PREVENTION OF CARDIOVASCULAR DISEASE AT POPULATION LEVEL

Modelling strategies for primary prevention of cardiovascular disease

Report
(8 July 2009)

Pelham Barton, Lazaros Andronis

West Midlands Health Technology Assessment Collaboration
Public Health, Epidemiology and Biostatistics
University of Birmingham
Edgbaston
Birmingham, B15 2TT
UK
Tel. + 44 (0) 121 414 6852
Fax + 44 (0) 121 414 7878
http://www.wmhtac.bham.ac.uk

ID No:

West Midlands Health Technology Assessment Collaboration

The West Midlands Health Technology Assessment Collaboration (WMHTAC) is an organisation involving several universities and academic groups who collaboratively undertake research synthesis to produce health technology assessments. Most of our members are based in the Department of Public Health, Epidemiology & Biostatistics, University of Birmingham, however other members are drawn from a wide field of expertise including economists and mathematical modellers from the Health Economics Facility, University of Birmingham.

WMHTAC produce systematic reviews, health technology assessments and economic evaluations for NHS R&D HTA programme (NCCHTA), the National Institute for Health and Clinical Excellence (NICE), and for the health service in the West Midlands. WMHTAC also undertakes methodological research on research synthesis, and provides training in systematic reviews and health technology assessment.

Name of other institution(s) involved

WMHTAC work in close collaboration with the Peninsula Technology Appraisal Group (PenTAG) with respect to providing support to the CPHE.

Contents

Executive Summary

The National Institute for Health and Clinical Excellence ('NICE' or 'the Institute') has been asked by the Department of Health (DH) to develop guidance on a public health programme aimed at preventing cardiovascular disease (CVD) in different populations.

This report is the economic modelling report to be delivered to the Programme Development Group (PDG). It complements three effectiveness reports and an economic review addressing question 1 defined in the final scope as:
Which multiple risk-factor interventions are effective and cost effective in the primary prevention of CVD within a given population? Where the data allows, how does the effectiveness and cost effectiveness of interventions vary between different population groups?

At the request of the programme development group (PDG), the scope of the modelling was extended beyond multiple risk-factor programmes for which there is direct evidence of effectiveness to consider also single risk factor programmes for which there is direct or indirect evidence of effectiveness. An example of this is modelling of a legislative programme to reduce the use of trans fatty acids (TFAs) in food. Here the effectiveness can be estimated based on the known relative risks incurred by the consumption of TFAs.

A spreadsheet model has been developed which will allow a relative risk to be applied to each year's risk of primary CVD within the population. An alternative form allows percentage reductions in cholesterol and systolic blood pressure to be applied separately for males and females. In their current forms, the models have been built on the assumption that these effects apply uniformly across age and risk groups and, in the case of the "Relative Risk" model, across the ten years and equally for males and females. It would not be difficult to amend the model to allow variation in the effect by any of these factors if such amendment were felt appropriate.

The model has been applied to estimate the effects in terms of outcomes such as quality adjusted life years (QALYs) gained and savings in health care costs for a

given effectiveness. This gives an estimate of how much it would be worth spending to achieve such an outcome.

The results strongly suggest that any legislative intervention that is likely to achieve an appreciable reduction in risk of CVD can be expected to produce a net cost saving to the public sector as well as improving health. Only if a very large sum of money needs to be spent in implementing the legislation would this cease to be the case.

No attempt has been made to include the effects of smoking cessation in the analysis of multi-factor interventions using the "Risk Factor Modifying" model. To do so with any attempt at realism would require the proportion of smokers in each of the risk groups used for the modelling.

Similarly, the analysis is restricted to effects on primary CVD prevention. An intervention which is recommended on the basis of this analysis and is known to have only beneficial effects on other aspects of health can be recommended more strongly as a result.

1. Introduction

The National Institute for Health and Clinical Excellence ('NICE' or 'the Institute') has been asked by the Department of Health (DH) to develop guidance on a public health programme aimed at preventing cardiovascular disease (CVD) in different populations.

This report is the economic modelling report to be delivered to the Programme Development Group (PDG). It complements three effectiveness reports and an economic review addressing question 1 defined in the final scope as:
Which multiple risk-factor interventions are effective and cost effective in the primary prevention of CVD within a given population? Where the data allows, how does the effectiveness and cost effectiveness of interventions vary between different population groups?

The PDG subsequently responded to stakeholder feedback and explicitly also considered single risk factor interventions. Accordingly, this report also considers such interventions.

1.1 Background

Evaluating complex changes between populations is problematic for a number of reasons, for example: it is difficult to design studies which evaluate entire cities, regions or countries; control sites can become 'contaminated' (that is, if the intervention affects people living in the control area); unreasonable expectations about the speed of effect; and failure to address 'upstream' influences such as policy or manufacturing practices. Some population programmes have been accompanied by a substantial reduction in the rate of CVD deaths. However, the degree to which these are attributable to the programme is debatable.

The precise nature of the populations and interventions to be covered, and those which are not included are defined in the final scope (as extended by the PDG) as follows:

POPULATION	
COVERED BY GUIDANCE	**NOT COVERED BY GUIDANCE**
Groups to be covered are populations defined on a geographical basis. The area will usually be at least a region of a country (such as Merseyside) or an urban or rural area (such as Paisley and Nottingham or New Forest). In the UK, the geographical area would not be less than what is currently covered by a Primary Care Trust. A population could also be made up of people living in a designated geographical area that fulfils the criteria above who also share a specific characteristic, such as all South Asian men over 50 who live in Sheffield. Populations will include both adults and children.	The guidance will not focus on individuals who are clinically diagnosed as being at high risk of developing – or who have already been diagnosed with – CVD. However, as populations include people at different stages of disease, it will have some relevance for them. (Individuals at high risk of developing CVD are covered by other NICE guidance, see section 6.)
ACTIVITIES /INTERVENTIONS	
COVERED BY GUIDANCE	**NOT COVERED BY GUIDANCE**
Single or multiple risk-factor approaches to preventing CVD among a given population. These include addressing one or more risk factors through one or more of the following types of intervention: • educational/behavioural (including the use of mass media) • fiscal • environmental • legislative	Secondary prevention activities and those aimed only at people who are at high risk of developing CVD. (If an intervention covers both primary and secondary prevention, it will only be included if the primary component is sufficiently disaggregated and can be reported separately.)

OR Programmes that include a pharmacological element alongside a broader, non-pharmacological multiple risk-factor approach (as indicated in 4.2.1a) will be included when they involve a primary prevention element and where data can be disaggregated to allow consideration of the impact of the non-pharmacological elements.	OR Interventions which focus on screening for CVD risk factors (for example, cholesterol-level screening) and do not attempt to modify them
OR Natural experiments, such as changes in the diet of Eastern Europeans brought about by social change, where relevant evidence is available	

1.2 Structure of this report

The structure of this report is as follows:

- Chapter 2 describes the interventions to be modelled and the sources of information for the modelling.
- Chapter 3 describes the modelling process.
- Chapter 4 discusses the review findings, highlighting their applicability, limitations and any gaps.

2. Interventions and information sources

The cost-effectiveness review (Andronis et al, 2009) identified a number of potentially cost-effective community based interventions. However, none of the studies found in that review could be regarded as directly applicable, for two main reasons. First, the rules of evaluation (such as costing perspective, and discounting rates to be applied) did not correspond with those currently required by NICE: this could be resolved by repeating the analysis using the appropriate evaluation rules. Second, the background against which the evaluation was carried out may have changed considerably since the time of the intervention. For example, an important part of the HeartBeat Wales programme was the introduction of food labelling. Since such food labelling is now widespread, the benefit of that part of the programme would already be included in the background for any new programme. To produce a useful estimate of the effect of such a programme now would require detailed information on the changes in the background to the programme, together with the difference such changes would make to the effectiveness of the programme.

At the request of the programme development group (PDG), and in recognition of consistent feedback from consultation with stakeholders, the scope of the modelling was extended beyond multiple risk factor programmes to consider also single risk factor programmes for which there is direct or indirect evidence of effectiveness. An example of this is modelling of a legislative programme to reduce the use of trans fatty acids (TFAs) in food. Here the effectiveness can be estimated based on the known relative risks incurred by the consumption of TFAs.

Finally, it is possible to model the effects in terms of outcomes such as quality adjusted life years (QALYs) gained and savings in health care costs for a given effectiveness. This gives an estimate of how much it would be worth spending to achieve such an outcome.

2.1 Information sources

The information required for the modelling consists of three parts. First is the background pattern of risks. For this we have used the Joint British Societies' Report

(Joint British Societies, 2005) for the risk factor equation and the distribution of risk factors in the population. We have used national statistics for other information about the general population.
The second type of information relates to the effectiveness of potential interventions. For this, we have used the results of our reviews together with expert papers presented to the PDG.

Finally, we need to be able to convert cases prevented into outcomes such as QALYs gained and healthcare costs saved. For this, we have relied heavily on the inputs to previous modelling undertaken for NICE (Ward et al, 2005).

3. Details of modelling undertaken

Specific interventions have been modelled in accordance with their potential effects. Additionally, a range of hypothetical analyses have been carried out to assess the possible effects of hypothetical interventions. The aim in each case is to estimate the following outcomes:

- CVD cases prevented or postponed;
- CVD deaths prevented or postponed;
- Life-years gained;
- Quality adjusted life-years (QALYs) gained;
- Cost savings to the NHS resulting from cases prevented or postponed.

In the case of specific interventions where it is possible to assess the costs of providing the intervention, a full cost-effectiveness analysis has been completed. Where this has not been possible, an estimate has been made of the maximum cost for such an intervention to be cost-effective at thresholds of £20,000 and £30,000 per QALY gained.

