

PUBLIC HEALTH POLICY AND PRACTICE

Substantial potential for reductions in coronary heart disease mortality in the UK through changes in risk factor levels

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Study objective: The UK government called for a 40% reduction in cardiovascular disease mortality in those aged under 75 by 2010. This paper examines the potential for cardiovascular risk factor changes to reduce coronary heart disease deaths in Scotland, and then extrapolates the findings to the UK population.

Design: Secondary analysis of published data using a previously validated mortality model. The model combines uptake and effectiveness of treatments with risk factor trends by sex and age group. It was used to estimate the expected reductions in coronary heart disease mortality: (a) if recent risk factor trends simply continued; (b) if additional risk factor reductions were achieved in line with Scandinavia and the United States. An "analysis of extremes" sensitivity analysis was then carried out.

Setting: Scotland and UK.

Participants: Projected Scottish population aged 45+ in 2010 (2.4 million) and UK population of 26.8 million.

Main results: Continuation of current trends would result in 2169 fewer coronary deaths in 2010 (minimum estimate 1191 from sensitivity analyses to maximum 3870). About 4749 fewer deaths (minimum 3085, maximum 7155) could be achieved by: (a) a reduction in smoking prevalence from 30% to 18% (about 1668 fewer deaths); (b) a mean population cholesterol reduction from 6.2 to 5.2 mmol/l (about 2167 fewer deaths); (c) a 3.7 mm Hg fall in diastolic blood pressure (about 914 fewer deaths). Extrapolation from the Scottish population to the UK suggests 24 000 fewer deaths in 2010 if current trends continue, or 53 000 fewer deaths with the additional reductions.

Conclusions: With additional interventions it would be possible to almost halve current UK coronary heart disease mortality. Even without gains from medical treatments, the UK government target of 28 000 fewer deaths in 2010 does not seem challenging.

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Coronary heart disease mortality rates have halved in most industrialised countries since the 1970s (fig 1). However, mortality has declined less in the UK, and coronary heart disease remains the single largest cause of death.¹ The UK government recently endorsed cardiovascular disease as a top priority, and the *Saving Lives* white paper set the target of 200 000 fewer coronary heart disease deaths by 2010 (with 28 000 fewer in the year 2010).¹

It is thus vital to explain the observed declines in coronary mortality, and evaluate the potential for further reductions.

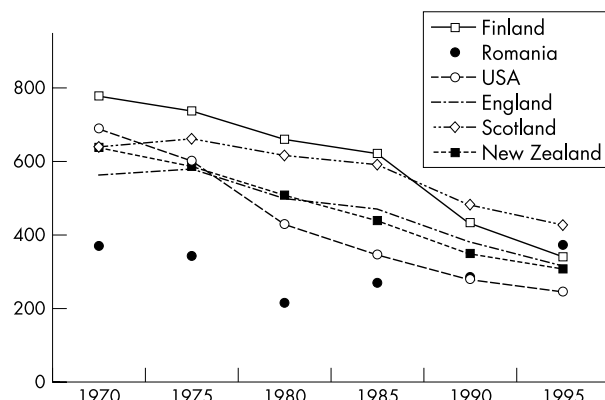


Figure 1 International trends in age standardised coronary heart disease mortality in men aged 35–74 between 1979 and 1995 (WHO statistics, 1998).

Large long term cohorts, such as the Framingham study² and the British Regional Heart Study³ have shown substantial reductions in coronary heart disease risk from changes in major risk factors, such as smoking, blood pressure, and cholesterol.

