i>(P</i> -values not calculable; study authors reported it not significant).	
Early detection of disease screening				
Karlslose <i>et al.</i> ¹⁵	Patients, aged 30–49, from GPs in Denmark ($n = 2000$).	I: were invited to a general hearing check, including manual pure-tone airconduction audiometry (with an annual 45-min consultation with their GP) ($n = 1005$). Positive test result: 19%	Exposure to leisure noise at follow-up. I: 42; C: 48.7 (95% CI of difference: –13.2 to –0.1)	Post-results after 5 years of follow-up
		C: no screening ($n = 465$)	Exposure to occupational noise. I: 46.4; C: 50.5 (95% CI of difference: –10.6 to –2.6)	
			Use of hearing protection. I: 46.4; C: 50.5 (95% CI of difference: –10.6 to –2.6)	
Larsen <i>et al.</i> ¹³	Men and women aged 50–55 living in two regions in Norway ($n = 13961$).	I: invited to once only flexible sigmoidoscopy or combination of FS and FOBT ($n = 3598$).	Smoking (measured 1–6)	Post-results after 3 years of follow-up
		Positive test result: 14%	I: 2.56 (baseline) to 2.45 (follow-up) C: 2.49 (baseline) to 2.34 (follow-up) <i>(P</i> = 0.013)	
		C: no intervention ($n = 3462$)	Exercise:	
			I: 6.09 (baseline) to 6.10 (follow-up)	
			C: 5.89 (baseline) to 6.10 (follow-up)	
			<i>(P</i> < 0.001)	
			Diet: servings of fruit, berries and vegetables:	
			I: 2.28 (baseline) to 2.15 (follow-up)	
			C: 2.15 (baseline) to 2.19 (follow-up)	
			<i>(P</i> = 0.001)	

cholesterol) between the participants that received their blood cholesterol test results compared with those not receiving their results. However, in individuals with normal blood cholesterol levels (<5.2 mmol/l), those who did not receive their blood test results had greater decreases in saturated fat intake defined as % of total energy intake (-1.6%, 95% CI: -2.7 to -0.5; baseline: 13%) than did those who received their blood test results (-0.3%, 95% CI: -1.3 to 0.7, baseline: 12%).

Changes in physical exercise after screening were investigated in one study.¹⁸ The proportion of patients reporting vigorous exercise more than once a month was, after 3 years, significantly higher in the group screened for cardiovascular diseases (29%) than in unscreened individuals (22%) ($P = 0.01$).

Two studies investigated the effect of screening on alcohol consumption.^{14,18} In the cardiovascular screening study, no significant difference between the screened and unscreened group was observed.¹⁸ High alcohol use defined as 'reported weekly intake of >21 units for men and >14 for women' was 11% in the control group and 10.4% in the screened group ($P = 0.55$). No difference in weekly alcohol intake (measured in grams) was observed between individuals screened for ALDH2 and individuals not screened.¹⁴ At follow-up, alcohol intake in the screened group at low risk increased by 22 g (baseline: 269 g) and in the control group by 19 g (baseline: 288 g; P -value not calculable; study authors reported it not significant). High-risk individuals in the screened group decreased their intake by 21 g (baseline: 211 g) whereas the control group increased their intake by 34 g (baseline: 218 g). However, overall there was no significant difference in change between the screened and unscreened group (P -value not calculable; not significant according to the study authors).

The study of Hutchison *et al.*¹⁹ investigated to what extent follow-up recommendations were followed. In this study the effect of screening for hypercholesterolemia by means of a risk appraisal questionnaire on meeting the criteria for cholesterol testing (Toronto working group's criteria²⁰) was investigated. Of those without pre-existing coronary heart disease who met the criteria for cholesterol testing, 45 of 421 subjects in the screened group (11%) versus 9 of 504 subjects in the unscreened group (1.8%) had a cholesterol test performed during the 3 months after the initial questionnaire posting ($P < 0.0001$). Of the patients without a history of coronary heart disease who did not meet the criteria for testing, 30 of 1128 subjects in the screened group (2.7%) and 18 of 1099 subjects in the unscreened group (1.6%) had a cholesterol test during the 3 month follow-up period ($P = 0.175$).