3.1 The basic model structure

The modelling process consists of five stages:

1. Determining the estimated outcomes as far as QALYs lost and costs to the NHS for a case of CVD;
2. Assessing the pattern of CVD cases prevented or postponed for an intervention of known effectiveness, applied to a single combination of age, sex, and risk;
3. Combining the results from stages 1 and 2 to estimate the potential outcomes for a single combination of age, sex, and risk;
4. Aggregating the results from stage 3 across all levels of risk to estimate the potential outcomes for a single combination of age and sex;
5. Aggregating the results from stage 4 to give total estimated outcomes at population level.

At stage 1, a lifetime horizon is feasible. However, at stage 2, it is only appropriate to apply a time horizon of around 10 years, given the nature of the risk equation and the

assumptions necessary. Accordingly the model gives an estimate of lifetime effects from a reduction in the number of cases within 10 years. Lifetime benefits would clearly be greater.

3.1.1 Determining the estimated outcomes for a case of CVD

The first stage of the model consists of an estimate of the expected lifetime costs, life years and QALYs following a first CVD event. Comparing these to life expectancy without an event gives us the life year loss and QALY loss from such an event. The main source of information to answer this question is the report by ScHARR (Ward et al, 2005) which considered the use of statins for the prevention of CVD.

Table 3.1 CVD event types and additional mortality for a 65-year-old male

Event type	Proportion	Additional mortality	
		First year	Later yrs
Stable Angina	0.214	0.0070	0.0070
Unstable Angina	0.083	0.1077	0.0124
Myocardial Infarction	0.173	0.0626	0.0159
Fatal CHD	0.097		
TIA	0.100	0.0348	0.0348
Stroke	0.270	0.0520	0.0208
Fatal CVD (ex CHD)	0.063		

Sources: Ward et al (2005), pages 138, 142.

Consider the example of a 65 year old male having a first CVD event. Available data from the ScHARR statins model (Ward et al, 2005) are summarised in Tables 3.1 and 3.2. Costs following an event have been re-estimated where possible, and otherwise inflated to 2008 prices. There is some methodological disagreement on how to account for co-morbidities in handling quality of life scores. The simplest approach would be to credit CVD-free individuals with full health, and apply the quality of life scores in Table 3.2 following a CVD event. However, such an approach would be contrary to the general principle of conservative modelling that has been taken in this work.. An alternative, used in the base case analysis by ScHARR, is to apply population norms for quality of life scores, and treat the values in Table 3.2 as

multipliers applied to these population norms. The ScHARR report (Ward et al, 2005, p. 151) quotes the results of a regression analysis giving a baseline utility of $1.06-0.004n$ at age n years. For simplicity, the utility at the age of event has been applied to calculate QALYs lost as a result of an event. This somewhat offsets the fact that the population utilities include some CVD patients, but is still likely to be a conservative valuation overall.

Table 3.2 CVD event types – costs and quality of life effects for a 65-year-old male

Event type	Proportion	Costs following event		QoL following event
		First year	Later yrs	
Stable Angina	0.214	£232	£232	0.808
Unstable Angina	0.083	£541	£232	0.770
Myocardial Infarction	0.173	£5,244	£232	0.760
Fatal CHD	0.097	£1,341		
TIA	0.100	£1,224	£304	1.000
Stroke	0.270	£9,259	£2,489	0.629
Fatal CVD (ex CHD)	0.063	£8,102		

Sources: Ward et al (2005), pages 146, 153. Costs following event have been inflated to 2008, except where GP contact costs have been identified, in which case the updated PSSRU cost has been used.

Data from the Government Actuary's Department (2009) indicate a life expectancy for 65 year old males of 17.29 years. The age-dependent utility is 0.784, giving a quality-adjusted life expectancy of $0.784\times17.29=13.56$ QALY. For such an individual with stable angina, the estimated life expectancy is reduced to 15.42 years (see Appendix 1 for method used here). The quality-adjusted life expectancy is then calculated as $0.784\times0.808\times15.42=9.77$ QALY. Thus the undiscounted life year loss and QALY loss for the event are $17.29-15.42=1.87$ and $13.56-9.77=3.79$ respectively. Further, the lifetime cost estimate for such an event is $15.42\times£232=£3{,}578$. Applying a discount rate of 3.5%, the estimated discounted life expectancy is 10.84 years before the event, reduced to 10.08 years following the event. The discounted quality-adjusted life expectancy before and after the event are thus respectively

$0.784 \times 10.84 = 8.50$ and $0.784 \times 0.808 \times 10.08 = 6.38$ QALY. This gives a discounted loss of 0.76 life years (2.12 QALY), with lifetime costs of $10.08 \times £232 = £2{,}338$.

Similar calculations are made for the other types of CVD event: the results for a 65 year old male are shown in Tables 3.3 and 3.4. The overall results for all ages from 40 to 90 male and female are given in Appendix 2.

Table 3.3 CVD events – undiscounted effects for a 65-year-old male

Event type	Proportion	LY lost	QALY lost	Lifetime costs
Stable Angina	0.214	1.87	3.79	3,578
Unstable Angina	0.083	4.41	5.78	3,297
Myocardial Infarction	0.173	4.36	5.85	8,011
Fatal CHD	0.097	17.29	13.56	1,341
TIA	0.100	6.50	5.10	4,202
Stroke	0.270	4.97	7.48	37,434
Fatal CVD (ex CHD)	0.063	17.29	13.56	8,102
Overall	1	6.28	7.00	13,593

Table 3.4 CVD events – discounted effects for a 65-year-old male

Event type	Proportion	LY lost	QALY lost	Lifetime costs
Stable Angina	0.214	0.76	2.12	2,338
Unstable Angina	0.083	1.91	3.11	2,380
Myocardial Infarction	0.173	1.89	3.17	7,088
Fatal CHD	0.097	10.84	8.50	1,341
TIA	0.100	2.97	2.33	3,313
Stroke	0.270	2.19	4.16	28,307
Fatal CVD (ex CHD)	0.063	10.84	8.50	8,102
Overall	1	3.27	4.00	10,539

3.1.2 Assessing the pattern of cases prevented or postponed for an intervention of known effectiveness

Two versions of the model have been created. One uses a relative risk applied to the annual risk of a first CVD event, while the other uses modifications to the risk factor

equation directly. For convenience, the relative risk version of the model is described in detail, and the variation for the other version follows.

Table 3.5 shows the calculations for a 65-year-old male with a 10-year CVD risk of 12.5%. The intervention is assumed to have a relative risk of 0.9 for each of the 10 years modelled.

Table 3.5 CVD events over 10 years for 65-year-old male with 12.5% 10-year risk

		no intervention		intervention		undiscounted	discounted
Age	OC death	risk CVD	CVD free	risk CVD	CVD free	cas prev	cas prev
A	B	C	D	E	F	G	H
65	0.00791	0.00819	0.98396	0.00737	0.98477	0.00081	0.00081
66	0.00844	0.01074	0.96518	0.00967	0.96703	0.00103	0.00100
67	0.00911	0.01197	0.94493	0.01077	0.94789	0.00111	0.00103
68	0.00989	0.01285	0.92356	0.01156	0.92766	0.00114	0.00103
69	0.01052	0.01354	0.90147	0.01219	0.90671	0.00115	0.00100
70	0.01121	0.01412	0.87878	0.01271	0.88515	0.00113	0.00095
71	0.01242	0.01462	0.85518	0.01316	0.86266	0.00111	0.00090
72	0.01341	0.01506	0.83100	0.01356	0.83955	0.00107	0.00084
73	0.01428	0.01546	0.80647	0.01392	0.81605	0.00103	0.00078
74	0.01553	0.01582	0.78138	0.01424	0.79194	0.00097	0.00071
					totals	0.01055	0.00906

Column A simply shows the age at the start of each year. Column B gives the risk of other causes death in the year, defined as the probability of other causes death conditional on survival to the start of the year. Yearly all-cause death rates have been adjusted for the proportion of CVD deaths to obtain this estimate. Column C is the assumed risk profile in the absence of an intervention, so that (for example) someone who has survived to age 70 without a CVD event has a probability of 0.01412 of a first CVD event in the next year. This is obtained from applying the algorithm of Anderson et al (1991). Column D gives the probability of CVD-free survival to the end of each year. It is calculated by a formula such as $D_{67} = (1 - B_{67})(1 - C_{67})D_{66}$, where D_{67} represents the entry in column D on the row for age 67, and so on. In other words, the CVD-free survival is multiplied each year by two factors, one representing other cause death and a second representing first CVD event. The multiplicative formula allows appropriately for competing risks. Column E is simply calculated as $E_{65} = 0.9C_{65}$, and so on, showing the intervention effect. Then column F is calculated as $F_{67} = (1 - B_{67})(1 - E_{67})F_{66}$, by analogy with column D. Next, the estimated cases

prevented each year are calculated by a formula such as $G_{67} = (D_{66} - D_{67}) + (F_{66} - F_{67})$. Finally, column H gives the discounted figure from column G at a rate of 3.5% as required by NICE. For example, $H_{67} = G_{67} / (1.035^{2})$.

For the alternative risk-factor modification version of the model, the annual risk of CVD in column E is calculated directly from the modified risk equation instead of working in terms of column C.

