Modelling the health impacts of the diets described in '*Eating the Planet*' published by Friends of the Earth and Compassion in World Farming

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Summary

Friends of the Earth (FoE) have commissioned the British Heart Foundation Health Promotion Research Group (BHF HPRG) to model the health impacts of the different diets described in the report '*Eating the Planet: feeding and fuelling the world sustainably, fairly and humanely – a scoping study'* that was published by Compassion in World Farming and Friends of the Earth earlier this year[1].

The report found the global potential for producing food in 2050 ranges from 58 to 161 EJ/yr but that this potential 'depends strongly on the choice of diet'. It is lowest in the case of diets high in meat and dairy and highest in the case of what the authors characterise as the 'Less Meat' diet and the 'Fair Less Meat' diet. The Less Meat diet would mean that we in the UK would need to consume 58% less meat and dairy product than we do at present: the Fair Less Meat diet would mean an 83% reduction.

The modelling carried out by the BHF HPRG found that if people in the UK consumed the Less Meat diet then (under the most conservative assumptions about food waste) 32,000 deaths would be averted or delayed each year. 26,000 of these deaths would be from cardiovascular disease (CVD, i.e. coronary heart disease (CHD) and stroke) and 6,000 would be from cancer. Furthermore costs to the NHS would be reduced by £0.85bn if the Less Meat diet were achieved. The equivalent figures for the Fair Less Meat diet would be 45,000 lives averted or delayed each year (36,000 from CVD and 9,000 from cancer) and £1.2bn in NHS costs.

Background

The growing and increasingly affluent world population means that food production – particularly of meat and dairy products - is putting mounting pressure on the environment – the climate, land,

[1] Erb K-H, Haberl H, Kraussmann F et al. Eating the planet: feeding and fuelling the world sustainably, fairly and humanely – a scoping study. Compassion in World Farming and Friends of the Earth: London, 2010

water, etc. Therefore Friends of the Earth (FoE) and Compassion in World Farming recently commissioned the Institute of Social Ecology, Alpen Adria Universität Klagenfurt, Vienna, Austria, and the Potsdam Institute for Climate Impact Research, Germany to model future global food production under a number of different scenarios varying by food consumption patterns (diets), farming methods and land use. This research – reported in '*Eating the Planet: feeding and fuelling the world sustainably, fairly and humanely – a scoping study'* - was published by FoE and Compassion in World Farming in 2010[2] and found that the global potential for producing food in 2050 ranges from 58 to 161 EJ/yr (Exajoules per year) but that this potential 'depends strongly on the choice of diet'.

It concludes that enough food could be produced to feed the growing population of the world provided that people – particularly in developed countries – consume less meat and dairy products. The research suggested that such diets might be healthier but did not quantify the health benefits.

The health benefits of consuming less meat and dairy in countries such as the UK are in fact less than clear. It is generally accepted that consuming meat and dairy products that are lower in saturated fat and salt would be good for health. It has long been known that high saturated fat and salt intakes (to which meat and dairy products contribute substantially) increase the risk of cardiovascular disease (CVD, i.e. coronary heart disease (CHD) and stroke). Moreover it has been known for decades that replacing some meat and dairy products with plant based foods – particularly fruit and vegetables – would have beneficial effects on both risk of CVD and of some forms of cancer.

However nutritionists have been cautious about recommending a lower consumption of meat and dairy products per se because these foods are rich in minerals and vitamins – such as iron, calcium, niacin and vitamin A. - that are known to be essential for normal growth and body maintenance and so beneficial to health. Accordingly FoE asked the British Heart Foundation Health Promotion Research Group (BHF HPRG) to estimate the health effects of the diets modelled in the *Eating the Planet* report.

Methods

Diets to be modelled

Details of the diets FoE asked the BHF HPRPG to model are shown in Table 1. These details were taken from Table A of the *Eating the Planet* report.

[2] Erb K-H, Haberl H, Kraussmann F et al. *Eating the planet: feeding and fuelling the world sustainably, fairly and humanely – a scoping study.* Compassion in World Farming and Friends of the Earth: London, 2010.