Effects of early detection of disease screening

Only two studies dealt with screening for early detection of disease.^{13,15} The study of Larsen *et al.*¹³ investigated the effects of screening for colorectal cancer on smoking, diet and exercise. The study of Karlsmose *et al.*¹⁵ investigated the effects of screening for hearing loss on exposure to noise.

In the trial of colorectal cancer smoking,¹³ and diet were measured on a scale from 1 (never) to 6. For smoking '6' indicated '>20 cigarettes per day' and for diet 'consumption >3 times per day'. Exercise was measured on a scale from 2 to 12.

Unscreened individuals showed a decline in smoking of 0.14 points (baseline score: 2.49) versus 0.11 in the screened group (baseline score: 2.56) ($P = 0.013$; P -value from original article and derived from linear regression analyses).

Diet was measured with various variables: servings of fruit, berries and vegetables, consumption of boiled potatoes, poultry, meat, fatty fish and chocolate. The screened group lowered their consumption of fruit, berries and vegetables with 0.13 points (baseline score: 2.28), whereas the unscreened group increased their intake with 0.04 points (baseline score: 2.15; difference between screened and unscreened group: 0.17; $P = 0.001$; derived from linear regression analyses). No difference in intake was detected between the screen negatives and the screen positives ($P = .346$).

The improvement in the amount of exercise in the screened group was significantly lower ($P < 0.001$) than in the unscreened group (+0.01 (baseline: 6.09) versus +0.21 (baseline: 5.89)).

The study of screening for hearing loss found that after screening¹⁵ there was a significant change in exposure to leisure noise between screened and unscreened individuals (42 and 49%, respectively; $P = 0.045$) after 5 years. However, no differences were detected for exposure to occupational noise (screened: 46%; unscreened: 50%; 95% CI of difference: -10.6 to 2.6) and to the use of hearing protection (screened: 42%; unscreened: 47%; 95% CI of difference: -4.0 to 14.7).

Summary of the results

In table 2 a summary of the results is shown. For all five health behaviour variables (smoking, diet, exercise, alcohol consumption and adherence) we list whether the outcome was better, equal or worse in the screened group compared with the unscreened group.

Discussion

The number of trials studying the effect of screening on health behaviour appears to be very limited. The trials on screening for risk factors provide indications to suggest a

Table 2 Summary of results per outcome variable

	<i>Risk factor screening</i>					<i>Early detection of disease screening</i>	
	<i>Wood et al.¹⁷</i>	<i>Hutchison et al.¹⁹</i>	<i>OXCHECK¹⁸</i>	<i>Strychar et al.¹⁶</i>	<i>Komiya et al.¹⁴</i>	<i>Karlsmose et al.¹⁵</i>	<i>Larsen et al.¹³</i>
Smoking	+		=				-
Diet			+	=,*			-
Exercise			+				-
Alcohol consumption			=		=		
Adherence		+=				=	

+, health behaviour better in screened compared to unscreened group; -, health behaviour worse in screened compared to unscreened group; =, no difference in health behaviour between screened and unscreened group; *, worse health behaviour in screen negatives compared to screen positives.

positive effect on health behaviour, while the number of trials on screening for early detection of disease was too small to allow for conclusions on effects on health behaviour.

The present review has several limitations. As in every systematic review we had to rely on published studies. When studies are not published it is extremely difficult to find them. It is known that studies with negative results are less likely to be published,²¹ both due to researcher's reluctance to submit the manuscript or the journal's unwillingness to publish them. This publication bias may have resulted in an underestimation of the negative effects of screening on health behaviour.