3.1.3 Estimating outcomes for a single combination of age, sex, and risk

The age and sex specific outcomes as illustrated in Section 3.1.1 can be combined with the estimated pattern of events saved as calculated in Section 3.1.2. Multiplying the cases prevented from column G in Table 3.5 by the undiscounted results in Appendix 2 gives us the results in Table 3.6 for a 65-year-old male with a 12.5% 10-year CVD risk. For discounted results, the relevant figures in Appendix 2 are discounted to the age at event. Multiplying by the figures in column H thus gives us outcomes discounted to the starting age as required. These are shown in Table 3.7.

Table 3.6 Undiscounted outcomes for 65-year-old male with a 12.5% 10-year CVD risk

Age	Cases prevented	Deaths prevented	LY gain	QALY gain	Cost saved
65	0.00081	0.00013	0.0051	0.0057	11
66	0.00103	0.00017	0.0061	0.0068	14
67	0.00111	0.00018	0.0062	0.0069	14
68	0.00114	0.00018	0.0059	0.0067	14
69	0.00115	0.00018	0.0056	0.0063	14
70	0.00113	0.00016	0.0063	0.0066	14
71	0.00111	0.00016	0.0058	0.0060	13
72	0.00107	0.00015	0.0052	0.0054	12
73	0.00103	0.00015	0.0046	0.0049	12
74	0.00097	0.00014	0.0041	0.0043	11
Totals	0.01055	0.00160	0.0549	0.0596	129

Table 3.7 Discounted outcomes for 65-year-old male with a 12.5% 10-year CVD risk

Age	Cases prevented	Deaths prevented	LY gain	QALY gain	Cost saved
65	0.00081	0.00013	0.0027	0.0032	9
66	0.00100	0.00016	0.0031	0.0038	10
67	0.00103	0.00017	0.0031	0.0038	11
68	0.00103	0.00016	0.0030	0.0036	10
69	0.00100	0.00016	0.0028	0.0034	10
70	0.00095	0.00014	0.0031	0.0035	10
71	0.00090	0.00013	0.0028	0.0031	9
72	0.00084	0.00012	0.0025	0.0028	8
73	0.00078	0.00011	0.0022	0.0025	8
74	0.00071	0.00010	0.0019	0.0021	7
Totals	0.00906	0.00138	0.0271	0.0319	92

3.1.4 Aggregating across different risk factors

To aggregate across different risk factors requires the distribution of risk factors in any given age group. The best source of this information is the JBS 2 report (Joint British Societies, 2005, page v11).This gives prevalence in 10 year age groups. For ease of modelling, the "under 10%" risk group has been taken at 7.5% and the "over 30%" risk group at 32.5%. The undiscounted and discounted results are shown for an intervention with relative risk 0.9 in Tables 3.8 and 3.9 respectively.

Table 3.8 Undiscounted results for 65-year-old males

10-year risk	proportion	Cases prevented	Deaths prevented	LY gain	QALY gain	Cost saved
0.075	0.010	0.00648	0.00098	0.0334	0.0361	79
0.125	0.088	0.01055	0.00160	0.0549	0.0596	129
0.175	0.197	0.01443	0.00220	0.0759	0.0825	178
0.225	0.223	0.01806	0.00276	0.0958	0.1045	224
0.275	0.153	0.02145	0.00329	0.1149	0.1255	267
0.325	0.329	0.02460	0.00379	0.1330	0.1457	308
Overall		0.01924	0.00295	0.1028	0.1123	239

Table 3.9 Discounted results for 65-year-old males

10-year risk	proportion	Cases prevented	Deaths prevented	LY gain	QALY gain	Cost saved
0.075	0.010	0.00551	0.00083	0.0164	0.0193	56
0.125	0.088	0.00906	0.00138	0.0271	0.0319	92
0.175	0.197	0.01251	0.00191	0.0376	0.0444	127
0.225	0.223	0.01579	0.00242	0.0477	0.0564	160
0.275	0.153	0.01892	0.00291	0.0573	0.0681	192
0.325	0.329	0.02189	0.00339	0.0666	0.0793	223
Overall		0.01694	0.00261	0.0513	0.0608	172

Tables 3.10 and 3.11 respectively show the overall figures undiscounted and discounted for age groups between 40 and 79 both males and females.

Table 3.10 Undiscounted estimate of effects for an intervention with relative risk 0.9

Per 1000	Cases prevented	Deaths prevented	LY gain	QALY gain	£000 saved
Males 40-49	9.01	1.07	67.9	96.5	157
Males 50-59	14.21	2.08	99.6	120.1	216
Males 60-69	19.24	2.95	102.8	112.3	239
Males 70-79	20.46	2.88	65.3	68.0	195
Females 40-49	7.56	0.75	61.2	88.0	158
Females 50-59	9.16	1.29	75.8	91.0	162
Females 60-69	12.50	2.02	84.9	90.0	180
Females 70-79	15.24	2.29	64.7	63.8	164

Table 3.11 Discounted estimate of effects for an intervention with relative risk 0.9

Per 1000	Cases prevented	Deaths prevented	LY gain	QALY gain	£000 saved
Males 40-49	7.67	0.90	21.5	36.0	82
Males 50-59	12.30	1.79	39.5	53.4	133
Males 60-69	16.94	2.61	51.3	60.8	172
Males 70-79	18.24	2.58	40.5	44.6	158
Females 40-49	6.40	0.63	17.3	30.3	77
Females 50-59	7.82	1.08	27.1	37.4	95
Females 60-69	10.81	1.76	39.1	45.5	124
Females 70-79	13.40	2.01	37.7	39.5	130

3.1.5 Aggregating to obtain population effects

To obtain population effects, the size of the relevant population must be taken into account. The relevant sources here are ONS data (Office of National Statistics, 2009) for the total population by 10-year age groups in England and Wales. The ScHARR report on statins (Ward et al, 2005, p. 140) was used to provide an estimate of the prevalence of CVD history within the population, thereby allowing an estimate of the total population for primary prevention. The results are shown in Table 3.12. Scaling up the results from Tables 3.10 and 3.11 gives us total estimates as shown in Tables 3.13 and 3.14 respectively.

Table 3.12 Population estimates

	Population in 000s	CVD prevalence per 1000	CVD free population in 000s
Males 40-49	3927	7.2	3898
Males 50-59	3257	23.2	3181
Males 60-69	2659	36.1	2563
Males 70-79	1748	44.2	1671
Females 40-49	3996	3.04	3983
Females 50-59	3346	11.0	3309
Females 60-69	2815	21.4	2754
Females 70-79	2090	34.7	2018

Table 3.13 Undiscounted estimates of total population effects for an intervention with relative risk 0.9

	000s of cases prevented	000s of deaths prevented	000s of LY gained	000s of QALYs gained	£millions saved
Males 40-49	35	4.2	265	376	612
Males 50-59	45	6.6	317	382	688
Males 60-69	49	7.6	264	288	614
Males 70-79	34	4.8	109	114	325
Females 40-49	30	3.0	244	351	630
Females 50-59	30	4.3	251	301	536
Females 60-69	34	5.6	234	248	495
Females 70-79	31	4.6	130	129	331
Totals	289	40.6	1814	2188	4232

Table 3.14 Discounted estimates of total population effects for an intervention with relative risk 0.9

	000s of cases prevented	000s of deaths prevented	000s of LY gained	000s of QALYs gained	£millions saved
Males 40-49	30	3.5	84	140	319
Males 50-59	39	5.7	126	170	423
Males 60-69	43	6.7	131	156	441
Males 70-79	30	4.3	68	75	264
Females 40-49	26	2.5	69	121	307
Females 50-59	26	3.6	90	124	314
Females 60-69	30	4.8	108	125	343
Females 70-79	27	4.1	76	80	262
Totals	251	35.2	751	990	2671

3.2 Results for specific interventions

Specific interventions modelled here are multifactor interventions based on the North Karelia and Stanford Five City projects and the possible effects of legislation to ban transfats and reduce salt consumption.

3.2.1 The North Karelia project

From our previous review, the effect of the North Karelia project included net percentage reductions in serum cholesterol of 3% for men and 1% for women, and systolic blood pressure of 3% for men and 5% for women. Including only those effects in the "Risk Equation Modifying" model gives undiscounted results by age groups as shown in Table 3.15 and discounted results in Table 3.16. The combined population results are given in Tables 3.17 and 3.18.

Table 3.17 Undiscounted estimate of effects from intervention based on North Karelia project

Per 1000	Cases prevented	Deaths prevented	LY gain	QALY gain	£000 saved
Males 40-49	3.53	0.41	26.4	38.0	62
Males 50-59	4.72	0.68	33.0	40.2	72
Males 60-69	5.57	0.86	30.5	33.4	70
Males 70-79	5.54	0.79	18.4	19.2	54
Females 40-49	3.42	0.34	27.4	39.8	72
Females 50-59	3.84	0.53	31.5	38.2	68
Females 60-69	4.66	0.76	32.0	34.2	68
Females 70-79	5.12	0.77	22.3	22.1	56

Table 3.18 Discounted estimate of effects from intervention based on North Karelia project

Per 1000	Cases prevented	Deaths prevented	LY gain	QALY gain	£000 saved
Males 40-49	3.05	0.35	8.4	14.3	32
Males 50-59	4.15	0.60	13.2	18.0	45
Males 60-69	5.01	0.78	15.3	18.3	51
Males 70-79	5.06	0.72	11.5	12.8	45
Females 40-49	2.93	0.29	7.8	13.8	35
Females 50-59	3.32	0.45	11.3	15.8	40
Females 60-69	4.09	0.67	14.8	17.4	47
Females 70-79	4.59	0.69	13.1	13.8	45

Table 3.19 Undiscounted estimates of total population effects from intervention based on North Karelia project