Attributing falls in mortality to specific risk factor changes or effective medical interventions such as aspirin,⁴ and β blockers,⁵ is difficult because favourable trends in both have occurred simultaneously. Furthermore, risk factor changes such as cholesterol lowering may be achieved through "lifestyle" change or pharmacologically.⁶ In 1996, Capewell *et al* developed and refined a Scottish coronary heart disease mortality model,⁷ which combined data from multiple sources on patient numbers, treatment effectiveness, and risk factor trends. Analysing the observed fall of 6747 deaths between 1975 and 1994, about 60% was attributed to changes in major risk factors and 40% to specific cardiological treatments. The estimates were validated against the actual mortality falls observed, and replicated, using independent data in New Zealand.⁸ Despite different settings, timescales, and methodologies, models suggest that reductions in major risk factors account for over half the observed mortality declines, and treatments just under half.^{9–11}

This study builds on earlier work in Scotland. Having incorporated more recent and robust coefficients relating changes in population risk factor levels and coronary heart disease mortality rates,¹² we now extend the model to estimate the number of deaths that could be prevented or postponed between 1994 and 2010. Initially, by simply assuming that risk factors continue to decline at their current rates, and then by

Table 1 Contribution of changes in population risk factors to the projected fall in coronary heart disease mortality in Scotland between 1994 and 2010. (1) Current trend assuming that risk factors continue to fall at same relative rates, (2) assuming additional reductions

Risk factor	% Risk factor reduction (1994 to 2010) men women		Total deaths prevented or postponed in 2010 as a result of reductions in risk factors since 1994 (maximum and minimum estimates)	Proportion of total deaths prevented or postponed*
Smoking				
(1) assuming current trend	29	26	937 (505–1862)	19
(2) additional reduction	41	29	1668 (1308–2387)	22
Cholesterol				
(1) assuming current trend	2	9	774 (507–951)	15
(2) additional reduction	13	16	2167 (1419–2664)	29
Population blood pressure				
(1) assuming current trend	3	8	459 (180–1057)	9
(2) additional reduction	7	16	914 (357–2104)	12
Total risk factors				
(1) assuming current trends			2169 (1191–3870)	43
(2) additional reductions			4749 (3085–7155)	62

*Percentages may not sum to totals because of rounding.

assuming larger but feasible risk factor reductions. These results are then applied to the UK population to estimate the potential mortality reductions achievable.

METHODS

The model uses regression coefficients estimated from large cohort studies and MONICA analyses^{7 12–15} to describe the relation between population changes in specific cardiovascular risk factors, and population mortality rates from coronary heart disease. For each major risk factor, the subsequent reduction in deaths is estimated as the product of the specific regression coefficient, the relative risk factor reduction, and the number of coronary heart disease deaths observed at the beginning of the time period of interest. The coefficients were decreased for older age groups to reflect the epidemiological evidence suggesting that relative risk attenuates with age^{15 16} (appendices 1 and 2, see journal web site).

Extension of the model to 2010

The refined model was extended from 1975 through 1994 to the year 2010, using deaths and population size by sex and age group for Scotland annually from 1986 to 1998,¹⁷ and projected population estimates to 2010. The “baseline” deaths expected in 2010 were calculated by applying the age specific death rates in 1994 to the 2010 projected population. Projected death rates from coronary heart disease in 2010 were then estimated by extrapolating current trends to the year 2010 using five year rolling averages.

(1) Current trends in risk factors between 1994 and 2010

We firstly assumed that the average annual trends in total cholesterol and blood pressure observed in the Glasgow MONICA population¹² between 1986 and 1995, continued until 2010 and extrapolated to the wider Scottish population. Trends in smoking prevalence were estimated using Scottish data from the General Household Survey.^{18 19} Only limited information was available for those aged over 65; where necessary it was assumed that risk factor reductions were only 50% of those seen in younger age groups.

(2) Additional reductions in risk factors between 1994 and 2010

The calculations were then repeated assuming greater risk factor reductions. Realistic and feasible risk reductions were chosen, based on data from comparable populations.

