Cost effectiveness of lowering cholesterol concentration with statins in patients with and without pre-existing coronary heart disease: life table method applied to health authority population

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Abstract

Objectives—To estimate the cost effectiveness of statins in lowering serum cholesterol concentration in people at varying risk of fatal cardiovascular disease and to explore the implications of changing the criteria for intervention on cost and cost effectiveness for a purchasing authority.

Design—A life table method was used to model the effect of treatment with a statin on survival over 10 years in men and women aged 45–64. The costs of intervention were estimated from the direct costs of treatment, offset by savings associated with a reduction in coronary angiographies, non-fatal myocardial infarctions, and revascularisation procedures. The robustness of the model to various assumptions was tested in a sensitivity analysis.

Setting—Population of a typical district health authority.

Main outcome measure—Cost per life year saved.

Results—The average cost effectiveness of treating men aged 45–64 with no history of coronary heart disease and a cholesterol concentration >6.5 mmol/l for 10 years with a statin was £136 000 per life year saved. The average cost effectiveness for patients with pre-existing coronary heart disease and a cholesterol concentration >5.4 mmol/l was £32 000. These averages hide enormous differences in cost effectiveness between groups at different risk, ranging from £6000 per life year in men aged 55–64 who have had a myocardial infarction and whose cholesterol concentration is above 7.2 mmol/l to £361 000 per life year saved in women aged 45–54 with angina and a cholesterol concentration of 5.5–6.0 mmol/l.

Conclusions—Lowering serum cholesterol concentration in patients with and without pre-existing coronary heart disease is effective and safe, but treatment for all those in whom treatment is likely to be effective is not sustainable within current NHS resources. Data on cost effectiveness data should be taken into account when assessing who should be eligible for treatment.

Introduction

The results of the Scandinavian simvastatin survival study provide robust evidence for the effectiveness of lowering cholesterol concentration with simvastatin in patients aged 35–70 years who have a history of coronary heart disease and a serum cholesterol concentration >5.4 mmol/l.¹ More recently, the west of Scotland coronary prevention study has provided convincing evidence for the benefit and safety of pravastatin in middle aged men without coronary heart disease and a moderately raised cholesterol concentration (initial value >6.4 mmol/l).²

Given this evidence for the effectiveness of statins, can the NHS afford to treat all who might benefit? A typical health commission with a population of 500 000 will have around 50 000 men aged 45 to 64, of whom some 20 000 will have a cholesterol concentration over 6.4 mmol/l and therefore would probably benefit from treatment. The current cost of statins at typical daily doses is around £540 a year,³ and to treat all who might benefit would cost £10.8m per annum. In addition, up to 2000 adults in this age group with cholesterol concentrations between 5.5 and 6.4 mmol/l and pre-existing coronary heart disease would also benefit from treatment.

Cost effectiveness studies of lowering cholesterol with statins have used estimates of the likely changes in serum lipid concentrations to predict the benefits of intervention on morbidity and mortality.^{4–7} Various estimates of the cost effectiveness of secondary prevention based on the results of the Scandinavian trial have been reported, suggesting an average cost of £85 000 to £136 000 per life saved^{8,9} or £23 110 to £32 440 per life year saved.¹⁰

The Scandinavian trialists reported that the relative risk reduction with treatment is the same whatever the initial cholesterol concentration.¹¹ Because serum cholesterol concentration is an independent risk factor for fatal coronary events,^{12–19} the absolute risk reduction will depend on the patient's cholesterol value before treatment. Also, the relative risk reduction is likely to be the same for patients in different absolute risk groups because of other independent risk factors such as age, sex, and the nature of the patient's pre-existing coronary heart disease. This assumption is supported by the fact that the relative risk reductions reported in the Scottish trial were similar to those in the Scandinavian trial, although the study populations were dissimilar. The various combinations of risk factors will therefore result in widely differing risks of fatal cardiovascular disease, and so the cost effectiveness of lowering cholesterol concentration will also vary widely.

We estimated the cost effectiveness of statins in lowering serum cholesterol concentration in people at varying risk of fatal cardiovascular disease on the basis of published estimates of the benefits of intervention. We also explored the cost and cost effectiveness implications for a typical purchasing authority of changing the criteria at which treatment of hypercholesterolaemia might be recommended.