	000s of cases prevented	000s of deaths prevented	000s of LY gained	000s of QALYs gained	£millions saved
Males 40-49	14	1.6	103	148	240
Males 50-59	15	2.2	105	128	230
Males 60-69	14	2.2	78	86	180
Males 70-79	9	1.3	31	32	91
Females 40-49	14	1.3	109	159	287
Females 50-59	13	1.7	104	126	226
Females 60-69	13	2.1	88	94	187
Females 70-79	10	1.6	45	45	114
Totals	102	14.0	664	818	1555

Table 3.20 Discounted estimates of total population effects from intervention based on North Karelia project

	000s of cases prevented	000s of deaths prevented	000s of LY gained	000s of QALYs gained	£millions saved
Males 40-49	12	1.4	33	56	126
Males 50-59	13	1.9	42	57	143
Males 60-69	13	2.0	39	47	131
Males 70-79	8	1.2	19	21	75
Females 40-49	12	1.1	31	55	140
Females 50-59	11	1.5	37	52	133
Females 60-69	11	1.8	41	48	130
Females 70-79	9	1.4	26	28	91
Totals	90	12.3	269	364	969

For the cost-effectiveness analysis of this intervention, Tosteson et al (1997) report that it was costed at US$10 (price year 1985) per person reached for the first year, and US$5 per year thereafter. Converting into sterling and inflating to 2008 gives us a cost estimate of £30 per person for the first year and £15 thereafter. Applying these costs over ten years gives us an estimated (discounted) cost of £144 per person reached. This should be multiplied by the total population in the age range 40-79 to give us an estimated project cost of $£144 \times 24{,}000{,}000 = £3.5\,\text{billion}$. Table 3.20 shows a saving in healthcare costs of approximately £1 billion. This gives us a net cost of £2.5 billion for a gain of approximately 360,000 QALY at an incremental cost-effectiveness ratio of approximately £7,000/QALY. This is without taking into account the benefit from smoking reduction.

3.2.2 The Stanford Five City project

Tosteson et al (1997) report results for the Stanford Five City Project of a 4% reduction in systolic blood pressure and 2% decrease in serum cholesterol, achieved at a cost of $4.95 per person per year (price year 1993). Converting to sterling and inflating to 2008 gives a cost of £5.05 per person per year. A discounted total over 10 years is then about £44, which multiplies up to about £1 billion total cost for the project. Tables 3.21 to 3.24 show the outcomes from the "Risk Equation Modifying" model. The total healthcare cost saving almost equals the estimated cost of the project and it is not sensible to quote an ICER in this case. Including any appreciable benefit from smoking reduction would make the programme cost saving as well as improving health.

Table 3.21 Undiscounted estimate of effects from intervention based on Stanford Five City project

Per 1000	Cases prevented	Deaths prevented	LY gain	QALY gain	£000 saved
Males 40-49	3.68	0.43	27.5	39.5	64
Males 50-59	4.91	0.71	34.4	41.9	75
Males 60-69	5.80	0.90	31.7	34.8	73
Males 70-79	5.78	0.82	19.1	20.0	57
Females 40-49	3.28	0.32	26.3	38.2	69
Females 50-59	3.68	0.50	30.2	36.6	65
Females 60-69	4.46	0.73	30.7	32.8	65
Females 70-79	4.91	0.74	21.4	21.2	54

Table 3.22 Discounted estimate of effects from intervention based on Stanford Five City project

Per 1000	Cases prevented	Deaths prevented	LY gain	QALY gain	£000 saved
Males 40-49	3.17	0.37	8.8	14.9	34
Males 50-59	4.32	0.62	13.7	18.8	47
Males 60-69	5.22	0.81	16.0	19.0	53
Males 70-79	5.27	0.75	12.0	13.3	47
Females 40-49	2.81	0.28	7.5	13.3	34
Females 50-59	3.18	0.43	10.8	15.1	38
Females 60-69	3.92	0.64	14.2	16.7	45
Females 70-79	4.40	0.66	12.5	13.3	43

Table 3.23 Undiscounted estimates of total population effects from intervention based on Stanford Five City project

	000s of cases prevented	000s of deaths prevented	000s of LY gained	000s of QALYs gained	£millions saved
Males 40-49	14	1.7	107	154	250
Males 50-59	16	2.3	109	133	240
Males 60-69	15	2.3	81	89	188
Males 70-79	10	1.4	32	33	94
Females 40-49	13	1.3	105	152	275
Females 50-59	12	1.7	100	121	217
Females 60-69	12	2.0	85	90	179
Females 70-79	10	1.5	43	43	109
Totals	102	14.1	662	817	1552

Table 3.24 Discounted estimates of total population effects from intervention based on Stanford Five City project

	000s of cases prevented	000s of deaths prevented	000s of LY gained	000s of QALYs gained	£millions saved
Males 40-49	12	1.4	34	58	131
Males 50-59	14	2.0	44	60	148
Males 60-69	13	2.1	41	49	136
Males 70-79	9	1.2	20	22	78
Females 40-49	11	1.1	30	53	134
Females 50-59	11	1.4	36	50	127
Females 60-69	11	1.8	39	46	125
Females 70-79	9	1.3	25	27	87
Totals	90	12.3	269	364	968

3.2.3 Legislation to ban transfats

The expert paper submitted to the Programme Development Group (Lincoln, 2009) suggests that it is possible to reduce trans fatty acid (TFA) levels by approximately 0.7% of total fat content, as a conservative estimate, and that a 1% increase in energy intake from TFAs carries a relative risk of 1.12 of CHD death. For modelling purposes, this relative risk is taken to apply to all CVD events, and so a reduction of 0.7% gives us a relative risk of $1.12^{-0.7} = 0.924$. Putting this figure into the "Relative Risk" model leads to the outcomes shown in Tables 3.25 to 3.28.

Table 3.25 Undiscounted estimate of effects from intervention based on legislation against trans fatty acids

Per 1000	Cases prevented	Deaths prevented	LY gain	QALY gain	£000 saved
Males 40-49	6.87	0.82	51.7	73.5	120
Males 50-59	10.81	1.58	75.8	91.4	165
Males 60-69	14.62	2.24	78.2	85.4	182
Males 70-79	15.54	2.19	49.6	51.7	148
Females 40-49	5.76	0.57	46.7	67.1	121
Females 50-59	6.98	0.98	57.7	69.3	123
Females 60-69	9.51	1.54	64.6	68.5	137
Females 70-79	11.59	1.74	49.2	48.5	125

Table 3.26 Discounted estimate of effects from intervention based on legislation against trans fatty acids

Per 1000	Cases prevented	Deaths prevented	LY gain	QALY gain	£000 saved
Males 40-49	5.85	0.69	16.4	27.4	62
Males 50-59	9.36	1.36	30.0	40.7	101
Males 60-69	12.88	1.98	39.0	46.3	131
Males 70-79	13.86	1.96	30.7	33.9	120
Females 40-49	4.88	0.48	13.2	23.1	59
Females 50-59	5.96	0.82	20.6	28.5	72
Females 60-69	8.23	1.34	29.8	34.6	95
Females 70-79	10.19	1.53	28.6	30.1	99

Table 3.27 Undiscounted estimates of total population effects from intervention based on legislation against trans fatty acids

	000s of cases prevented	000s of deaths prevented	000s of LY gained	000s of QALYs gained	£millions saved
Males 40-49	27	3.2	202	286	466
Males 50-59	34	5.0	241	291	524
Males 60-69	37	5.7	200	219	466
Males 70-79	26	3.7	83	86	247
Females 40-49	23	2.3	186	267	480
Females 50-59	23	3.2	191	229	408
Females 60-69	26	4.2	178	189	377
Females 70-79	23	3.5	99	98	252
Totals	220	30.9	1380	1666	3221

Table 3.28 Discounted estimates of total population effects from intervention based on legislation against trans fatty acids

	000s of cases prevented	000s of deaths prevented	000s of LY gained	000s of QALYs gained	£millions saved
Males 40-49	23	2.7	64	107	243
Males 50-59	30	4.3	96	129	322
Males 60-69	33	5.1	100	119	335
Males 70-79	23	3.3	51	57	200
Females 40-49	19	1.9	53	92	234
Females 50-59	20	2.7	68	94	239
Females 60-69	23	3.7	82	95	261
Females 70-79	21	3.1	58	61	199
Totals	191	26.8	571	754	2033

The figures in Table 3.28 suggest that an intervention costing about £2 billion would still be cost saving if it could achieve the desired effect. Allowing for discounting, the equivalent annual cost would be about £240 million. An intervention could cost more than this and still be cost-effective. Table 3.29 shows the possibilities here.

Table 3.29 Maximum intervention cost at which an intervention based on legislation against trans fatty acids could be cost-effective

Threshold ICER (£/QALY)	Maximum one-off cost	Maximum annual cost over 10 years
20,000	£17 billion	£2.0 billion
30,000	£25 billion	£2.9 billion

The 0.7% TFA reduction represents a conservative estimate of what is possible. Assuming a uniform decrease from 2% to 0.5%, in line with effects observed in Denmark, would generate a TFA reduction of 1.5%. Benefits in deprived groups might be substantially larger, given the 6% daily intake observed in some disadvantaged groups. On the other hand, it is possible that legislation would not achieve the full modelled effect. Section 3.3 of this report gives the maximum acceptable cost for an intervention given a range of possible relative risks.