The Mesh term 'Mass Screening' was used instead of the text word 'screening'. We decided to do so as 'screening' is a widely used term and we were only interested in large population-based screening programmes. This choice may have resulted in missing studies, which were not adequately provided with the appropriate Mesh term. For 1998 we checked in Medline whether using 'screening' as text word provided extra included trials compared with the Mesh term 'Mass Screening'. No additional trials were found.

The search strategy resulted in 1332 titles from which only seven studies could be included. Most studies were excluded because they were not set up as an RCT or the study did not report on health behaviour. The decision to include only RCTs may have led to the exclusion of a number of cohort studies. This is certainly the case for well-established screening programmes, such as cervical cancer screening or breast cancer screening, where it is considered unfeasible and unethical to randomize participants into a screening group and a non-screening group. Unfortunately, the number of screening trials that included health behaviour as an outcome measure appeared to be very limited. As

health behaviour is not the primary outcome measure in most screening programmes, it is possible that health behaviour was studied but not reported in some trials. We contacted all eleven corresponding authors²²⁻³² of reports on screening RCTs in which a screened group and an unscreened group had been compared. None of the eight responding authors reported to have collected these data.

The present review is the first to summarize all existing evidence on the relation between screening and health behaviour. The results of our review are of importance for public health. In an era where unhealthy behaviour accounts for a substantial part of the total burden of disease and the availability of screening programmes has continued to increase, the effect of screening on health behaviour is essential. Results of our review indicate that screening influences health behaviour in a positive direction for risk factor screening, while the number of trials on screening for early detection of disease was too small to allow for conclusions on effects on health behaviour.

In most risk factor screening programmes, especially screening for cardiovascular diseases, participants are recommended to make beneficial health behaviour changes. It is encouraging to see that in this review in three of four cardiovascular screening trials small improvements in health behaviour were observed. More information is necessary concerning the stability of these changes and the effects in groups difficult to reach (for instance migrants and subjects with a low socio-economic status). Participants in the OXCHECK study were on the average relatively healthy and from higher social class.³³ These participants may be more inclined and more able to change their health behaviour. This finding is consistent with other studies, which showed that attendance of a health check at the general practitioner

was lowest among those from the lower social class.^{33–35} This trend can also be observed in other preventive initiatives, as the uptake of cancer screening is lowest in those who are most socially deprived.^{36–39} The study on risk factor screening in which no improvement in health behaviour was observed was conducted in maintenance workers, i.e. a population with a low socio-economic status.

It is striking that in the extensive field of screening studies only seven RCT studies could be found on the relationship between screening and health behaviour. This paucity of included trials calls for including health behaviour effects in all future RCTs on the effectiveness of screening interventions. The indications that screening for early detection of diseases may have unintended negative side effects on health behaviour warrants further exploration. Beneficial effects of screening are often small and accrue over a long time. Therefore, any small harm in health behaviour change across a large number of people may outweigh the benefit gained by screening. Alternatively, small positive behaviour changes among screening participants may enhance the beneficial health effects of screening programmes. From our analysis, it seems that different types of screening (risk factor and early disease screening) may impact on individual's health behaviour patterns differently. More research to explicate this relationship is needed.

Authors' contributions

M.D. carried out the literature search, the data selection and extraction, did the analyses and drafted the manuscript. F.V. assisted with the data selection and extraction and assisted in drafting the manuscript. K.M. participated in the design of the study and was involved in drafting the manuscript. M.L.E. and K.S. helped to draft the manuscript and assisted in interpreting the data. P.B. was involved in designing the study, interpreting the data and drafting the manuscript. All authors read and approved the final manuscript.