Methods

The benefits of lowering cholesterol concentration have been assumed to be a reduction in the numbers of deaths from cardiovascular disease and in the numbers of non-fatal acute coronary events, coronary angiographies, and revascularisation procedures.

We used a life table method to estimate the life years gained by lowering serum cholesterol concentration in

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Table 1—Survival of imaginary cohort of 1000 men aged 45-54 with pre-existing coronary heart disease according to treatment for raised cholesterol concentration

Mortality per 1000 population												
		General population		Patients with pre-existing coronary heart disease				No of deaths expected		No surviving at end of year		
				No treatment		With treatment						
Year	Average age (years)	All cause	Coronary heart disease	Coronary heart disease	All cause	Coronary heart disease	All cause	No treatment	With treatment	No treatment	With treatment	
Column No*:	1	2	3	4	5	6	7	8	9	10	11	12
	1	50	3.45	0.78	2.41	5.07	1.40	4.06	5	4	995	996
	2	51	3.82	0.88	2.72	5.66	1.58	4.51	6	4	989	991
	3	52	4.24	1.00	3.07	6.31	1.78	5.02	6	5	983	986
	4	53	4.69	1.13	3.47	7.04	2.01	5.58	7	6	976	981
	5	54	5.20	1.28	3.92	7.85	2.28	6.20	8	6	968	975
	6	55	5.77	1.44	4.43	8.76	2.57	6.89	8	7	960	968
	7	56	6.39	1.63	5.01	9.77	2.90	7.67	9	7	951	961
	8	57	7.08	1.84	5.66	10.90	3.28	8.52	10	8	940	953
	9	58	7.85	2.08	6.39	12.16	3.71	9.48	11	9	929	944
	10	59	8.70	2.35	7.22	13.57	4.19	10.54	13	10	916	934
Total									84	66	9650	9721

*See Methods for explanation.

the population of this health commission. The method is illustrated in table 1, which is the life table for an imaginary cohort of 1000 men with pre-existing coronary heart disease aged 45-54 (average age at start 50 years). The method for deriving the numbers in each column in table 1 are as follows:

Columns 3 and 4 are the age specific death rates from all causes and from cardiovascular disease in one year age bands for the general population, estimated from a log-linear regression of published death rates in five year age bands.²⁰ Cardiovascular disease includes codes 401-405, 410-414, 430-438 of the ninth revision of the *International Classification of Diseases* (ICD-9).

Column 5 shows the death rates from cardiovascular disease for men with pre-existing coronary heart disease, estimated with the formula $r/(pr + (1 - p))$, where r is the mortality ratio of those with pre-existing coronary heart disease to those without and p is the proportion of the population with pre-existing coronary heart disease. We assumed that $r = 3.4$.¹⁴

Column 6 shows the death rate from all causes for those with pre-existing coronary heart disease, or column 3 minus column 4 plus column 5, given that the death rate from non-cardiovascular causes in those with pre-existing coronary heart disease is the same as in the general population.

Column 7 shows the mortality from cardiovascular disease in men with pre-existing coronary heart disease receiving treatment with a statin; the rate is $0.58 \times$ column 5, given that that treatment with statin reduces cardiovascular mortality by 42%.¹

Column 8 shows the death rate from all causes in men with pre-existing coronary heart disease, or column 3 minus column 4 plus column 7, given that the reduction in all cause mortality after treatment is entirely due to a reduction in deaths from cardiovascular disease.

Column 9 shows the expected number of deaths without statin treatment, or the number surviving at start of year $\times$ column 6.

Column 10 shows the expected number of deaths with treatment, or the number surviving at start of year $\times$ column 8.

Column 11 shows the number surviving at end of year without treatment, or number surviving at start of year $\times (1 - \text{column 6})$.

Column 12 shows the number surviving at end of year with treatment, or the number surviving at start of year $\times (1 - \text{column 8})$.

Total shows the life years survived by the cohort, or the sum of the number surviving at the end of each year $+ 0.5 \times$ total number of deaths.