3.2.4 Legislation to reduce salt intake

The expert paper on salt intake (Cappucio, 2009) suggests that a reduction of 3 g per day in salt intake is a reasonably conservative estimate of the potential effects of

legislation to reduce salt intake, and that a reduction of 6 g per day is a reasonable aspiration. According to He and MacGregor (2003), reductions in salt consumption of 3 g per day and 6 g per day would lead to mean reductions in systolic blood pressure of 2.5 mmHg and 5 mmHg respectively. To fit the risk reduction model, these reductions must be expressed as percentages and can be taken as approximately 2 percent and 4 percent respectively. Tables 3.30 to 3.34 give results for a reduction of 3 g per day in salt intake, while Tables 3.35 to 3.39 give equivalents for a reduction of 6 g per day. Summarised results for other values appear in section 3.3.2 where generic interventions to reduce systolic blood pressure are considered.

Table 3.30 Undiscounted estimate of effects from reduction of 3 g per day in salt intake

Per 1000	Cases prevented	Deaths prevented	LY gain	QALY gain	£000 saved
Males 40-49	1.32	0.15	9.9	14.2	23
Males 50-59	1.76	0.25	12.3	15.0	27
Males 60-69	2.08	0.32	11.3	12.5	26
Males 70-79	2.06	0.29	6.8	7.2	20
Females 40-49	1.18	0.12	9.5	13.7	25
Females 50-59	1.32	0.18	10.8	13.2	24
Females 60-69	1.60	0.26	11.0	11.8	23
Females 70-79	1.76	0.26	7.7	7.6	19

Table 3.31 Discounted estimate of effects from reduction of 3 g per day in salt intake

Per 1000	Cases prevented	Deaths prevented	LY gain	QALY gain	£000 saved
Males 40-49	1.14	0.13	3.2	5.3	12
Males 50-59	1.55	0.22	4.9	6.7	17
Males 60-69	1.87	0.29	5.7	6.8	19
Males 70-79	1.88	0.27	4.3	4.8	17
Females 40-49	1.01	0.10	2.7	4.8	12
Females 50-59	1.14	0.15	3.9	5.4	14
Females 60-69	1.41	0.23	5.1	6.0	16
Females 70-79	1.57	0.24	4.5	4.8	15

Table 3.32 Undiscounted estimates of total population effects from reduction of 3 g per day in salt intake

	000s of cases prevented	000s of deaths prevented	000s of LY gained	000s of QALYs gained	£millions saved
Males 40-49	5.2	0.60	39	55	90
Males 50-59	5.6	0.81	39	48	86
Males 60-69	5.3	0.82	29	32	67
Males 70-79	3.4	0.49	11	12	34
Females 40-49	4.7	0.46	38	55	99
Females 50-59	4.4	0.60	36	44	78
Females 60-69	4.4	0.72	30	32	64
Females 70-79	3.5	0.53	15	15	39
Totals	36.6	5.04	238	293	557

Table 3.33 Discounted estimates of total population effects from reduction of 3 g per day in salt intake

	000s of cases prevented	000s of deaths prevented	000s of LY gained	000s of QALYs gained	£millions saved
Males 40-49	4.4	0.51	12	21	47
Males 50-59	4.9	0.71	16	21	53
Males 60-69	4.8	0.74	15	17	49
Males 70-79	3.1	0.45	7	8	28
Females 40-49	4.0	0.39	11	19	48
Females 50-59	3.8	0.51	13	18	46
Females 60-69	3.9	0.64	14	16	45
Females 70-79	3.2	0.48	9	10	31
Totals	32.2	4.43	96	131	347

Table 3.34 Maximum intervention cost at which a reduction of 3 g per day in salt intake could be cost-effective

Threshold ICER (£/QALY)	Maximum one-off cost	Maximum annual cost over 10 years
20,000	£3.0 billion	£340 million
30,000	£4.3 billion	£500 million

Table 3.35 Undiscounted estimate of effects from reduction of 6 g per day in salt intake

Per 1000	Cases prevented	Deaths prevented	LY gain	QALY gain	£000 saved
Males 40-49	2.66	0.31	19.9	28.6	46
Males 50-59	3.55	0.51	24.8	30.2	54
Males 60-69	4.18	0.65	22.9	25.1	53
Males 70-79	4.16	0.59	13.8	14.4	41
Females 40-49	2.37	0.23	19.0	27.6	50
Females 50-59	2.66	0.36	21.8	26.5	47
Females 60-69	3.22	0.53	22.2	23.7	47
Females 70-79	3.54	0.53	15.4	15.3	39

Table 3.36 Discounted estimate of effects from reduction of 6 g per day in salt intake

Per 1000	Cases prevented	Deaths prevented	LY gain	QALY gain	£000 saved
Males 40-49	2.29	0.27	6.3	10.7	24
Males 50-59	3.12	0.45	9.9	13.6	34
Males 60-69	3.76	0.58	11.5	13.7	38
Males 70-79	3.80	0.54	8.6	9.6	34
Females 40-49	2.03	0.20	5.4	9.6	24
Females 50-59	2.30	0.31	7.8	10.9	28
Females 60-69	2.83	0.46	10.3	12.0	33
Females 70-79	3.17	0.48	9.0	9.6	31

Table 3.37 Undiscounted estimates of total population effects from reduction of 6 g per day in salt intake

	000s of cases prevented	000s of deaths prevented	000s of LY gained	000s of QALYs gained	£millions saved
Males 40-49	10.4	1.21	77	111	181
Males 50-59	11.3	1.63	79	96	173
Males 60-69	10.7	1.66	59	64	135
Males 70-79	7.0	0.98	23	24	68
Females 40-49	9.4	0.93	76	110	199
Females 50-59	8.8	1.20	72	88	157
Females 60-69	8.9	1.45	61	65	129
Females 70-79	7.1	1.07	31	31	79
Totals	73.6	10.15	478	590	1120

Table 3.38 Discounted estimates of total population effects from reduction of 6 g per day in salt intake

	000s of cases prevented	000s of deaths prevented	000s of LY gained	000s of QALYs gained	£millions saved
Males 40-49	8.9	1.03	25	42	95
Males 50-59	9.9	1.42	31	43	107
Males 60-69	9.6	1.50	29	35	98
Males 70-79	6.3	0.90	14	16	56
Females 40-49	8.1	0.79	22	38	97
Females 50-59	7.6	1.02	26	36	92
Females 60-69	7.8	1.28	28	33	90
Females 70-79	6.4	0.96	18	19	63
Totals	64.8	8.91	194	263	699

Table 3.39 Maximum intervention cost at which a reduction of 6 g per day in salt intake could be cost-effective

Threshold ICER (£/QALY)	Maximum one-off cost	Maximum annual cost over 10 years
20,000	£6.0 billion	£700 million
30,000	£8.6 billion	£1.0 billion

3.3 Results for hypothetical interventions

In this section, we consider hypothetical interventions and estimate the maximum acceptable cost of an intervention to achieve a given effect. As in previous sections, this is applied to a population with a starting age of 40-79 and estimates the lifetime effects of events prevented over 10 years.

3.3.1 Relative risk

Using the "Relative Risk" model, Table 3.40 shows the estimated outcomes for an intervention achieving a given relative risk of a primary CVD event, assuming that this applies uniformly across the modelled population. The equivalent discounted figures are shown in Table 3.41, and the acceptable costs for cost saving, or staying within a cost-effectiveness threshold of £20,000 or £30,000 per QALY appear in Table 3.42. A 0.5 reduction in relative risk, halving the CVD burden, was estimated to generate discounted savings of approximately £14 billion (Table 3.41).

Table 3.40 Undiscounted outcomes for intervention with given relative risk

Relative risk	000s of cases prevented	000s of deaths prevented	000s of LY gained	000s of QALYs gained	£millions saved
0.999	3	0.4	18	22	42
0.995	14	2.0	90	109	210
0.99	29	4.0	180	217	420
0.98	57	8.1	360	435	841
0.97	86	12	541	653	1262
0.96	115	16	722	871	1684
0.95	144	20	903	1090	2107
0.94	173	24	1084	1309	2531
0.93	202	28	1266	1528	2955
0.92	231	32	1448	1748	3380
0.91	260	37	1631	1968	3806
0.9	289	41	1814	2188	4232
0.85	436	61	2732	3295	6376
0.8	585	82	3659	4412	8538
0.75	735	103	4593	5537	10718
0.7	886	124	5536	6671	12918
0.65	1039	146	6487	7815	15136
0.6	1193	168	7447	8967	17374
0.55	1349	190	8414	10129	19631
0.5	1507	212	9390	11301	21909

Table 3.41 Discounted outcomes for intervention with given relative risk

Relative risk	000s of cases prevented	000s of deaths prevented	000s of LY gained	000s of QALYs gained	£millions saved
0.999	2	0.3	7	10	26
0.995	12	1.7	37	49	132
0.99	25	3.5	74	98	265
0.98	50	7.0	149	197	530
0.97	75	10	224	295	796
0.96	100	14	299	394	1063
0.95	125	18	374	493	1330
0.94	150	21	449	592	1597
0.93	175	25	524	692	1865
0.92	201	28	600	791	2133
0.91	226	32	675	891	2402
0.9	251	35	751	990	2671
0.85	378	53	1132	1492	4024
0.8	507	71	1516	1997	5389
0.75	637	89	1903	2507	6766
0.7	768	108	2294	3021	8155
0.65	900	126	2689	3540	9557
0.6	1033	145	3088	4062	10971
0.55	1168	164	3490	4589	12397
0.5	1304	183	3895	5121	13836

Table 3.42 Maximum acceptable cost (£million per programme) for intervention with given relative risk

	For cost saving		For £20,000/QALY		For £30,000/QALY	
Relative risk	one-off	annual	one-off	annual	one-off	annual
0.999	26	3	223	26	321	37
0.995	132	15	1115	130	1607	187
0.99	265	31	2231	259	3214	373
0.98	530	62	4466	519	6434	747
0.97	796	93	6705	779	9659	1122
0.96	1063	123	8947	1039	12890	1497
0.95	1330	154	11193	1300	16125	1873
0.94	1597	186	13443	1562	19366	2250
0.93	1865	217	15697	1824	22613	2627
0.92	2133	248	17954	2086	25865	3005
0.91	2402	279	20215	2349	29122	3383
0.9	2671	310	22480	2612	32385	3762
0.85	4024	467	33862	3934	48780	5667
0.8	5389	626	45338	5267	65313	7588
0.75	6766	786	56911	6612	81984	9524
0.7	8155	947	68582	7967	98795	11477
0.65	9557	1110	80350	9335	115747	13447
0.6	10971	1275	92218	10713	132842	15433
0.55	12397	1440	104187	12104	150081	17436
0.5	13836	1607	116256	13506	167466	19455

3.3.2 Percentage reduction in systolic blood pressure

Using the "Risk Equation Modifying" model, Table 3.43 shows the estimated outcomes for an intervention achieving a given percentage reduction in systolic blood pressure, assuming that this applies uniformly across the modelled population.