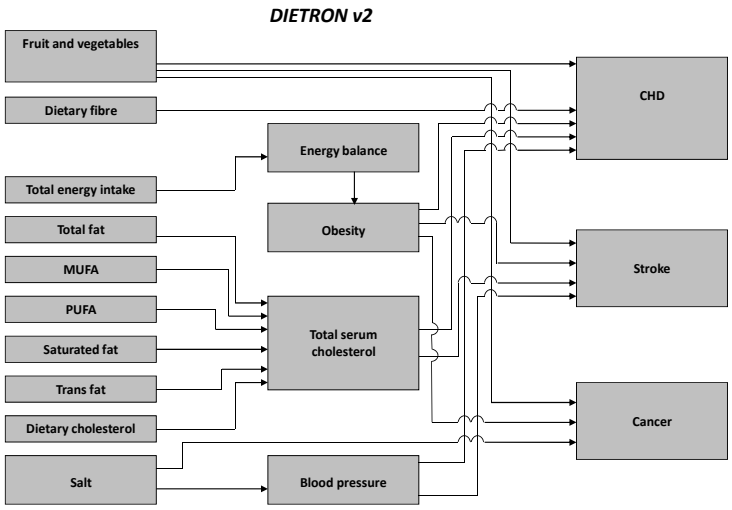
Table 1. Diet (food availability) in kilocalories per capita per day in the Western European region

	As of 2000	Projected to 2050		
	Baseline	Current Trends	Less Meat	Fair Less Meat
Cereals	988	990	1480	1447
Roots	137	130	205	195
Sugar crops	373	420	365	194
Pulses	32	32	62	46
Oil crops	502	520	492	261
Vegetables and fruits	274	270	410	391
Meat (ruminants)	115	125	42	18
Pigs, poultry, eggs	466	490	214	71
Milk, butter, dairy	427	450	193	65
Fish	50	47	21	47
Other crops	64	50	36	64
Total	3428	3524	3520	2799
%E from meat and dairy	29%	30%	13%	6%

Conceptual model

Modelling the health impacts of the diets for 2050 described in the *Eating the Planet* report (Current Trends, Less Meat and Fair Less Meat) was based on a conceptual framework that leads from consumption of foods and nutrients through to biological risk factors for ill health, through to adverse health outcomes. The conceptual framework has been used to build a model called DIETRON and this is illustrated in Figure 1.

Figure 1. Conceptual model for the modelling described here



Details of how the DIETRON model was constructed can be found in a paper that has been accepted for publication in the Journal of Epidemiology and Community Health[3]. In summary: meta-analyses of individual-level studies that quantified the relative risk of increased consumption/increased risk factor level on disease outcomes were used to build the model. The disease outcomes modelled are deaths from CVD (CHD and stroke) and 10 forms of cancer: oesophagus, colorectum, gallbladder, pancreas, breast, endometrium, kidney, mouth/larynx/pharynx, stomach, lung.

Sensitivity of the model to the results from the meta-analyses was assessed with Monte Carlo simulations. The model described in the forthcoming paper is Version 1 of the model. Version 2 of the model (displayed in Figure 1 and used here) is a slight improvement on Version 1 that allows modelling of diets that incorporates changes in the total energy intake of diets.

It should be noted that DIETRON does not model the effects of changing the intakes of iron, calcium, niacin and other minerals and vitamins often found in high amounts in meat and dairy products. This is because there are – to our knowledge – no good meta-analyses of the effects of different levels of these nutrients on disease outcomes, the results of which could be incorporated into the model. Additionally, the health outcome of nutritional inadequacy is generally disability, whereas the outcomes assessed by the DIETRON model are deaths from chronic disease.

Data inputs for modelling

The DIETRON model needs two sets of inputs for a given population:

(i) Data on the average nutritional quality of the diet (total energy intake; fruit and vegetables; total fat; saturated fat; mono-unsaturated fat (MUFA); poly- unsaturated fat (PUFA); trans fat; dietary cholesterol; salt; fibre);
(ii) Age and sex specific estimates of the number of deaths from CHD, stroke and 10 different forms of cancer: oesophagus, colorectum, gallbladder, pancreas, breast, endometrium, kidney, mouth/larynx/pharynx, stomach, lung.

These data requirements meant the following:

- The diets described in the *Eating the Planet* report had to be converted from description by food categories to description by nutritional quality. To do this we used 2008 food purchase data for the UK from the Family Food Survey[4].
- Since we do not have access to mortality data for 2050, we used UK mortality data for 2007 from routinely collected statistics[5]. This has implications for interpretation of the results because it means that the modelling takes no account of trends in mortality rates between now and 2050. Instead, the results should be interpreted as the likely change in health outcomes if the proposed diets were achieved in the present day.

