

Primary care

Modelling the decline in coronary heart disease deaths in England and Wales, 1981-2000: comparing contributions from primary prevention and secondary prevention

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Abstract

Objective To investigate whether population based primary prevention (risk factor reduction in apparently healthy people) might be more powerful than current government initiatives favouring risk factor reduction in patients with coronary heart disease (CHD) (secondary prevention).

Design, setting, and participants The IMPACT model was used to synthesise data for England and Wales describing CHD patient numbers, uptake of specific treatments, trends in major cardiovascular risk factors, and the mortality benefits of these specific risk factor changes in healthy people and in CHD patients.

Results Between 1981 and 2000, CHD mortality rates fell by 54%, resulting in 68 230 fewer deaths in 2000. Overall smoking prevalence declined by 35% between 1981 and 2000, resulting in approximately 29 715 (minimum estimate 20 035, maximum estimate 44 675) fewer deaths attributable to smoking cessation: approximately 5035 in known CHD patients and approximately 24 680 in healthy people. Population total cholesterol concentrations fell by 4.2%, resulting in approximately 5770 fewer deaths attributable to dietary changes (1205 in CHD patients and 4565 in healthy people) plus 2135 fewer deaths attributable to statin treatment (1990 in CHD patients, 145 in people without CHD). Mean population blood pressure fell by 7.7%, resulting in approximately 5870 fewer deaths attributable to secular falls in blood pressure (520 in CHD patients and 5345 in healthy people) plus approximately 1890 fewer deaths attributable to antihypertensive treatments in people without CHD. Approximately 45 370 fewer deaths were thus attributable to reductions in the three major risk factors in the population: some 36 625 (81%) in people without recognised CHD and 8745 (19%) in CHD patients.

Conclusions Compared with secondary prevention, primary prevention achieved a fourfold larger reduction in deaths. Future CHD policies should prioritise population-wide tobacco control and healthier diets.

Introduction

Coronary heart disease (CHD) remains the largest cause of death in the United States, Europe, and Australasia.¹ Since the 1980s, CHD mortality rates have halved in Britain and other industrialised countries.¹ Studies in the US, Europe, and New Zealand consistently suggest that 50-75% of the falls in cardiac deaths can be attributed to population-wide improvements in the major risk factors, particularly smoking, cholesterol, and blood pressure.²⁻⁵ Modern cardiologic treatments for CHD patients generally explain the remaining 25-50% of the fall in mortality.²⁻⁵

Risk factor reduction should be a central component of all CHD policies. However, disagreement continues about whether to prioritise risk factor reduction across the whole population (primary prevention) or mainly to target CHD patients (secondary prevention). Current funding in the US⁶ and the United Kingdom clearly favours secondary prevention.

In this study, we analysed the decrease in CHD mortality in England and Wales between 1981 and 2000, using the only validated and comprehensive CHD model available in the UK,⁴ to estimate the proportions attributable to changes in major cardiovascular risk factors in apparently healthy people (primary prevention) and in patients with CHD (secondary prevention).

Methods

IMPACT CHD model—The IMPACT CHD mortality model has been validated and is described elsewhere.^{3 5 7 8} We used the model to synthesise data for the adult population of England and Wales—35.5 million people aged between 25 and 84—describing numbers of CHD patients, uptake of treatments, trends in major cardiovascular risk factors in apparently healthy people and specific patient groups, and the mortality benefits of the reductions in specific risk factors in people with and without CHD.⁴

Data sources—Sources of data included national surveys, official statistics, clinical audits, controlled trials, and meta-analyses.⁹



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Primary prevention: risk factor trends and mortality benefits in the general population—For risk factor changes, the model uses regression (β) coefficients obtained from large meta-analyses, cohort studies, and MONICA analyses.⁴⁻⁹ We estimated the reduction in the number of deaths produced by the decrease in each major risk factor as the product of three variables: the number of CHD deaths observed in the base year (1981), the relative reduction in that risk factor, and the β coefficient, each stratified by age and sex.⁴⁻⁹ To estimate the impact of the population-wide reduction in cholesterol due to dietary change, we subtracted the estimated effect of statins for primary prevention from the overall number of deaths prevented or postponed in the population due to change in mean cholesterol concentration.⁴