References

- 1 Barlow J. Psychological consequences of hypercholesterolaemia. *Br J Gen Pract* 1993;**43**:435–6.
- 2 Jones A, Davies DH, Dove JR *et al.* Identification and treatment of risk factors for coronary heart disease in general practice: a possible screening model. *BMJ (Clin Res Ed)*. 1988;**296**:1711–4.
- 3 Miles A, Wardle J, McCaffery K *et al.* The effects of colorectal cancer screening on health attitudes and practices. *Cancer Epidemiol Biomarkers* 2003;**12**:651–5.
- 4 Kinlay S, Heller RE. Effectiveness and hazards of case finding for a high cholesterol concentration. *BMJ* 1990;**300**:1545–7.
- 5 Marteau TM, Kinmonth AL, Thompson S *et al.* The psychological impact of cardiovascular screening and intervention in primary care: a problem of false reassurance? British Family Heart Study Group. *Br J Gen Pract* 1996;**46**:577–82.
- 6 Stewart-Brown S, Farmer A. Screening could seriously damage your health. *BMJ* 1997;**314**:533–4.
- 7 Tijmstra T, Bieleman B. The psychosocial impact of mass screening for cardiovascular risk factors. *Fam Pract* 1987;**4**:287–90.
- 8 Bankhead CR, Brett J, Bukach C *et al.* The impact of screening on future health-promoting behaviours and health beliefs: a systematic review. *Health Technol Assess* 2003;**7**:1–92.
- 9 Irwig L, McCaffery K, Salkeld G *et al.* Informed choice for screening: implications for evaluation. *BMJ* 2006;**332**:1148–50.
- 10 Hoff G, Thiis-Evensen E, Grotmol T *et al.* Do undesirable effects of screening affect all-cause mortality in flexible sigmoidoscopy programmes? Experience from the Telemark Polyp Study 1983–1996. *Eur J Cancer Prev* 2001;**10**:131–7.
- 11 Marteau TM, Lerman C. Genetic risk and behavioural change. *BMJ* 2001;**322**:1056–9.
- 12 Glanville JM, Lefebvre C, Miles JN *et al.* How to identify randomized controlled trials in MEDLINE: ten years on. *J Med Libr Assoc* 2006;**94**:130–6.
- 13 Larsen IK, Grotmol T, Almendingen K *et al.* Impact of colorectal cancer screening on future lifestyle choices: a three-year randomized controlled trial. *Clin Gastroenterol Hepatol* 2007;**5**:477–83.
- 14 Komiya Y, Nakao H, Kuroda Y *et al.* Application of aldehyde dehydrogenase 2 (ALDH2) genetic diagnosis in support of decreasing alcohol intake. *J Occup Health* 2006;**48**:161–5.
- 15 Karlsmose B, Lauritzen T, Engberg M *et al.* A randomised controlled trial of screening for adult hearing loss during preventive health checks. *Br J Gen Pract* 2001;**51**:351–5.
- 16 Strychar IM, Champagne F, Ghadirian P *et al.* Impact of receiving blood cholesterol test results on dietary change. *Am J Prev Med* 1998;**14**:103–10.
- 17 Wood DA, Kinmonth AL, Davies GA *et al.* Randomised controlled trial evaluating cardiovascular screening and intervention in general practice: principal results of British family heart study. *BMJ* 1994;**308**:313–20.
- 18 OXCHECK Study Group. Effectiveness of health checks conducted by nurses in primary care: final results of the OXCHECK study. Imperial Cancer Research Fund OXCHECK Study Group. *BMJ* 1995;**310**:1099–104.
- 19 Hutchison B, Birch S, Evans CE *et al.* Screening for hypercholesterolaemia in primary care: randomised controlled trial of postal questionnaire appraising risk of coronary heart disease. *BMJ* 1998;**316**:1208–13.
- 20 Toronto Working Group on Cholesterol Policy. *Detection and Management of Asymptomatic Hypercholesterolaemia: A Policy Document*. Toronto, Ontario: Ministry of Health, 1989.
- 21 Thornton A, Lee P. Publication bias in meta-analysis: its causes and consequences. *J Clin Epidemiol* 2000;**53**:207–16.
- 22 Aitken JF, Youl PH, Janda M *et al.* Increase in skin cancer screening during a community-based randomized intervention trial. *Int J Cancer* 2006;**118**:1010–6.