Table 3.43 Undiscounted outcomes for intervention with given percentage reduction in systolic blood pressure

Percentage reduction in SBP	Equivalent salt reduction (g/day)	000s of cases prevented	000s of deaths prevented	000s of LY gained	000s of QALYs gained	£millions saved
0.5	0.75	9	1.3	59	73	139
1	1.5	18	2.5	118	146	278
1.5	2.25	27	3.8	178	219	417
2	3	37	5.0	238	293	557
2.5	3.75	46	6.3	297	367	697
3	4.5	55	7.6	357	441	838
3.5	5.25	64	8.9	418	515	979
4	6	74	10.1	478	590	1120
4.5	6.75	83	11.4	539	664	1262
5	7.5	92	12.7	600	739	1405

The equivalent discounted figures are shown in Table 3.44, and the acceptable costs for cost saving, or staying within a cost-effectiveness threshold of £20,000 or £30,000 per QALY appear in Table 3.45. In each of these tables, the equivalent daily reduction in salt intake is also shown, as explained in Section 3.2.4 above.

Table 3.44 Discounted outcomes for intervention with given percentage reduction in systolic blood pressure

Percentage reduction in SBP	Equivalent salt reduction (g/day)	000s of cases prevented	000s of deaths prevented	000s of LY gained	000s of QALYs gained	£millions saved
0.5	0.75	8	1.1	24	33	86
1	1.5	16	2.2	48	65	173
1.5	2.25	24	3.3	72	98	260
2	3	32	4.4	96	131	347
2.5	3.75	40	5.5	121	164	435
3	4.5	48	6.7	145	197	522
3.5	5.25	57	7.8	169	230	610
4	6	65	8.9	194	263	699
4.5	6.75	73	10.0	219	296	787
5	7.5	81	11.2	243	330	876

Table 3.45 Maximum acceptable cost (£million per programme) for intervention with given percentage reduction in systolic blood pressure

Percentage reduction in SBP	Equivalent salt reduction (g/day)	For cost saving		For £20,000/QALY		For £30,000/QALY	
		one-off	annual	one-off	annual	one-off	annual
0.5	0.75	86	10	737	86	1062	123
1	1.5	173	20	1476	172	2128	247
1.5	2.25	260	30	2218	258	3197	371
2	3	347	40	2962	344	4269	496
2.5	3.75	435	50	3708	431	5344	621
3	4.5	522	61	4456	518	6423	746
3.5	5.25	610	71	5207	605	7505	872
4	6	699	81	5960	692	8590	998
4.5	6.75	787	91	6715	780	9679	1124
5	7.5	876	102	7473	868	10771	1251

3.3.3 Percentage reduction in cholesterol

Using the "Risk Equation Modifying" model, Table 3.46 shows the estimated outcomes for an intervention achieving a given percentage reduction in cholesterol, assuming that this applies uniformly across the modelled population. The equivalent discounted figures are shown in Table 3.47, and the acceptable costs for cost saving,

or staying within a cost-effectiveness threshold of £20,000 or £30,000 per QALY appear in Table 3.48.

Table 3.46 Undiscounted outcomes for intervention with given percentage reduction in cholesterol

Percentage reduction in cholesterol	000s of cases prevented	000s of deaths prevented	000s of LY gained	000s of QALYs gained	£millions saved
0.5	7	1.0	47	57	109
1	14	2.0	93	115	219
1.5	22	3.0	140	173	329
2	29	4.0	187	231	439
2.5	36	5.0	234	289	550
3	43	6.0	282	348	661
3.5	51	7.0	329	406	772
4	58	8.0	377	465	884
4.5	65	9.0	425	524	996
5	73	10.0	473	583	1109

Table 3.47 Discounted outcomes for intervention with given percentage reduction in cholesterol

Percentage reduction in cholesterol	000s of cases prevented	000s of deaths prevented	000s of LY gained	000s of QALYs gained	£millions saved
0.5	6	0.9	19	26	68
1	13	1.7	38	51	136
1.5	19	2.6	57	77	205
2	25	3.5	76	103	274
2.5	32	4.4	95	129	343
3	38	5.3	114	155	412
3.5	45	6.1	134	181	481
4	51	7.0	153	208	551
4.5	58	7.9	172	234	621
5	64	8.8	192	260	691

Table 3.48 Maximum acceptable cost (£million per programme) for intervention with given percentage reduction in cholesterol

Percentage reduction in cholesterol	For cost saving		For £20,000/QALY		For £30,000/QALY	
	one-off	annual	one-off	one-off	annual	one-off
0.5	68	8	581	67	837	97
1	136	16	1163	135	1676	195
1.5	205	24	1748	203	2519	293
2	274	32	2334	271	3365	391
2.5	343	40	2923	340	4213	489
3	412	48	3514	408	5065	588
3.5	481	56	4106	477	5919	688
4	551	64	4701	546	6776	787
4.5	621	72	5298	616	7637	887
5	691	80	5897	685	8501	988

4. Discussion

The results in Chapter 3 strongly suggest that any legislative intervention that is likely to achive an appreciable reduction in risk of CVD can be expected to produce a net cost saving to the public sector as well as improving health. Only if a very large sum of money needs to be spent in implementing the legislation would this cease to be the case. The conclusion that population wide primary CVD prevention is likely to be cost-saving is reassuringly consistent with findings elsewhere (see for example Abelson et al, 2001, Catford, 2009, Trust for America's Health, 2008, Wanless, 2004). Findings are also consistent with a recent FSA report on salt reduction. Their five year campaign cost approximately £15 million and achieved a reduction of 0.9 g per day, representing approximately 6000 fewer cardiovascular deaths per year.

A spreadsheet model has been developed which will allow a relative risk to be applied to each year's risk of primary CVD within the population. An alternative form allows percentage reductions in cholesterol and systolic blood pressure to be applied separately for males and females. The reductions modelled of up to 5% for systolic blood pressure and cholesterol are entirely consistent with the reductions carefully documented in regional programmes such as North Karelia, Stanford and HeartBeat Wales. In their current forms, the models have been built on the assumption that these effects apply uniformly across age and risk groups and, in the case of the "Relative Risk" model, across the ten years and equally for males and females. It would not be difficult to amend the model to allow variation in the effect by any of these factors if such amendment were felt appropriate.

A specific example modelled a 0.7% reduction in daily trans fatty acid (TFA) intake. A uniform decrease from 2% to 0.5% as seen in Denmark would generate a TFA reduction twice as large. Further, the benefits in deprived groups might be larger still, given the 6% daily intake reported in some UK groups.

From a modelling point of view, the nature of the intervention is unimportant in itself. What matters is whether a given outcome can be achieved (by any type of intervention) for a given cost.

4.1 Strengths of the analysis

The model is designed to be transparent to the reader, and involves relatively few assumptions, the effect of each of which can be easily tested. The estimates are based on a series of conservative assumptions, so the true benefits are likely to be substantially larger than reported here.

A 0.5 reduction in the relative risk of CVD was estimated to generate discounted savings of approximately £14 billion. This is consistent with the results of Luengo-Fernández and colleagues (2006), who, with a very different methodology, estimated the total burden of CVD to cost £29 billion.

Results have been given for cholesterol and systolic blood pressure reductions of no more than 5%. In fact, larger reductions in entire populations have been documented in recent years. For cholesterol, reductions have been reported of 22% in Finland since 1972, 14% in Iceland since 1980, and 10% in Sweden since 1986 (Laatikainen et al, 2005, Asplund et al, 2009, Björck et al, 2009). For blood pressure, reductions have been reported of 7.7% in England since 1981, 6.5% in Finland since 1972 and 3.5% in Italy since 1980 (Unal et al, 2004, Laatikainen et al, 2005, Palmieri et al, 2009).

When considering multifactor programmes, a conservative feature of the modelling is that the effects of reduction in smoking prevalence have been omitted. These would generate substantial further reductions in mortality and morbidity, with corresponding financial savings (Unal et al, 2004, Laatikainen et al, 2005, Palmieri et al, 2009).

A further conservative feature is the focus on primary prevention alone. The sort of programmes considered in this report would also benefit the 3 to 4 million patients with recognised CVD in the UK (Unal et al, 2005).

The model assumed a uniform distribution of benefit across social groups. In fact, it is well recognised that the more deprived groups experience disproportionately more disease, and thus would enjoy extra gain from population wide risk factor reductions. Taking this into account would again serve to increase our current conservative estimate of reduction in mortality and morbidity.