A similar life table can be constructed for men and women in the two age bands without previous coronary

Table 2—Values of uniformly distributed parameters used in model

Parameter	Mid-point estimate	Minimum	Maximum	References
Prevalence of angina:				
Men aged 45-54	0.02	0.01	0.03	White <i>et al</i> ²¹
Women aged 45-54	0.02	0.01	0.03	
Men aged 55-64	0.05	0.04	0.06	White <i>et al</i> ²¹
Women aged 55-64	0.05	0.04	0.06	
Prevalence of previous myocardial infarction:				
Men aged 45-54	0.0125	0.005	0.02	White <i>et al</i> ²¹
Women aged 45-54	0.0125	0.005	0.02	
Men aged 55-64	0.05	0.04	0.06	Scandinavian Simvastatin Survival Study Group, ¹ Shepherd <i>et al</i> ²
Women aged 55-64	0.02	0.01	0.03	
Proportion of non-fatal myocardial infarctions prevented to life years saved	0.28	0.18	0.38	Scandinavian Simvastatin Survival Study Group, ¹ Shepherd <i>et al</i> ²
Proportion of coronary angiographies prevented to life years saved	0.4	0.3	0.5	
Proportion of revascularisation procedures prevented to life years saved	0.38	0.28	0.48	Sawitz <i>et al</i> , ²² local data
Discount rate	0.05	0.0	0.1	
Cost of non-fatal myocardial infarction (£)	4300	3800	4800	Sculpher <i>et al</i> , ²³ local data
Cost of revascularisation procedure (£)	5000	4500	5500	

Table 3—Mean (SD) values of normally distributed parameters used in model

	Mean (SD)	Reference
Relative risk of fatal coronary heart disease:		
Patient with angina	2.4 (0.4)	Shaper <i>et al</i> ¹⁴
Patient with previous myocardial infarction	6.0 (0.8)	
Patient in cholesterol fifth:		Martin <i>et al</i> ¹³
1	1.0 (0.0)	
2	1.5 (0.15)	
3	1.8 (0.2)	
4	2.4 (0.2)	
5	3.8 (0.3)	
Patient with pre-existing disease treated with statin	0.58 (0.06)	Scandinavian Simvastatin Survival Study Group ¹
Patient without pre-existing disease treated with statin	0.67 (0.08)	

Table 4—Benefits of treating hypercholesterolaemia in patients with pre-existing coronary heart disease

	Cholesterol fifth (value (mmol/l))				
	2 (5.5-6.0)	3 (6.1-6.5)	4 (6.6-7.2)	5 (≥7.3)	2-5 (≥5.5)
No treated (n = 3795)					
Men aged 45-54:					
Angina	115	115	115	115	461
Myocardial infarction	72	72	72	72	288
Men aged 55-64:					
Angina	194	194	194	194	774
Myocardial infarction	194	194	194	194	774
Women aged 45-54:					
Angina	113	113	113	113	453
Myocardial infarction	71	71	71	71	283
Women aged 55-64:					
Angina	113	113	113	113	453
Myocardial infarction	77	77	77	77	309
No of life years of treatment (n = 35 619)					
Men aged 45-54:					
Angina	1122	1121	1118	1112	4472
Myocardial infarction	695	693	689	680	2757
Men aged 55-64:					
Angina	1807	1802	1790	1763	7162
Myocardial infarction	1764	1750	1721	1658	6893
Women aged 45-54:					
Angina	1112	1111	1110	1107	4440
Myocardial infarction	692	691	689	685	2758
Women aged 55-64:					
Angina	1076	1074	1070	1060	4281
Myocardial infarction	724	721	714	699	2858
No of expected deaths from coronary heart disease (n = 627)*					
Men aged 45-54:					
Angina	7	8	9	11	36
Myocardial infarction	7	8	9	12	36
Men aged 55-64:					
Angina	5	5	6	7	22
Myocardial infarction	46	51	60	79	237
Women aged 45-54:					
Angina	31	33	37	47	149
Myocardial infarction	4	4	5	7	20
Women aged 55-64:					
Angina	13	14	16	19	63
Myocardial infarction	13	14	16	22	64
No of discounted lives saved (n = 137)†					
Men aged 45-54:					
Angina	1	1	2	3	6
Myocardial infarction	2	2	2	4	10
Men aged 55-64:					
Angina	4	5	7	1	27
Myocardial infarction	10	12	16	22	60
Women aged 45-54:					
Angina	0	1	1	1	3
Myocardial infarction	1	1	1	2	4
Women aged 55-64:					
Angina	2	2	3	4	11
Myocardial infarction	3	3	4	6	16
No of discounted life years saved (n = 442)†					
Men aged 45-54:					
Angina	3	4	5	8	20
Myocardial infarction	5	6	8	12	30
Men aged 55-64:					
Angina	14	17	22	34	87
Myocardial infarction	34	40	52	78	203
Women aged 45-54:					
Angina	1	2	2	3	8
Myocardial infarction	2	2	3	5	13
Women aged 55-64:					
Angina	5	6	8	13	32
Myocardial infarction	8	9	12	19	49

*On the basis of current death rates.²⁰

†For economic analysis, lives saved in the future are worth less than those saved today. Discount rate used is 5%.

heart disease, with angina, and with previous myocardial infarction, and within these categories for subjects with cholesterol values in different fifths. The assumptions about the relative risk of fatal cardiovascular disease for these different categories of patient are given in table 2.