(a) Smoking

The UK target to reduce smoking prevalence to 24% among adults by 2010 does not seem challenging,²⁰ and may be

achieved simply on the basis of current trends. In contrast, the US *Healthy People 2010* smoking prevalence target of 12% by 2010²¹ seems demanding, and for Scotland between 1994 and 2010 would require a 60% relative reduction in smoking prevalence. A more realistic compromise, smoking prevalence of 18% in 2010 in all ages under 75, was therefore chosen. Smoking prevalences are already lower than 18% among people aged over 65 in the UK.²²

(b) Cholesterol

Reductions in population mean cholesterol levels have been modest in Scotland; less than 5% in men and women aged 45–64 between 1985–94.¹² The annual relative falls of 1% in men and 1.4% in women observed in Gothenberg, Sweden¹² (another Northern Europe population) were therefore applied to the Scottish population (target levels for 2010 would then resemble those observed in the 1990s in populations such as Gothenberg, Stanford, USA and Perth, Australia¹²).

(c) Blood pressure

Finally, an additional 3.7 mm Hg decrease in population mean diastolic blood pressure between 1994 and 2010 was tested. Such falls have been observed in several countries within the MONICA study.¹²

Sensitivity analysis

Because of the uncertainties surrounding some values, an analysis of extremes^{23 24} sensitivity analysis was performed.²⁴ Estimated mortality reductions were generated using minimum and maximum plausible values for the main parameters⁸ (appendix 2).

RESULTS

Trends observed in Scotland, 1986–1998

Overall annual declines in coronary heart disease mortality rates were 2.6% in men, and 2.2% in women, ranging from 5% in the younger age groups to 1% in women aged over 85.

Estimated changes in coronary heart disease mortality in Scotland between 1994 and 2010

Assuming that current trends in age specific death rates continued to 2010, 11 287 deaths would be expected in 2010 (6048 among men, 5239 in women, overall reductions of 39% and 32% respectively from 1994). The estimated age specific percentage declines between 1998 (the most recent year for which data were available) and 2010 in those aged 45–54, 55–64 and 65–74 would be 46%, 42%, and 36% in men and 45%, 40%, and 32% in women respectively.

Table 2 Risk factor levels at 1994 baseline and projections to 2010, for men and women aged 45–65 years

Year	Smoking (prevalence)		Cholesterol (mmol/l)		Diastolic blood pressure (mm Hg)	
	Men	Women	Men	Women	Men	Women
1994 (baseline)	34	34	6.2	6.5	78.3	74.8
2010 (current trends)	23	24	6.0	5.7	75.1	70.7
2010 (additional reductions)	18	18	5.2	5.1	72.0	66.5

Table 3 Reduction in CHD mortality achievable in 2010 with (1) current risk factor trends and (2) additional risk factor reductions: distribution by age and sex

Age groups	Men		Women	
	Number of deaths prevented or postponed	%*	Number of deaths prevented or postponed	%
45–54				
(1) current trend	147	7	56	3
(2) additional reduction	328	7	98	2
55–64				
(1) current trend	359	17	234	11
(2) additional reduction	944	20	429	9
65–74				
(1) current trend	528	24	172	8
(2) additional reduction	745	16	532	11
75+				
(1) current trend	379	17	295	14
(2) additional reduction	604	13	1070	23
Totals (all ages)				
(1) current trend	1413	65	756	35
(2) additional reduction	2620	55	2129	45

*Proportion of all deaths prevented or postponed in 2010 by risk factor reductions. Percentages and number of deaths may not sum to totals due to rounding.

Cardiovascular risk factor changes

(a) Based on *current trends* only

Projections of current risk factor trends suggest that 2169 deaths would be prevented or postponed in 2010 as a result of the reductions since 1994 (minimum estimate from sensitivity analyses 1191, maximum 3870, table 1). These 2169 fewer deaths would result from 937 attributable to falling trends in smoking (from a population prevalence of 30% to 21%), 774 attributable to a reduction in cholesterol (from 6.3 mmol/l to 5.8 mmol/l among under 65s), and 459 attributable to falls in population diastolic blood pressure (from 76 mm Hg to 73 mm Hg among under 65s, tables 1 and 2).

(b) *Additional reductions* in major risk factors (tables 1 and 2)

A total of about 4749 deaths (minimum 3085, maximum 7155) could be prevented or postponed by additional but feasible reductions in the major cardiovascular risk factors.