4.2 Limitations of the analysis

In a different context, Box and colleagues (1978) stated “all models are wrong, but some are useful”. Our conclusion is clearly subject to a number of important limitations necessitated by the nature of the decision problem itself, and by the limited resources available to produce this report.

The most obvious limitation of the modelling carried out here is the lack of a full sensitivity analysis. Many essential data inputs (such as the distribution of risk factors in the population) were only readily available as point estimates. Although it would be possible to assess the effects of specific changes in these parameters, this would not account for the uncertainties inherent in the various modelling assumptions. Any attempt to reflect the uncertainty in parameter inputs would risk a spurious impression that the full uncertainty in the decision problem had been included. However, the results in Section 3.3 provide a measure of sensitivity analysis on the effectiveness of interventions, but this should be interpreted allowing for the uncertainties elsewhere in the model. Further, such a sensitivity analysis would be likely to emphasise the much larger benefits that would be estimated using a less robustly conservative approach.

Much of the population data was available only in 10-year age bands. This applies particularly in relation to the distribution of types of CVD event among primary cases, and accounts for some irregularities in the tables in Appendix 2. However, when these results were applied over a 10-year period with a starting age of 45, 55, 65, or 75, the effects of the irregularities would tend to cancel out to a large extent, so that the relative error in the overall figures will be small compared to the relative error in the individual years' figures.

Apart from the increased mortality following a non-fatal primary CVD event, no attempt has been made to include recurrence. This means that the estimates of life years lost and cost savings are likely to be underestimates, and, to that extent, the analysis is somewhat conservative. Additionally, benefits over a lifetime would clearly be greater than those restricted to the 10 year horizon used in the model for events prevented.

No attempt has been made to include the effects of smoking cessation in the analysis of multi-factor interventions using the "Risk Factor Modifying" model. To do so with any attempt at realism would require the proportion of smokers in each of the risk groups used for the modelling. An assumption of uniformity between these groups is unrealistic. Given the large reductions in smoking prevalence seen in most Western countries, it is likely that substantial mortality and morbidity benefits and cost savings could be made as a result of smoking cessation as part of such programmes.

Similarly, the analysis is restricted to effects on primary CVD prevention. An intervention which is recommended on the basis of this analysis and is known to have only beneficial effects on other aspects of health can be recommended more strongly as a result. Benefits have also been restricted to the population without CVD. The four million CVD patients in the UK would also benefit from population wide reductions in cholesterol, blood pressure, and smoking.

The analysis is limited to the effects on people aged between 40 and 79 at the time of the intervention. The main reason for this is that this is the age range for which the distribution of population risks was available. At various points in the analysis, data which properly relates only to ages 70-74 has been applied to ages 70-79. Given the very high event rates in elderly individuals, substantial additional benefits might reasonably be expected.

A further limitation is the 10 year time frame for prevention of cases. In the undiscounted analysis, a case postponed within this 10 year time frame does not contribute to the total reckoning for cases prevented, but the life years and QALYs lost are lower for a case postponed, so there is at least that measure of benefit. A case postponed beyond the 10 year times frame is credited at its full value. The discounted analysis gives a further benefit to postponed cases.

4.3 Recommendations for further research

Various groups studying both prevention and treatment of CVD have developed more sophisticated models than the one used here. It would be helpful to decision making bodies if such groups could be encouraged to produce results from their models in a similar format to the tables in Section 3.3 and Appendix 2, and to maintain these

tables as further information becomes available. In particular, they will need updating as necessary to take account of changes in background characteristics including mortality and changes in preferred treatment of primary CVD. This will require adequate resources for the modelling. The sum required will, however, be much smaller than the value gained from the policy decisions that such modelling will support.

Further research into the causal links in the model, in particular the underlying risk equation, is likely to be of some benefit. However, it is unlikely that small changes in such factors will change policy conclusions and such research would mainly serve the purpose of ensuring that the model remains up to date.

4.4 Conclusions

Population-wide prevention interventions appear consistently powerful and cost-saving. The general consistency with results from very different methodologies in the USA, Australia, and the UK Treasury is reassuring.

This is a relatively simple and transparent model with clearly acknowledged limitations. The cumulative conservative assumptions mean that the scale of current benefits and cost-savings are almost certainly under-estimated.

5. Appendices

Appendix 1. Life expectancy calculations

Suppose an individual has an annual risk of mortality λ. Then the probability of survival at time *t* is $e^{-\lambda t}$, so the life expectancy is $\int_0^\infty e^{-\lambda t}dt = \left[\frac{-1}{\lambda}e^{-\lambda t}\right]_0^\infty = \frac{1}{\lambda}$. Thus a known life expectancy can be approximated by an annual risk equal to the reciprocal of the life expectancy.

Now suppose the individual has additional mortality μ in the first year and *v* in subsequent years. Then the life expectancy can be approximated as

$$\int_0^1 e^{-(\lambda+\mu)t}dt + \int_1^\infty e^{-(\lambda+\mu)}e^{-(\lambda+\nu)(t-1)}dt = \frac{1-e^{-(\lambda+\mu)}}{\lambda+\mu} + \frac{e^{-(\lambda+\mu)}}{\lambda+\nu} = \frac{\lambda+\nu+e^{-(\lambda+\mu)}(\mu-\nu)}{(\lambda+\mu)(\lambda+\nu)}.$$

Now $e^{-(\lambda+\mu)} \approx 1-(\lambda+\mu)$, so the life expectancy can be approximated by

$$\frac{\lambda+\nu+(-\lambda-\mu)(\mu-\nu)}{(\lambda+\mu)(\lambda+\nu)} = \frac{\lambda+\nu+\mu-\nu-\lambda\mu+\lambda\nu-\mu^2+\mu\nu}{(\lambda+\mu)(\lambda+\nu)}$$

$$= \frac{\lambda+\mu+\lambda\nu+\mu\nu-\lambda\mu-\mu^2}{(\lambda+\mu)(\lambda+\nu)} = \frac{(\lambda+\mu)(\lambda+\nu-\mu)}{(\lambda+\mu)(\lambda+\nu)} = \frac{(\lambda+\nu-\mu)}{(\lambda+\nu)}.$$

This is the formula used to estimate the life expectancy following a particular CVD event.

For discounted life expectancy, note that applying an annual discount rate of ρ effectively multiplies the value of survival at time *t* by $e^{-\rho t}$. Thus if the undiscounted life expectancy is $\frac{1}{\lambda}$, then the discounted life expectancy may be approximated by

$$\int_0^\infty e^{-\lambda t}e^{-\rho t}dt = \frac{1}{\lambda+\rho}.$$

The approximations used in developing these formulae are well within the range of reasonable modelling approximations given the assumptions made in other parts of the model.

Appendix 2. Estimated outcomes following a first CVD event

Tables A2.1 and A2.2 give estimated results for males and females respectively for the outcomes expected from a primary CVD event at any given age. The explanation of the tables is in Section 3.1.1 of this report.

Table A2.1 Estimated outcomes for males experiencing a primary CVD event

		Undiscounted			Discounted		
Age	Deaths	Cost	LY lost	QALY lost	Cost	LY lost	QALY lost
40	0.101	19706	8.6372	13.7326	10629	2.6403	9.6878
41	0.101	19351	8.3430	13.2795	10552	2.6048	9.5464
42	0.101	18994	8.0523	12.8326	10473	2.5685	9.4031
43	0.101	18639	7.7683	12.3958	10392	2.5317	9.2589
44	0.101	18281	7.4879	11.9651	10309	2.4940	9.1127
45	0.101	17921	7.2112	11.5404	10223	2.4554	8.9644
46	0.101	17563	6.9410	11.1255	10135	2.4163	8.8150
47	0.101	17202	6.6744	10.7166	10045	2.3763	8.6635
48	0.101	16844	6.4144	10.3174	9953	2.3357	8.5108
49	0.101	16487	6.1608	9.9277	9859	2.2945	8.3570
50	0.134	18404	9.0444	11.6798	11512	3.3684	7.4314
51	0.134	18037	8.6665	11.2039	11398	3.3018	7.2940
52	0.134	17668	8.2980	10.7402	11280	3.2344	7.1554
53	0.134	17295	7.9347	10.2840	11159	3.1653	7.0144
54	0.134	16922	7.5809	9.8398	11034	3.0954	6.8720
55	0.134	16544	7.2325	9.4031	10905	3.0238	6.7270
56	0.134	16170	6.8973	8.9825	10775	2.9522	6.5818
57	0.134	15791	6.5674	8.5691	10640	2.8788	6.4339
58	0.134	15412	6.2467	8.1671	10501	2.8045	6.2845
59	0.134	15029	5.9314	7.7723	10358	2.7284	6.1321
60	0.160	15226	8.3164	9.1996	11297	3.8560	5.1415
61	0.160	14900	7.8775	8.7258	11151	3.7397	5.0158
62	0.160	14579	7.4611	8.2759	11005	3.6250	4.8909
63	0.160	14250	7.0515	7.8344	10853	3.5076	4.7632
64	0.160	13923	6.6588	7.4111	10698	3.3907	4.6352
65	0.160	13593	6.2778	7.0007	10539	3.2727	4.5055
66	0.160	13265	5.9134	6.6079	10377	3.1554	4.3755
67	0.160	12930	5.5556	6.2228	10209	3.0356	4.2425
68	0.160	12596	5.2140	5.8548	10038	2.9166	4.1093
69	0.160	12260	4.8837	5.4988	9862	2.7969	3.9743
70	0.143	12152	5.5870	5.8086	10310	3.2301	3.4617
71	0.143	11873	5.2089	5.4314	10142	3.0812	3.3425
72	0.143	11596	4.8540	5.0767	9973	2.9361	3.2246
73	0.143	11315	4.5114	4.7344	9798	2.7907	3.1050
74	0.143	11034	4.1861	4.4089	9620	2.6474	2.9853
75	0.143	10757	3.8828	4.1045	9442	2.5089	2.8675
76	0.143	10477	3.5909	3.8113	9258	2.3708	2.7482
77	0.143	10197	3.3153	3.5338	9072	2.2356	2.6294
78	0.143	9924	3.0601	3.2758	8888	2.1061	2.5131
79	0.143	9653	2.8200	3.0323	8702	1.9801	2.3978
80	0.137	8372	3.2050	3.1524	7808	2.3017	2.0231