[3] Scarborough P, Nnoaham KE, Clarke D, Capewell S, Rayner M Modelling the impact of a healthy diet on cardiovascular disease and cancer mortality. Journal of Epidemiology and Community Health, in press.
[4] DEFRA. *Family Food 2008. A report of the Expenditure and Food Survey.* DEFRA: London, 2009.
[5] British Heart Foundation, http://www.heartstats.org

Adjusting for wastage

The source of data that the authors of the *Eating the Planet* report used to construct the different diets were Food Balance Sheets provided by the Food and Agriculture Organization[6]. These provide estimates of the availability of a number of food commodities within a country based on production plus imports minus exports divided by the population of the country. However, not all of the food available is actually consumed. Much of it is lost as wastage at different stages in the food chain.

In order to account for wastage in converting food availability into nutrient intakes we first compared the baseline 2000 Western Europe diet (as described in the *Eating the Planet* report) with 2008 food purchase data for the UK (from the Family Food Survey). For each of the food categories included in the *Eating the Planet* diet ('cereals', 'roots' etc.) the difference between food availability and food purchase was used to estimate the amount of food lost as 'wastage'. The 'wastage conversion factors' are shown in Table 2, which suggests that of the 3,428kcal of food available to each adult in the UK per day, only 1,966kcal were actually consumed.

The *Eating the Planet* diets were then adjusted for wastage under two assumptions:

Assumption 1: Relative food wastage between food categories will remain constant between 2000 and 2050, and total food wastage will remain constant. This means that changes in total energy availability between now and 2050 proposed in Table 1 will be reflected in total energy intake and that energy intakes could change.

Assumption 2: Relative food wastage between food categories will remain constant between 2000 and 2050, but total food wastage will reduce or increase in order to keep total energy intake constant. This means that any reduction or increase in energy availability, as a consequence of the diets in Table 1, is matched by reduced or increased food waste, so that individuals within the population still consume the same number of calories.

Table 2: 'Wastage' conversion factors derived from comparison of 2000 Western Europe diet (food availability) and 2008 UK diet (food purchases)

	2008 UK kcal/person	2000 Western Europe kcal/person	Wastage conversion factor
Cereals	670	988	0.68
Roots	136	137	0.99
Sugarcrops	203	373	0.54
Pulses	17	32	0.52
Oilcrops	149	502	0.30
Vegetables and fruits	142	274	0.52
Meat (ruminants)	126	115	1.10
Pigs, poultry, eggs	170	466	0.36
Milk, butter, dairy	289	427	0.68
Fish	32	50	0.63
Other crops	31	64	0.49
Total	1966	3428	
% From Meat and Dairy	29.8%	29.4%	

[6] Food and Agriculture Organization. http://faostat.fao.org/default.aspx Accessed 15th September 2010.

NB: not all of the differences between the 2000 Western Europe diet and the 2008 food purchase data for the UK will be due to wastage. Some differences will be due to differences in the time and methods of data collection.

Conversion from food availability to nutritional quality

Food availability by food groups in the *Eating the Planet* diets was then converted to nutritional quality using nutritional intake data by food group from the 2008 Family Food Survey. The Family Food Survey uses more than 300 food groups to categorise the UK diet (e.g. cooked rice; marmalade). For each of these food groups, the survey provides an estimate of the contribution of that food group to the following components of the average UK diet: total energy intake; total fat; saturated fat; MUFA; PUFA; dietary cholesterol; fibre; fruit and vegetables; salt.

We therefore assigned each of the food groups used by the Family Food Survey to a single category in the *Eating the Planet* diets. We were then able to model the nutritional quality of the *Eating the Planet* diets, under the assumption that the foods consumed within each food category will remain the same (e.g. in nutrient content) between 2000 and 2050 (i.e. that changes in diet will be achieved by switching between food categories – e.g. switching meat for fruit and vegetables – rather than by switching between foods within food categories – e.g. switching apples for bananas).

Estimates of the costs of the modelled diets to consumers

The Family Food Survey provides estimates of the average amount of money spent by a UK adult on each of the food groups used in reporting that survey. By assigning the food groups used by the Family Food Survey to the *Eating the Planet* categories we were able to estimate the total cost of the modelled diets using 2008 food prices under the assumption that changes in the composition of the average UK diet would not affect prices for individual foods within the diet.

Estimates of change in costs to the NHS:

The NHS Programme Budgeting estimates for 2006/07[7] provide an estimate of the cost to the NHS in England of different diseases. These estimates (as proportions of the total budget for England) can be used to extrapolate the cost of each disease to the NHS in the whole of the UK by multiplying them by the total budget for the UK (calculated by adding the individual budgets for England, Scotland, Wales and Northern Ireland).