Secondary prevention: risk factor trends and mortality benefits in CHD patients—We estimated the mortality benefit attributable to reductions in each major risk factor (smoking, total cholesterol, and blood pressure) in CHD patients as the number of deaths prevented or postponed.⁴ CHD patients included those with acute myocardial infarction, survivors of myocardial infarction, revascularisation patients, and patients with unstable angina, chronic angina, and chronic heart failure.

Statins and other treatments—The model aimed to include all medical and surgical treatments provided in 2000. This included statins as primary and secondary prevention. We calculated the absolute reduction in mortality by using the relative reduction in mortality reported in the most recent meta-analysis.⁹ All other “secondary prevention” drugs and over the counter statins were excluded from this analysis.⁴ We used survival benefit over a one year time interval throughout.

Sensitivity analyses—Because of the uncertainties surrounding some values, we did a multiway sensitivity analysis (see bmj.com).¹⁰

Apportioning deaths prevented or postponed between primary and secondary prevention—We estimated the deaths prevented or postponed in apparently healthy people as the deaths prevented or postponed in the entire population minus the deaths prevented or postponed in each CHD patient group.

Results

Fall in CHD mortality between 1981 and 2000

Between 1981 and 2000, age specific CHD mortality in England and Wales fell by 62% in men and 45% in women aged 25-84. This resulted in 68 230 fewer deaths in 2000, compared with the 1981 baseline.⁴

Medical and surgical treatments together prevented or postponed 25 805 deaths (minimum estimate 17 110, maximum estimate 49 040), representing 42% of the total decrease in CHD deaths.⁴ Approximately 58% (45 370; 29 570-76 835) of the fall in mortality was attributable to reductions in risk factors—smoking, cholesterol, and blood pressure.⁴ In contrast, adverse trends in diabetes, obesity, and physical activity generated approximately 7645 (5395-10 730) additional deaths.⁴

Risk factor reductions in the general population and in CHD patients

Overall smoking prevalence fell by 35% between 1981 and 2000. This resulted in 29 715 (20 035-44 675) fewer deaths—5035 (17%; 3 100-8 255) in CHD patients and 24 680 (83%; 16 935-36 420) in “healthy people” (table 1).

Population total cholesterol concentrations fell by 4.2% between 1981 and 2000, resulting in 7900 (5285-16 695) fewer deaths (5770 were attributable to dietary reduction: 1205 (645-2455) in CHD patients; 4565 (3290-9650) in healthy people). Approximately 2135 (1350-4590) fewer deaths were attributable to statin treatments: 1990 (1305-4180) in CHD patients and 145 (45-410) in healthy people (table 1).

Mean population diastolic blood pressure fell by 7.7% between 1981 and 2000, resulting in 7755 (4250-15 465) fewer deaths (520 (285-940) in CHD patients; 5345 (3125-11 740) in healthy people), and 1890 (840-2785) fewer deaths were attributable to antihypertensive treatments in 7.1 million hypertensive people (table 1).⁴

All secondary prevention interventions accounted for 8745 (5335-15 830) fewer deaths (19% of the total number of 45 370 deaths prevented or postponed by change in the three major risk factors; minimum contribution 18.0%, maximum contribution 21.0%) (table 1). The remaining reduction in deaths (45 370 minus

Table 1 Fall in coronary heart disease mortality attributable to changes in risk factors in people with and without recognised coronary heart disease: England and Wales, 1981-2000