(i) 1668 fewer deaths assuming that smoking prevalence fell to 18%;

(ii) 2167 fewer deaths assuming that population mean cholesterol levels declined as in Gothenburg, Sweden (by 2010 reaching 5.2 mmol/l among men, and 5.1 mmol/l among women under 65);

(iii) 914 fewer deaths assuming an average further decrease in mean diastolic blood pressure of 3.7 mm Hg across all age and sex groups (from 76 mm Hg to 69 mm Hg among those aged under 65).

The number of deaths prevented or postponed in 2010 due to these additional risk factor changes could thus be increased more than twofold from 2169 if current trends continue, to 4749 (table 1). The absolute risk factor levels that would be achieved in 2010 are detailed in table 2.

In women, much of the benefit would occur among older age groups, whereas in men benefits would be more evenly distributed (table 3).

Comparison with UK targets and extrapolation to the UK population

The UK target calls for a 40% reduction in coronary mortality, with 28 000 lives to be saved in 2010.¹ Simple extrapolation from the Scottish model estimates (4749 lives saved with additional risk factor interventions in a population of 2.4 million) to the UK population of 26.8 million suggests that 53 000 lives could be saved in the year 2010. Conservatively assuming that 60% of these (32 000) are in the target age groups (<75), it seems that the 28 000 target could be met entirely through risk factor changes. Furthermore, substantial improvements in treatment efficacy and uptake are also expected.²⁵

DISCUSSION

Over 50 000 coronary deaths could be prevented or postponed in 2010 in the UK with the additional risk factor reductions. This would represent almost half the 110 000 current annual cardiac deaths in the UK.²⁶ Over 60% of the reduction would occur in the premature deaths aged under 75 specified in government targets. Most of the reduction would be seen among men, because of the lower mortality rates among younger women. Simple extrapolation of current mortality trends suggests that the UK target is not testing.²⁷

To date, the biggest mortality benefits have come from reductions in smoking,⁷ as elsewhere in Europe, the US, and New Zealand.^{7–11 16} However, reductions in cholesterol seem to have even greater potential to further reduce coronary heart disease mortality rates in the UK and elsewhere. Past falls

Key points

- We examined the potential for cardiovascular risk factor reductions to reduce coronary deaths in Scotland and the UK by 2010.
- Our cell based IMPACT CHD model combines information on patient numbers, treatment uptake and effectiveness, risk factor trends, and mortality benefits.
- If major risk factors continued to reduce at current rates, 2169 fewer coronary deaths would be observed in Scotland in 2010.
- Over 4000 deaths could be prevented if greater risk reductions, observed in other populations, were achieved for smoking, cholesterol, and blood pressure.
- Extrapolation to the UK population suggests that UK coronary heart disease mortality could be almost halved.

have been modest, and cholesterol levels in Britain remain higher than most other Western countries. Importantly, population coronary heart disease mortality is reduced more by a 1% relative reduction in cholesterol than by a 1% relative reduction in population mean blood pressure or smoking prevalence^{8 12 28–30} (appendix 2). The need for more effective dietary interventions is clear.

As with all models, this analysis contains a number of limitations (see appendices 1 and 2). Firstly, it considers only mortality, and not years of life lost or morbidity. Our estimates of deaths prevented or postponed would translate into substantial numbers of life years gained.³¹ Secondly, the model is cell based and comparatively simple.^{7 8} The results should be replicated in a more complex simulation model, to explicitly consider lag times and interactions between various interventions.^{7 8 11 32} We considered only deaths from coronary heart disease, and it is possible that some increase in death rates from other “competing causes”³³ may be observed. However, reductions in risk factors such as smoking would decrease deaths from other causes such as lung cancer.³⁴