Estimating the numbers of non-fatal myocardial infarctions, coronary angiographies, and revascularisation procedures prevented in each risk group is difficult

because the age-sex specific rates of these events and their relative risks for different patient categories are not known. However, the results of the Scandinavian and Scottish trials can be used to estimate the numbers of events prevented. There were 0.28 non-fatal myocardial infarctions and 0.38 revascularisation procedures prevented for every life year saved in the Scandinavian trial,¹⁰ with broadly similar results in the Scottish trial, which also reported that for every life year saved 0.4 coronary angiographies were avoided. The cost of a non-fatal myocardial infarction and revascularisation procedure are about £4300²² and £5000.²³ These published figures are similar to local contract prices for these procedures.

The costs of the treatment have been limited to drug costs. Given that in the Scandinavian trial two thirds of the patients required 20 mg daily and one third 40 mg daily, the average cost at current prices is £540 a year.³ The Department of Health traditionally discounts future costs and savings at 5-6%,²⁴ though the validity of this procedure has recently been questioned.²⁵ In the model we used a discount rate of 5% and a range of values from 0-10% in the sensitivity analysis.

The results of the model depend on assumptions made about the values of various input parameters. We carried out a sensitivity analysis with a range of potential values for each input parameter. The model was recalculated 1000 times using the Latin hypercube sampling technique to ensure that each input parameter was sampled across the complete range of its putative distribution.²⁶ The values used for each input parameter and the sampling distribution used are given in table 3.

Results

In Cambridge and Huntingdon the values for the cholesterol fifths are roughly <5.5 mmol/l, 5.5-6.0 mmol/l, 6.1-6.5 mmol/l, 6.6-7.2 mmol/l, and >7.2 mmol/l. Thus those in the lowest fifth would have cholesterol concentrations below those in the Scandinavian trial, and only those in the top two fifths would qualify for treatment in the Scottish trial. Of 95 800 resident men and women aged 45-64 years, 3795 had pre-existing coronary heart disease and a cholesterol concentration >5.4 mmol/l and some 18 100 men without coronary heart disease had a cholesterol concentration >6.4 mmol/l.

Table 4 shows the benefits of treatment for 10 years for patients with pre-existing coronary heart disease, stratified by age, sex, type of coronary heart disease, and cholesterol fifth. Table 5 shows the costs of treatment for the same groups. Table 6 shows the benefits and costs of treating men without a history of coronary heart disease. The values given in these tables are the results when middle values of the input parameters were entered in the model. In those with pre-existing coronary heart disease, 35 619 treatment years would save 442 life years and prevent 137 deaths, 128 non-fatal myocardial infarctions, 164 revascularisation procedures, and 177 coronary angiographies at a net cost of £14.1m—an average cost of £103 000 per life and £32 000 per life year saved. The cohort of men without coronary heart disease would undergo 174 364 treatment years to save 512 life years and prevent 90 deaths, 153 non-fatal myocardial infarctions, 207 revascularisation procedures, and 218 coronary angiographies at a net cost of £74.6m—an average cost of £0.8m per life saved and £147 000 per life year saved.

These averages hide large variations in cost effectiveness for different groups of patients at different degrees of risk. Treatment of hypercholesterolaemia is most cost effective in men aged 55-64 who have previously had a myocardial infarction and whose cholesterol concentration is above 7.2 mmol/l. Treatment costs £6000 per life year saved compared with £361 000 per life year saved

Table 5—Costs and cost effectiveness of treating hypercholesterolaemia in patients with pre-existing coronary heart disease