Risk factor	Change in population risk factor level (%)	Deaths prevented or postponed				Total
		Primary prevention*		Secondary prevention*		
		No (min-max)†	%	No (min-max)†	%	
Smoking:						
Overall	-35	24 680 (16 935-36 420)	83	5 035 (3 100-8 255)	17	29 715 (20 035-44 675)
Cholesterol:						
Overall	-4.2	4 710 (3 335-10 060)	60	3 190 (1 950-6 635)	40	7 900 (5 285-16 695)
Attributable to diet		4 565 (3 290-9 650)		1 205 (645-2 455)		5 770 (3 935-12 105)
Attributable to statins		145 (45-410)		1 990 (1 305-4 180)		2 135 (1 350-4 590)
Blood pressure:						
Overall	-7.7	7 235 (3 965-14 525)	93	520 (285-940)	7	7 755 (4 250-15 465)
Secular trend		5 345 (3 125-11 740)		520 (285-940)		5 870 (3 410-12 680)
Antihypertensive treatment		1 890 (840-2 785)		‡		1 890 (875-3 165)
All three major risk factors		36 625 (24 235-61 005)	81	8 745 (5 335-15 830)	19	45 370 (29 570-76 835)

*Primary prevention=in healthy people; secondary prevention=in people with coronary heart disease.

†All numbers rounded to nearest 5; min-max=minimum and maximum estimates.

‡Antihypertensive treatment in coronary heart disease patients was subsumed in secondary prevention medication component of IMPACT model.

8745) can be attributed to primary prevention in healthy people: 36 625 (24 235-61 005) fewer deaths, representing 81% of the total mortality decrease of 45 370 deaths prevented or postponed by change in the three major risk factors (minimum contribution 53.4%, maximum contribution 79.3%) (table 1).

Sensitivity analyses

The relative contribution to the overall decline in CHD deaths from primary and secondary prevention for each risk factor was little changed by whether best, minimum, or maximum estimates were considered (see *bmj.com*).

Risk factor reduction benefits in specific groups of CHD patients

In 2000, approximately 30 530 (18 630-54 180) deaths were prevented or postponed in patients with CHD. Some 23 770 (77.9%) were attributable to medical and surgical treatments, and 6760 (22.1%) were attributable to reductions in the three major risk factors (table 2).

Approximately 1990 (1305-4180) fewer deaths were attributable to statin treatments in CHD patients. The biggest contributions came from statin treatment for patients after acute myocardial infarction (460), revascularisation (675), or heart failure (750) (table 2).

Discussion

Mortality from coronary heart disease in England and Wales fell by 54% between 1981 and 2000.^{1 4} Approximately half of this reduction could be attributed to primary prevention, defined as reductions in the three major risk factors in people without recognised CHD. Primary prevention had a fourfold greater impact than secondary prevention (risk factor reductions in CHD patients). This was much as predicted by Rose and others.^{11 12} The fourfold advantage contrasted with the 25% to 29% split estimated by using the CHD policy model for the US population 1980-90.² However, the difference may reflect different categorisation of primary versus secondary prevention rather than true differences between populations.

The fourfold advantage of primary prevention becomes 12-fold greater when life years gained are considered.⁸ A death prevented or postponed in a patient with CHD gains an additional 7.5 years of life, compared with 21 years for primary prevention in a healthy person.⁸

The biggest single contribution was a decrease in overall smoking prevalence, from 39% in 1981 to 28% in 2000.⁴ The evidence base is now particularly solid for smoking cessation, with 50 year data from the Doll cohort and the recent Cochrane meta-analysis showing a 36% reduction in mortality in CHD patients who stop smoking.^{13 14} However, opportunities for smoking cessation in secondary prevention are limited, as around 50% of myocardial infarctions are rapidly fatal.¹⁵ It therefore makes sense to target smokers before they develop clinical disease.

Primary prevention also had an almost fourfold bigger impact on mortality than did secondary prevention for dietary based cholesterol reduction and a 10-fold bigger impact through blood pressure reduction. Antihypertensive treatments contributed fewer deaths.

UK population levels of both cholesterol and blood pressure declined modestly between 1981 and 2000.