- 23 Sankaranarayanan R, Ramadas K, Thomas G *et al.* Effect of screening on oral cancer mortality in Kerala, India: a cluster-randomised controlled trial. *Lancet* 2005;**365**:1927–33.
- 24 Andriole GL, Levin DL, Crawford ED *et al.* Prostate Cancer Screening in the Prostate, Lung, Colorectal and Ovarian (PLCO) Cancer Screening Trial: findings from the initial screening round of a randomized trial. *J Natl Cancer Inst* 2005;**97**:433–8.
- 25 Zick CD, Mathews CJ, Roberts JS *et al.* Genetic testing for Alzheimer's disease and its impact on insurance purchasing behavior. *Health Aff* 2005;**24**:483–90.
- 26 Chrissidis T, Saliangas K, Economou A *et al.* Mass screening for colorectal cancer: compliance in Almopca Region. *Tech Coloproctol* 2004;**8**(Suppl 1):s193–s195.
- 27 Taylor KL, Shelby R, Gelmann E *et al.* Quality of life and trial adherence among participants in the prostate, lung, colorectal, and ovarian cancer screening trial. *J Natl Cancer Inst* 2004;**96**:1083–94.
- 28 Faivre J, Dancourt V, Lejeune C *et al.* Reduction in colorectal cancer mortality by fecal occult blood screening in a French controlled study. *Gastroenterol* 2004;**126**:1674–80.
- 29 Vardulaki KA, Walker NM, Couto E *et al.* Late results concerning feasibility and compliance from a randomized trial of ultrasonographic screening for abdominal aortic aneurysm. *Br J Surg* 2002;**89**:861–4.
- 30 Niv Y, Lev-El M, Fraser G *et al.* Protective effect of faecal occult blood test screening for colorectal cancer: worse prognosis for screening refusers. *Gut* 2002;**50**:33–7.
- 31 Jorgensen OD, Kronborg O, Fenger C. A randomised study of screening for colorectal cancer using faecal occult blood testing: results after 13 years and seven biennial screening rounds. *Gut* 2002;**50**:29–32.
- 32 Engberg M, Christensen B, Karlsmose B *et al.* Can systematic general health screening and patient-physician health discussions improve the cardiovascular profile of the population? A randomized controlled trial in general practice with a 5-year follow-up. *Ugeskr Laeger* 2002;**164**:3354–60.
- 33 Thorogood M, Coulter A, Jones L *et al.* Factors affecting response to an invitation to attend for a health check. *J Epidemiol Community Health* 1993;**47**:224–8.
- 34 Griffiths C, Cooke S, Toon P. Registration health checks: inverse care in the inner city? *Br J Gen Pract* 1994;**44**:201–4.
- 35 Waller D, Agass M, Mant D *et al.* Health checks in general practice: another example of inverse care? *BMJ* 1990;**300**:1115–8.
- 36 Kim LG, Thompson SG, Marteau TM *et al.* Screening for abdominal aortic aneurysms: the effects of age and social deprivation on screening uptake, prevalence and attendance at follow-up in the MASS trial. *J Med Screen* 2004;**11**:50–3.
- 37 Maheswaran R, Pearson T, Jordan H *et al.* Socioeconomic deprivation, travel distance, location of service, and uptake of breast cancer screening in North Derbyshire, UK. *J Epidemiol Community Health* 2006;**60**:208–12.
- 38 McCaffery K, Wardle J, Nadel M *et al.* Socioeconomic variation in participation in colorectal cancer screening. *J Med Screen* 2002;**9**:104–8.
- 39 Sutton S, Wardle J, Taylor T *et al.* Predictors of attendance in the United Kingdom flexible sigmoidoscopy screening trial. *J Med Screen* 2000;**7**:99–104.