A number of further assumptions have been made. For example, whether mortality and risk factors will continue to decline at the same rate until 2010. It has also been assumed that the estimates obtained from Scotland can be extrapolated to the entire UK. Although socioeconomic factors may differ, this assumption seems justifiable as population distributions, life expectancy, and CHD risk factors are reasonably similar. Extensive sensitivity analyses were performed to consider higher or lower values for each regression coefficient.^{23 24} These influenced the number of deaths postponed or prevented, but did not change the relative contribution of each risk factor. International comparisons also suggest that much lower coronary death rates might well be achievable. Overall, the observed reduction between 1994 and 1998 has been slightly higher than expected from extrapolation. Our estimated reductions in 2010 may prove to be conservative. Furthermore, the recent National Service Framework for coronary heart disease treatment targets will probably also achieve substantial reductions.^{25 35}

Existing UK government *Saving Lives* targets¹ therefore seem achievable. However, continuation of the current trends cannot be assumed, given the “levelling off” in coronary heart disease mortality recently seen in the US.³⁶ Britain lags behind many other countries and coronary heart disease will remain the biggest cause of death for the foreseeable future. Fresh initiatives to reduce major cardiovascular risk factors could produce further substantial reductions in mortality.²⁸

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Additional information regarding this paper is available on the journal web site (www.jech.com/supplemental)

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REFERENCES

- 1 **Department of Health**. *Saving lives: our healthier nation*. London: Stationery Office, 1999.
- 2 **Dawber TR**, Meadors GF, Moore FEJ. Epidemiological approaches to heart disease: the Framingham Study. *Am J Public Health* 1951;**41**:279–86.
- 3 **Shaper AG**, Pocock SJ, Walker M, *et al*. British Regional Heart Study: cardiovascular risk factors in middle-aged men in 24 towns. *BMJ Clin Res Ed* 1981;**283**:179–86.
- 4 **Antiplatelet Trialists' Collaboration**. Collaborative overview of randomised trials of antiplatelet therapy—I: Prevention of death, myocardial infarction, and stroke by prolonged antiplatelet therapy in various categories of patients. *BMJ* 1994;**308**:81–106.
- 5 **Yusuf S**, Lessem J, Jha P, *et al*. Primary and secondary prevention of myocardial infarction and strokes: an update of randomly allocated, controlled trials. *J Hypertens Suppl* 1993;**11**:S61–73.
- 6 **Scandinavian Simvastatin Survival Study**. Randomised trial of cholesterol lowering in 4444 patients with coronary heart disease: the Scandinavian Simvastatin Survival Study (4S). *Lancet* 1994;**344**:1383–9.
- 7 **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.
- 8 **Capewell S**, Beaglehole R, Seddon M, *et al*. Explaining the decline in coronary heart disease mortality in Auckland, New Zealand between 1982 and 1993. *Circulation* 2000;**102**:1151–6.
- 9 **Beaglehole R**. Medical management and the decline in mortality from coronary heart disease. *BMJ Clin Res Ed* 1986;**292**:33–5.
- 10 **Goldman L**, Cook EF. The decline in ischemic heart disease mortality rates. An analysis of the comparative effects of medical interventions and changes in lifestyle. *Ann Intern Med* 1984;**101**:825–36.
- 11 **Hunink MG**, Goldman L, Tosteson AN, *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.
- 12 **Kuulasmaa K**, Tunstall PH, Dobson AJ, *et al*. Estimation of contribution of changes in classic risk factors to trends in coronary-event rates across the WHO MONICA Project. *Lancet* 2000;**355**:675–87.
- 13 **Dobson AJ**. Relationship between risk factor trends and disease trends. *Ann Med* 1994;**26**:67–71.
- 14 **Van den Hoogen PC**, Feskens EJ, Nagelkerke NJ, *et al*. The relation between blood pressure and mortality due to coronary heart disease among men in different parts of the world. Seven Countries Study Research Group. *N Engl J Med* 2000;**342**:1–8.
- 15 **Law MR**, Wald NJ, Thompson SG. By how much and how quickly does reduction in serum cholesterol concentration lower risk of ischaemic heart disease? *BMJ* 1994;**308**:367–72.
- 16 **Fichtenberg CM**, Glantz SA. Association of the California Tobacco Control Program with declines in cigarette consumption and mortality from heart disease. *N Engl J Med* 2001;**343**:1772–7.
- 17 **Information and Statistics Division**, Common Services Agency for the NHS in Scotland. Edinburgh: 2000.
- 18 **Gilbert, GN**, Arber, S, Dale A. *General Household Survey*. Office Of Population Censuses And Surveys, 1973. Guildford: University Of Surrey, 1980.
- 19 **Office of Population Censuses and Surveys Social Survey Division**. *General Household Survey, 1994–1995 [computer file]*. Colchester, Essex: UK Data Archive [distributor], 13 May 1996. SN: 3196, SN: 3538. SN: 3804
- 20 **McElduff P**, Dobson A, Jamrozik K, *et al*. Opportunities for control of coronary heart disease in Australia. *Aust N Z J Public Health* 2001;**25**:24–30.
- 21 **US Department of Health and Human Services**, Office of Disease Prevention and Health Promotion. *Healthy people*. Washington: US Department of Health, 2000.
- 22 **Erens B**, Primatesta P. Department of Health. *Health Survey for England. Cardiovascular disease 1998*. London: The Stationery Office, 1999.
- 23 **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.