Table 2 Fall in coronary heart disease mortality in England and Wales between 1981 and 2000: numbers of deaths prevented or postponed by treatments and by changes in risk factors in people with coronary heart disease, categorised into specific groups

Patient groups	No of deaths prevented or postponed*	Minimum and maximum estimates	Percentage
After acute myocardial infarction			
All treatments:	3 840	2 865-5 080	66.5
Statin	460	430-1 340	8.0†
Smoking cessation	1 450	880-2 315	25.1
Cholesterol reduction (diet)	335	250-560	5.8
Blood pressure reduction	140	70-230	2.4
Total	5 765	4 060-8 185	100
After CABG surgery or angioplasty			
All treatments:	3 055	1 740-7 620	74.0
Statin	675	380-1 495	16.3†
Smoking cessation	820	510-1 150	19.8
Cholesterol reduction (diet)	195	65-320	4.7
Blood pressure reduction	60	40-130	1.4
Total	4 130	2 355-9 225	100
Angina			
Revascularisation	2 320	1 185-3 495	100
Chronic angina in the community			
All treatments:	1 105	720-2 395	43.6
Statin	105	95-275	4.2†
Smoking cessation	1 115	715-1 605	44.0
Cholesterol reduction (diet)	200	95-460	7.5
Blood pressure reduction	115	75-170	4.5
Total	2 535	1 605-4 630	100
Acute myocardial infarction			
All treatments	4 780	3 225-8 290	100
Unstable angina			
All treatments	910	620-1 620	100
Heart failure requiring hospital admission			
All treatments:	4 535	2 295-7 680	85.2
Statin	415	290-575	7.7†
Smoking cessation	595	400-1 025	11.2
Cholesterol reduction (diet)	130	55-265	2.5
Blood pressure reduction	60	15-97	1.2
Total	5 325	2 765-9 070	100
Heart failure in the community			
All treatments:	3 220	1 950-6 345	67.6
Statin	335	110-490	7.0†
Smoking cessation	1 055	600-2 160	22.1
Cholesterol reduction (diet)	350	175-845	7.3
Blood pressure reduction	140	85-310	3.0
Total	4 770	2 810-9 665	100
All groups			
All treatments:	23 770‡	14 600-42 530	77.9
Statin	1 990	1 305-4 180	6.5†
Smoking cessation	5 035	3 100-8 255	16.5
Cholesterol reduction (diet)	1 205	645-2 455	3.9
Blood pressure reduction	520	285-940	1.7
Total	30 530	18 630-54 180	100

CABG=coronary artery bypass graft.

*All numbers rounded to nearest 5, so sums may differ from totals in table 1.

†Statin percentages already included within treatments.

‡This total mirrors the treatment effect (25 805) reported in our previous publication,¹⁵ which included antihypertensive treatment in people without coronary heart disease (1888) and statin treatment as primary prevention (145).

Having considered therapeutic interventions in our model, we attributed the remainder of the cholesterol and blood pressure declines to lifestyle changes—either physical activity or diet.

The current findings support the population prevention approach.¹¹ It has been repeatedly shown that achieving apparently small mortality benefits across the entire population would produce far larger

What is already known on this topic

Coronary heart disease (CHD) mortality has halved since 1981 in the UK, resulting in 68 230 fewer deaths in 2000

Current government initiatives favour risk factor reduction in CHD patients (secondary prevention), but population based primary prevention (risk factor reduction in apparently healthy people) might be more powerful

What this study adds

Approximately 45 370 fewer CHD deaths were attributable to reductions in smoking, cholesterol, and blood pressure in the whole population

Some 36 625 (81%) of these fewer deaths occurred in people without recognised CHD and 8745 (19%) in CHD patients

Compared with secondary prevention, primary prevention achieved a fourfold larger reduction in deaths

overall gains than merely targeting people at high risk in order to achieve big reductions in mortality in a relatively small number of people.^{11 12}

Modelling studies have several strengths. They can transparently integrate and simultaneously consider huge amounts of data from many sources. Explicit assumptions can be tested by using sensitivity analyses. Modelling studies also have limitations. They are dependent on the variable quality and extent of available data. Rigorous sensitivity analyses are therefore essential.¹⁰ In our study, the relative contribution of primary and secondary prevention to the overall decline in CHD deaths was reasonably consistent whether considering best, minimum, or maximum estimates. Finally, lag times may be relatively unimportant over two decades. Substantial mortality reductions occur within one or two years of reducing cholesterol or stopping smoking.¹⁴

Approximately 1990 fewer deaths were attributable to statin treatment in CHD patients, and 145 to statins as primary prevention. This estimate is less than the recently quoted UK government figure of "7000 lives saved by statins in 2003."¹⁶ Realistic assumptions about long term prescribing and compliance are essential.