	Cholesterol fifth (value (mmol/l))				
	2 (5.5-6.0)	3 (6.1-6.5)	4 (6.6-7.2)	5 (≥ 7.3)	2-5 (≥ 5.5)
Discounted net costs (£000s); total £14 141 000					
Men aged 45-54:					
Angina	483	480	475	463	1900
Myocardial infarction	288	284	276	258	1106
Men aged 55-64:					
Angina	747	735	712	659	2853
Myocardial infarction	661	633	580	464	2337
Women aged 45-54:					
Angina	483	482	479	474	1918
Myocardial infarction	296	295	291	283	1165
Women aged 55-64:					
Angina	456	451	443	423	1772
Myocardial infarction	291	285	271	242	1089
Net cost per life saved (£000s); average £103 000					
Men aged 45-54:					
Angina	465	387	289	180	293
Myocardial infarction	182	151	112	68	114
Men aged 55-64:					
Angina	167	138	102	62	105
Myocardial infarction	63	52	37	21	39
Women aged 45-54:					
Angina	1046	871	652	410	660
Myocardial infarction	415	345	258	161	261
Women aged 55-64:					
Angina	268	222	165	102	168
Myocardial infarction	112	92	68	41	70
Net cost per life year saved (£000s); average £32 000					
Men aged 45-54:					
Angina	154	128	95	59	97
Myocardial infarction	60	49	36	22	37
Men aged 55-64:					
Angina	53	44	32	19	33
Myocardial infarction	20	16	11	6	11
Women aged 45-54:					
Angina	361	300	225	141	227
Myocardial infarction	143	118	88	55	89
Women aged 55-64:					
Angina	90	74	55	34	56
Myocardial infarction	37	30	22	13	22

Table 6—Benefits, cost, and cost effectiveness of treating hypercholesterolaemia in patients without pre-existing coronary heart disease

	Cholesterol fifth (value (mmol/l))		
	4 (6.6-7.2)	5 (≥ 7.3)	4 and 5 (≥ 6.6)
No treated (n = 18 110)			
Men aged 45-54	5 570	5 570	11 141
Men aged 55-64	3 485	3 485	6 969
Life year treatment (n = 174 364)			
Men aged 45-54	54 484	54 352	108 836
Men aged 55-64	32 874	32 654	65 528
No of expected deaths from coronary heart disease (n = 1748)			
Men aged 45-54	314	361	675
Men aged 55-64	499	573	1 073
No of discounted lives saved (n = 96)			
Men aged 45-54	17	20	36
Men aged 55-64	27	32	59
No of discounted life years saved (n = 546)			
Men aged 45-54	79	125	205
Men aged 55-64	133	208	341
Discounted net cost (£000s; total £74 611)			
Men aged 45-54	23 643	23 439	47 082
Men aged 55-64	13 938	13 591	27 529
Net cost per life saved (£000s; average £778 000)			
Men aged 45-54	1 424	1 178	1 290
Men aged 55-64	515	420	464
Net cost per life year saved (£000s; average £136 000)			
Men aged 45-54	297	187	230
Men aged 55-64	105	65	80

*On the basis of current death rates.[20]

in women aged 45-54 with angina and a cholesterol concentration of 5.5-6.0 mmol/l.

Table 7 shows the results of the sensitivity analysis for several key results of the model. For patients with

pre-existing coronary heart disease the estimated average cost effectiveness ranged from £15 000 to £70 000. Rank correlation of the inputs and outputs in the sensitivity analysis showed that the effectiveness of treatment was the parameter having the greatest influence on the result ($r=0.76$). Correlation coefficients for all other input variables were <0.5 . For men without coronary heart disease, average cost effectiveness ranged from £70 000 to £424 000, with the effectiveness of treatment again being the parameter having the greatest influence ($r=0.95$). The sensitivity analysis also shows that even if the "best case" scenario for the lowest risk group is compared with the "worst case" scenario for the highest risk group, treatment is still seven times more costly per life year saved in the lowest risk group.

In deciding which patients should be treated, while taking into account cost effectiveness data, the effect of changing criteria for intervention on the total cost of treatment, average cost effectiveness, and marginal cost effectiveness should be considered. The following are five groups of patients at decreasing risk of coronary heart disease, all of whom fulfil the criteria for intervention of the Scandinavian or Scottish trial:

- Group 1—men aged 45-64 and women aged 55-64 with previous myocardial infarction and a cholesterol concentration >5.4 mmol/l
- Group 2—men aged 45-64 and women aged 55-64 with angina and a cholesterol concentration >5.4 mmol/l
- Group 3—men aged 55-64 with no history of coronary heart disease and cholesterol >6.5 mmol/l
- Group 4—women aged 45-54 with angina or previous myocardial infarction and a cholesterol concentration >5.4 mmol/l
- Group 5—men aged 45-54 with no history of coronary heart disease and a cholesterol concentration >6.5 mmol/l.