- 24 **Briggs A**. Economics notes: handling uncertainty in economic evaluation. *BMJ* 1999;**319**:120.
- 25 **Department of Health**. *National Service Framework for coronary heart disease*. 2000. (<http://www.doh.gov.uk/pdfs/chdnfs.pdf>).
- 26 **British Heart Foundation**. *British Heart Foundation statistics database 2000, annual compendium 2000. Coronary heart disease statistics*. Oxford: British Heart Foundation, 2000.
- 27 **Britton A**, McPherson K. *Monitoring the progress of the 2010 target for coronary heart disease mortality: estimated consequences on CHD incidence and mortality from changing prevalence of risk factors. A report for the Chief Medical Officer, 2000*. London: London School of Hygiene and Tropical Medicine, 2000.
- 28 **Vartiainen E**, Puska P, Pekkanen J, *et al*. Changes in risk factors explain changes in mortality from ischaemic heart disease in Finland. *BMJ* 1994;**309**:23–7.
- 29 **Sigfusson N**, Sigvaldson H, Steingrimsdottir L, *et al*. Decline in ischaemic heart disease in Iceland and change in risk factor levels. *BMJ* 1991;**302**:1371–5.
- 30 **Dobson A**, Filipiak B, Kuulasmaa K, *et al*. Relations of changes in coronary disease rates and changes in risk factor levels: methodological issues and a practical example. *Am J Epidemiol* 1996;**143**:1025–34.
- 31 **Grover SA**, Gray-Donald K, Joseph L, *et al*. Life expectancy following dietary modification or smoking cessation. Estimating the benefits of a prudent lifestyle. *Arch Intern Med* 1994;**154**:1697–704.
- 32 **Gunning-Schepers LJ**. The health benefits of prevention - a simulation approach. *Health Policy* 1989;**12**:1–256.
- 33 **Bonneux L**, Looman C, Barendregt J, *et al*. Regression analysis of recent changes in cardiovascular morbidity and mortality in the Netherlands. *BMJ* 1997;**314**:789–91.
- 34 **Tsevat J**, Weinstein MC, Williams LW, *et al*. Expected gains in life expectancy from various coronary heart disease risk factor modifications. *Circulation* 1991;**83**:1194–201.
- 35 **Capewell S**, Pell JP, Morrison C, *et al*. Increasing the impact of cardiological treatments. How best to reduce deaths. *Eur Heart J* 1999;**20**:1386–92.
- 36 **Cooper R**, Cutler J, Desvigne-Nickens P, *et al*. Trends and disparities in coronary heart disease, stroke, and other cardiovascular diseases in the United States. *Circulation* 2000;**102**:3137–47.