Conclusions

Approximately half the recent large falls in CHD deaths in England and Wales can be attributed to primary prevention: reductions in the three major risk factors in people without recognised CHD. Primary prevention had a fourfold bigger impact on mortality than secondary prevention. Comprehensive CHD strategies should therefore focus on primary prevention, particularly tobacco control and healthier diets.

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- 1 British Heart Foundation Statistics Database. Coronary heart disease statistics, 2005. www.heartstats.org (accessed 12 Jun 2005).
- 2 Hunink MG, Goldman L, Tosteson AN, Mittleman MA, Goldman PA, Williams LW, et al. The recent decline in mortality from coronary heart disease, 1980-1990: the effect of secular trends in risk factors and treatment. *JAMA* 1997;277:535-42.
- 3 Capewell S, Morrison CE, McMurray JJ. Contribution of modern cardiovascular treatment and risk factor changes to the decline in coronary heart disease mortality in Scotland between 1975 and 1994. *Heart* 1999;81:380-6.
- 4 Unal B, Critchley J, Capewell S. Explaining the decline in coronary heart disease mortality in England and Wales, 1981-2000. *Circulation* 2004;109:1101-7.
- 5 Capewell S, Beaglehole R, Seddon M, McMurray J. Explaining the decline in coronary heart disease mortality in Auckland, New Zealand between 1982 and 1993. *Circulation* 2000;102:1511-6.
- 6 US Department of Health and Human Services. *Healthy people 2010. Vol 1: Understanding and improving health; Objectives for improving health*. Washington, DC: Government Printing Office, 2000.
- 7 Critchley J, Liu J, Zhao D, Wei W, Capewell S. Explaining the increase in coronary heart disease mortality in Beijing between 1984 and 1999. *Circulation* 2004;110:1236-44.
- 8 Unal B, Critchley JA, Fidan D, Capewell S. Life-years gained from modern cardiologic treatments and population risk factor changes in England and Wales, 1981-2000. *Am J Public Health* 2005;95:103-8.
- 9 Unal B, Critchley J, Capewell S. Appendices for IMPACT CHD mortality model. www.liv.ac.uk/PublicHealth/sc/bua/IMPACTModel-Appendices.pdf (accessed 22 Jun 2005).
- 10 Briggs A, Sculpher M, Buxton M. Uncertainty in the economic evaluation of health care technologies: the role of sensitivity analysis. *Health Econ* 1994;3:95-104.
- 11 Rose G. *The strategy of preventive medicine*. Oxford: Oxford University Press, 1992.
- 12 Emberson J, Whincup P, Morris R, Walker M, Ebrahim S. Evaluating the impact of population and high-risk strategies for the primary prevention of cardiovascular disease. *Eur Heart J* 2004;25:484-91.
- 13 Doll R, Peto R, Boreham J, Sutherland I. Mortality in relation to smoking: 50 years' observations on male British doctors. *BMJ* 2004;328:1519.
- 14 Critchley J, Capewell S. Mortality risk reduction associated with smoking cessation in patients with coronary heart disease: a systematic review. *JAMA* 2003;290:86-97.
- 15 Capewell S, MacIntyre K, Stewart S, Chalmers JW, Boyd J, Finlayson A, et al. Age, sex, and social trends in out-of-hospital cardiac deaths in Scotland 1986-95: a retrospective cohort study. *Lancet* 2001;358:1213-7.
- 16 Boyle R. Meeting the challenge of cardiovascular care in the new National Health Service. *Heart* 2004;90(suppl 4):iv3-5.

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