The cost implications for Cambridge and Huntingdon Health Commission of expanding the indications for cholesterol lowering treatment to include each successive risk group is shown in table 8. If only those patients in the highest risk group are treated, 1371 patients would require treatment at a net cost of £4.5m (over 10 years) and a benefit of 282 life years saved at £16 000 per life year. If the next highest risk group is also treated an additional 1688 patients will require treating at an additional cost of £11.1m and an additional benefit of 138 life years saved at a marginal cost of £47 000 per life year gained. The average cost effectiveness of treating both groups is £26 000 per life year saved. For treating the fifth risk group the marginal cost per life years saved is £230 000 compared with an average cost of £92 000.

Discussion

Lowering cholesterol has been shown to be safe and effective for patients with and without pre-existing coronary heart disease, but the cost of treating all those in whom treatment is likely to be effective is not sustainable within current NHS resources. In addition, other equally effective secondary prevention interventions, such as antiplatelet treatment²⁷ and dietary intervention,^{28 29} are cheaper. We have estimated the cost effectiveness of lowering cholesterol concentration in various at risk patient groups to identify groups in which intervention will be most efficient.

Although the validity of several assumptions was explored in a sensitivity analysis, no attempt was made to account for other assumptions. In particular, although the benefits of lowering cholesterol concentration were derived from large trials, our model assumes that they occur immediately treatment is started,

whereas not much effect was apparent in the Scandinavian or Scottish trial for six months to two years.^{1,2} Taking this into account would result in the intervention becoming less cost effective. The population on which this model is based is affluent compared with the rest of the United Kingdom. In an area with higher mortality from coronary heart disease the absolute benefits would be greater and thus the intervention would become more cost effective. Other than drug costs, costs of managing hypercholesterolaemia in the population have not been included in the model. This is reasonable in patients with pre-existing coronary heart disease, since the drug will simply be added to standard treatment and will incur few additional costs associated with doctor time. In patients without coronary heart disease there would be additional costs associated with measuring cholesterol concentrations in a large healthy population group, and in those subsequently treated there will be costs from increased use of doctor time.

The model does not account for several direct and indirect benefits that might accrue from lowering cholesterol concentration. For example, treatment may reduce morbidity from angina or congestive heart failure. This would reduce direct costs through reduction in need for other treatment and a reduction in patient consultations. Measuring these benefits is, however, difficult without published information about such outcomes, and the benefits are likely to be small in comparison to the total cost of drugs. Indirect societal costs, such as preventing illness related job losses, are also relevant but are, again, difficult to account for. We also did not assess the differing utility of preventing death or morbidity in the different risk groups as this type of analysis was beyond the scope of this study.

CONCLUSIONS

We have shown that the cost effectiveness of treatment of hypercholesterolaemia with statins varies greatly between different risk groups. Statin treatment should be reserved for patients who will get the most benefit—that is, those in whom intervention is most cost effective. If data on cost effectiveness are to be used in determining who should be eligible for treatment, our results emphasise the importance of considering the

Key messages

- Recent clinical trials provide good evidence for the benefits of lowering cholesterol concentration in primary and secondary prevention of heart disease
- Treatment of all who would benefit from intervention would be prohibitively expensive for the NHS
- Cost effectiveness of lowering cholesterol concentration varies greatly according to patient risk factors, treatment being most efficient in those at highest risk
- The marginal cost effectiveness of treatment increases greatly as lower risk groups are included in this preventive regimen

marginal cost effectiveness rather than the average cost effectiveness when assessing the impact of moving from one health care strategy to another.