Changes in disease-specific and total NHS costs for the UK can then be estimated for the mortality patterns predicted by the DIETRON model under each of the *Eating the Planet* diets. It is important

[7] Programme budgeting guidance 2006-07 [database on the Internet]. Department of Health. 2008 [cited April 2010]. Available from: http://www.dh.gov.uk/en/Publicationsandstatistics/Publications/PublicationsPolicyAndGuidance/DH_073055.

to note that the changes in NHS costs predicted in this way are simply estimates of the changes in the NHS budget in a single year if the total burden of CHD, stroke and cancer were to change.

The disease categories that have been used to estimate changes in costs to the NHS and the total costs of these diseases to the NHS in the UK in 2006/07 are shown in Table 3.

Table 3: Disease categories and costs from the NHS Budget Programming 2006/07, UK

DIETRON disease category	*NHS Programme Budgeting disease category*	*Total 2006/07 NHS costs*
Coronary heart disease	Coronary heart disease	£2.36bn
Stroke	Cerebrovascular disease	£0.98bn
Cancer:	*Cancer:*	
Mouth, Larynx and Pharynx;	Head and neck	£0.16bn
Oesophagus	Upper GI	£0.24bn
Stomach; Gallbladder; Pancreas; Colon	Lower GI	£0.41bn
Lung	Lung	£0.24bn
Endometrium; Kidney	Urological	£0.49bn
Breast	Breast	£0.49bn

Note: total cost of the NHS in 2006/07 is estimated to be £81.3bn[8]

Results:

The nutritional quality of the *Eating the Planet* diets under the two assumptions for wastage is shown in Tables 4a and 4b. The changes in the number of deaths from CHD, stroke and cancer that would be expected if people in the UK immediately switched to the three diets for 2050 is given in Tables 5a and 5b.

Under Assumption 1 (energy intakes allowed to vary), the Current Trends diet will lead to an extra 8,500 diet-related deaths each year, whilst switching to the Less Meat and Fair Less Meat diet will lead to 24,000 and 61,000 deaths averted or delayed respectively. Around 27,000 of the deaths averted with the Fair Less Meat diet are due to changes in obesity levels as a result of decreases in total energy intake.

[8] Scarborough P, Bhatnagar P, Wickramasinghe K, Allender S, Foster C, Rayner M. The economic burden of ill health due to diet, physical inactivity, smoking, alcohol and obesity in the United Kingdom: an update to 2006/07 NHS costs. In preparation.

The costs of the diets under Assumption 1 vary somewhat, ranging from £23.16 per person per week for the Current Trends diet to £17.93 for the Fair Less Meat diet. This can be partially explained by the lower consumption of relatively expensive meat products with diets that are lower in meat and dairy and the lower energy intake for the Fair Less Meat diet (less food means less expenditure on food).

Under Assumption 2 (energy intakes remain constant), the Current Trends diet will lead to an extra 2,500 diet related deaths, whilst switching to the Less Meat and Fair Less Meat diet will mean that 32,500 and 45,500 deaths are averted respectively. Around 30,000 of the deaths averted by the Fair Less Meat diet are due to an increased intake of fruit and vegetables, and 6,000 are due to reductions in saturated fat intake.

The costs of the diets under Assumption 2 vary less than under Assumption 1, ranging only from £20.14 to £22.65. This is because although people would consume different amounts of different products, the total calorie intake remains constant across all diets.

Tables 6a and 6b provide estimates of the change in NHS budget associated with each of the modelled diets under the two assumptions. The tables suggest that (under Assumption 2) the2007 costs to the NHS would be reduced by £0.85bn if the Less Meat diet were achieved. The equivalent figure for the Fair Less Meat diet would be £1.2bn.

Conclusions

This modelling exercise has shown that if the UK were to adopt a diet that was lower in meat and dairy then there would be substantial health benefits with associated savings to the NHS. We have measured these health benefits in deaths averted or delayed as this is the measure of health that is easiest to model. The epidemiological studies on which our model (DIETRON) is based generally use a combination of deaths and incident events to quantify the effects of dietary change on health. However, population level estimates of incident events for CVD and cancer are not readily available and so not easy to model.

The DIETRON model is built using only high quality meta-analyses, and the results that it generates have been shown to be robust to changes in the distribution of risk predicted by the meta-analyses[9]. For example, an uncertainty analysis that allowed the relative risks used in the DIETRON model to vary across the full range of the distributions described in the supporting meta-analyses revealed that the estimate of 45,500 deaths averted or delayed by achieving the Fair Less Meat diet are accompanied by 95% credible intervals that range from 37,000 to 53,300.