		Undiscounted			Discounted		
Age	Deaths	Cost	LY lost	QALY lost	Cost	LY lost	QALY lost
81	0.137	8193	2.9583	2.9175	7673	2.1622	1.9269
82	0.137	8015	2.7267	2.6966	7537	2.0274	1.8320
83	0.137	7843	2.5149	2.4937	7404	1.9005	1.7408
84	0.137	7673	2.3172	2.3040	7271	1.7789	1.6517
85	0.137	7510	2.1380	2.1311	7142	1.6657	1.5668
86	0.137	7346	1.9672	1.9662	7012	1.5551	1.4824
87	0.137	7176	1.8001	1.8050	6875	1.4442	1.3965
88	0.137	7006	1.6412	1.6514	6736	1.3360	1.3110
89	0.137	6830	1.4862	1.5014	6590	1.2278	1.2239
90	0.137	6700	1.3778	1.3939	6482	1.1504	1.1586

Table A2.2 Estimated outcomes for females experiencing a primary CVD event

		Undiscounted			Discounted		
Age	Deaths	Cost	LY lost	QALY lost	Cost	LY lost	QALY lost
40	0.091	24973	8.9440	14.2751	12359	2.5067	5.0150
41	0.091	24534	8.6544	13.8265	12271	2.4764	4.9400
42	0.091	24092	8.3682	13.3838	12181	2.4454	4.8641
43	0.091	23652	8.0885	12.9510	12090	2.4140	4.7880
44	0.091	23209	7.8121	12.5241	11995	2.3818	4.7110
45	0.091	22763	7.5392	12.1031	11898	2.3489	4.6332
46	0.091	22320	7.2726	11.6917	11799	2.3156	4.5550
47	0.091	21868	7.0067	11.2824	11696	2.2811	4.4752
48	0.091	21423	6.7498	10.8862	11592	2.2466	4.3957
49	0.091	20976	6.4964	10.4958	11485	2.2112	4.3153
50	0.106	21101	9.7704	12.9985	12581	3.2153	5.2003
51	0.106	20708	9.3773	12.4964	12467	3.1570	5.0959
52	0.106	20315	8.9937	12.0069	12350	3.0980	4.9911
53	0.106	19917	8.6157	11.5252	12230	3.0376	4.8849
54	0.106	19514	8.2431	11.0512	12105	2.9757	4.7773
55	0.106	19110	7.8802	10.5895	11977	2.9131	4.6692
56	0.106	18700	7.5229	10.1354	11845	2.8490	4.5597
57	0.106	18295	7.1791	9.6978	11712	2.7848	4.4506
58	0.106	17879	6.8370	9.2633	11572	2.7184	4.3390
59	0.106	17463	6.5045	8.8407	11428	2.6511	4.2268
60	0.171	17915	10.2543	11.2387	12853	4.4055	5.4347
61	0.171	17564	9.7532	10.7006	12705	4.2890	5.2815
62	0.171	17212	9.2705	10.1825	12554	4.1722	5.1291
63	0.171	16853	8.7946	9.6733	12397	4.0527	4.9744
64	0.171	16493	8.3369	9.1836	12237	3.9330	4.8205
65	0.171	16125	7.8862	8.7026	12070	3.8105	4.6643
66	0.171	15754	7.4481	8.2355	11898	3.6866	4.5075
67	0.171	15377	7.0226	7.7821	11721	3.5612	4.3500
68	0.171	14997	6.6095	7.3423	11538	3.4345	4.1919
69	0.171	14613	6.2089	6.9159	11349	3.3065	4.0331
70	0.152	13882	7.4244	7.4120	11536	4.0009	4.3511
71	0.152	13586	6.9456	6.9501	11364	3.8320	4.1671
72	0.152	13288	6.4870	6.5080	11188	3.6638	3.9848
73	0.152	12982	6.0425	6.0800	11005	3.4943	3.8022
74	0.152	12674	5.6180	5.6713	10818	3.3261	3.6216
75	0.152	12363	5.2133	5.2815	10625	3.1593	3.4433
76	0.152	12050	4.8280	4.9100	10429	2.9944	3.2674

		Undiscounted			Discounted		
Age	Deaths	Cost	LY lost	QALY lost	Cost	LY lost	QALY lost
77	0.152	11735	4.4618	4.5566	10228	2.8316	3.0942
78	0.152	11419	4.1144	4.2208	10022	2.6712	2.9239
79	0.152	11102	3.7856	3.9022	9813	2.5135	2.7569
80	0.147	9675	4.4439	4.0962	8925	3.0384	2.9440
81	0.147	9466	4.0876	3.7784	8770	2.8511	2.7652
82	0.147	9254	3.7506	3.4777	8612	2.6679	2.5909
83	0.147	9040	3.4325	3.1938	8449	2.4893	2.4212
84	0.147	8833	3.1446	2.9359	8290	2.3224	2.2624
85	0.147	8621	2.8687	2.6887	8125	2.1576	2.1060
86	0.147	8413	2.6159	2.4615	7962	2.0020	1.9581
87	0.147	8201	2.3746	2.2444	7793	1.8491	1.8130
88	0.147	7990	2.1500	2.0417	7623	1.7026	1.6739
89	0.147	7780	1.9415	1.8529	7452	1.5628	1.5411
90	0.147	7595	1.7688	1.6946	7300	1.4440	1.4269

6. References

Abelson P et al (2001) *Returns on investment in public health: an epidemiological and economic analysis prepared for the Department of Health and Ageing*. Report for the Department of Health and Ageing, Australia.

Anderson KM, Wilson PW, Odell PM, Kannel WB (1991) An updated coronary risk profile. A statement for health professionals. *Circulation* 83:356-362.

Andronis L, Barton P, Bayliss S, Hyde C (2009) Prevention of cardiovascular disease at population level [cost-effectiveness]. Report to NICE.

Asplund T et al. (2009) Explaining recent Iceland CHD trends using the IMPACT Model. Oral presentation for EUROPREVENT 8th May 2009.

Björck L, Rosengren A, Bennett K, Lappas G, Capewell S. (2009) Modelling the Decreasing CHD Mortality in Sweden between 1986 and 2002. *European Heart Journal* 30: 1046-1056.

Box GEP, Hunter WG, Hunter SJ. (1978) *Statistics for Experimenters*. New York: John Wiley & Sons Inc.

Cappuccio F (2009) *Expert testimony on salt and cardiovascular disease.* Expert paper presented to the Programme Development Group.

Catford J (2009) Advancing the 'science of delivery' of health promotion: not just the 'science of discovery'. *Health Promotion International* 24(1):1-5 (Editorial).

Government Actuary's Department (2009) http://www.gad.gov.uk/ Demography_Data/Life_Tables accessed 2 February 2009.

He FJ, MacGregor GA (2003) How far should salt intake be reduced? *Hypertension* 42: 1093-1099.

Joint British Societies (2005) JBS2: Joint British Societies' guidelines on prevention of cardiovascular disease in clinical practice. *Heart* 91[Suppl V]:v1-v52.

Laatikainen T, Critchley J, Vartiainen et al E. (2005) Explaining the Decline in CHD Mortality in Finland between 1982 and 1997. *American Journal of Epidemiology* 162: 764-773.

Lincoln P (2009) *Expert testimony on the public health harm caused by industrially produced Trans Fatty Acids and actions to reduce and eliminate them from the food system in the UK*. Expert paper presented to the Programme Development Group.

Luengo-Fernández R, Leal J, Gray A, Petersen S, Rayner M. (2006) Cost of cardiovascular diseases in the United Kingdom. *Heart* 92: 1384-1389.

Palmieri L, Bennett K, Giampaoli S, Capewell S. (2009) Explaining the Decrease in CHD Mortality in Italy between 1980 and 2000 *American Journal of Public Health*

Tosteson ANA, Weinstein MC, Hunink MGM et al (1997) Cost-effectiveness of populationwide educational approaches to reduce serum cholesterol levels. *Circulation* 95:24-30.

Trust for America's Health (2008) *Prevention for a healthier America: investments in disease prevention yield significant savings, stronger communities*. Report.

Unal B, Critchley JA, Capewell S. (2004) Explaining the decline in coronary heart disease mortality in England and Wales between 1981 and 2000 *Circulation* 109(9): 1101-1107.

Unal B, Critchley JA, Capewell S. (2005) Modelling The Decline In CHD Deaths In England And Wales, 1981-2000: Comparing contributions from primary prevention and secondary prevention. *BMJ* 331: 614-615.

Ward S, Lloyd Jones M, Pandor A, et al (2005) *Statins for the prevention of coronary events.* Technology assessment report commissioned by the HTA Programme on behalf of the National Institute for Clinical Excellence.

Wanless D et al (2004) *Securing good health for the whole population*. Her Majesty's Stationery Office. Report.