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Table 7—Results of sensitivity analysis for key output variables

Output variable	Median	Minimum	Maximum	Interquartile range
Patients with pre-existing coronary heart disease				
No treated	3 797	3 008	4 552	3 621-3 792
No of lives saved	136	70	218	120-153
No of life years saved	438	195	835	366-517
Patients without pre-existing coronary heart disease				
No treated	18 111	17 837	18 931	18 029-18 152
No of lives saved	95	66	221	79-109
No of life years saved	541	346	1 325	436-636
Net cost per life year saved (£000s)				
All patients aged 45-64 with coronary heart disease and cholesterol ≥ 5.5 mmol/l	32	15	70	27-39
Men aged 45-64 without coronary heart disease but with cholesterol ≥ 6.6 mmol/l	137	70	424	115-170
Men aged 55-64 with previous myocardial infarction and cholesterol ≥ 7.3 mmol/l	6	0.7	23	4-8
Women aged 45-54 with angina and cholesterol 5.5-6.0 mmol/l	360	154	914	297-448

Table 8—Cost implications of expanding indication for lowering cholesterol concentration in Cambridge and Huntingdon Health Commission

Groups treated*	Additional No to treat	Total No to treat	Additional cost (£000s)	Total cost (£000s)	Additional life years saved	Total life years saved	Marginal cost per life year saved (£000s)	Average cost per life year saved (£000s)
1	1 371	1 371	4 533	4 533	282	282	16	16
1 and 2	1 688	3 059	6 526	11 059	138	420	47	26
1-3	6 969	10 028	27 529	38 588	341	761	81	51
1-4	736	10 764	3 082	41 670	21	781	143	53
1-5	11 141	21 905	47 082	88 752	205	967	230	92

*See Results for definition of groups.

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Relation of indoor heating with asthma, allergic sensitisation, and bronchial responsiveness: survey of children in South Bavaria

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Abstract

Objective—To investigate the relation between different types of heating and the prevalence of atopic diseases, skin test reactivity, and bronchial hyperresponsiveness.

Design—Cross sectional survey among school-children aged 9-11 years. Skin prick tests, pulmonary function tests, and bronchial challenge in the children and self completion of a written questionnaire by the children's parents.

Subjects—1958 children in a rural area in southern Bavaria, Germany.

Main outcome measures—Prevalence of asthma, hay fever, and atopic dermatitis as determined by parents' answers to a questionnaire; the atopic status of the child assessed by skin prick tests; and bronchial responsiveness to cold air challenge in the children.

Results—After possible confounders were controlled for, the risk of developing hay fever (odds ratio=0.57; 95% confidence interval 0.34 to 0.98), atopy defined as at least one positive reaction to a panel of common aeroallergens (0.67; 0.49 to 0.93), sensitisation to pollen (0.60; 0.41 to 0.87), and of bronchial hyperresponsiveness (0.55; 0.34-0.90) was significantly lower in children living in homes where coal or wood was used for heating than in children living in homes with other heating systems.

Conclusions—Factors directly or indirectly related to the heating systems used in rural Bavarian homes decrease the susceptibility of children to becoming atopic and to developing bronchial hyperresponsiveness.

Introduction

It has been estimated that adults spend most of their time indoors,¹ where they could be exposed not only to passive smoking but to emissions from stoves used for heating and cooking. Though conflicting evidence exists about adverse effects of gas fuelled stoves on respiratory health,² coal and wood combustion have been reported to increase the risk of upper and lower respiratory tract infections.³⁻⁶

As little is known about the effects of different heating systems on the development of atopic sensitisation and related diseases, we aimed to investigate the relation between atopic diseases and indoor heating systems. We studied a rural population in southern Bavaria with a high proportion of households using coal or wood stoves for heating or cooking.

Methods

Sixty three primary schools were selected in a rural area in southern Bavaria that is characterised by little traffic (fewer than 10 000 cars passing the main street per day) and no industry. All 1958 schoolchildren attending the fourth grade of these schools were invited to participate in a cross sectional survey on asthma and allergies from September 1989 to July 1990.

The study was approved by the ethics committee of the Bavarian Medical Association, and informed consent was obtained from the parents.

QUESTIONNAIRE

A self administered questionnaire was distributed through the schools to the parents. Details of the questions used have been given elsewhere.^{7,8} Prevalences of diseases and symptoms, the number of siblings and other persons in the household, the parents' education, the number of cigarettes smoked at home, and dampness and the presence of pets in the home were assessed.

Children whose parents reported either asthma or recurrent "asthmatic" or "spastic" bronchitis were classified as having asthma. Hay fever and atopic dermatitis were defined as parents' report of a doctor's diagnosis of hay fever and the presence of atopic dermatitis, respectively. Children with one or more first degree relatives with asthma, hay fever, or eczema were defined as having a positive family history of atopy. Parents were also asked about the energy source used for heating and cooking, and about the presence of a central heating system.

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