The assumptions that support the DIETRON model are described fully in the paper to be published in the Journal of Epidemiology and Community Health. In brief, the model is multiplicative (ensuring that the impacts on health outcomes associated with changes in different aspects of the diet are

[9] Scarborough P, Nnoaham KE, Clarke D, Capewell S, Rayner M Modelling the impact of a healthy diet on cardiovascular disease and cancer mortality. Journal of Epidemiology and Community Health, in press

combined multiplicatively, therefore averting the possibility of a diet leading to more than 100% of deaths being averted or delayed in a given population). It also assumes that dietary changes are achieved by all individuals within a population shifting dietary patterns in a similar way, and that the impacts of changes in the nutritional quality of the diet on health outcomes follow a dose-response relationship at the individual-level. The model only includes the impact on health that is achieved by changes in the nutritional quality of the diet, and only those changes that have been supported by a high quality meta-analysis of cohort or experimental studies. Therefore, the results presented here are likely to underestimate the true changes in health outcomes as they do not include changes in health that are a result of differences in consumption of particular food groups. For example, the World Cancer Research Fund describes the causal link between consumption of red meat and processed meat with colorectal cancer as 'convincing'[10], however this association is not included in the DIETRON model as the association cannot be converted into a change in the nutritional quality of the diet.

As noted earlier, the DIETRON model does not estimate the impact of changes in the diet on diseases of nutritional inadequacy (e.g. anaemia from low iron intakes) that may be a result of a change in the consumption of meat and dairy products. The health outcome of nutritional inadequacy is generally disability whereas the health outcomes assessed by the DIETRON model are deaths from chronic disease. Nevertheless the effects of the *Eat the Planet* diets on the adequacy of levels of vitamin and minerals in the UK is likely to be small and so the effects of these diets on diseases of nutritional adequacy are also likely to be small.

The estimates of reductions in costs to the NHS are relatively crude because they do not take into account any future trends in mortality or costs associated with treating different diseases. They are also based on estimates of the amount of money that is currently spent on CVD and cancer by the NHS and not all of these costs will be avoidable (for example some of the costs will be for continued running of specialist cardiac centres, which would not be reduced if the number of cardiovascular events were to fall).

The diets we have modelled here are the diets outlined in the *Eating the Planet* report. In that report the authors justify the assumptions underlying the proposed composition of the diets. We make no judgment about whether these diets can realistically be achieved by 2050 or not.

[10] World Cancer Research Fund (WCRF) and American Institute for Cancer Research (AICR). Food, nutrition, physical activity, and the prevention of cancer: a global perspective. WCRF & AICR: Washington DC, 2009.

Table 4a: Nutritional quality and average cost of the modelled diets (Assumption 1)

	UK 2008 diet	Current Trends	Less Meat	Fair Less Meat
Total energy intake (kcal / d)	1,966	2,016	2,083	1,735
Total fat (g / d)	86.1	88.9	78.3	57.3
Saturated fat (g / d)	33.8	35.1	28.6	20.2
MUFAs (g / d)	31.5	32.5	28.9	21.3
PUFAs (g / d)	15.2	15.5	15.6	11.8
Dietary cholesterol (mg / d)	227	238	129	78
Fibre (g / d)	13.5	13.3	19.7	18.5
Salt (g / d)	6.2	6.2	5.9	5.3
Fruit and vegetables (g / d)	290	286	435	414
Meat (g / day)	178	190	74	27
Dairy (g / day)	333	351	150	51
Cost (£ / week)	22.65	23.16	21.34	17.93

Table 4b: Nutritional quality and average cost of the modelled diets (Assumption 2)

	UK 2008 diet	Current Trends	Less Meat	Fair Less Meat
Total energy intake (kcal / d)	1,966	1,966	1,966	1,966
Total fat (g / d)	86.1	86.7	73.9	64.9
Saturated fat (g / d)	33.8	34.3	27.0	22.8
MUFAs (g / d)	31.5	31.7	27.3	24.2
PUFAs (g / d)	15.2	15.1	14.7	13.4
Dietary cholesterol (mg / d)	227	232	121	88
Fibre (g / d)	13.5	13.0	18.6	21.0
Salt (g / d)	6.2	6.0	5.6	6.0
Fruit and vegetables (g / d)	290	279	410	469
Meat (g / day)	178	185	70	31
Dairy (g / day)	333	342	142	57
Cost (£ / week)	22.65	22.59	20.14	20.31

Table 5a: Change in mortality by cause, (assumption 1, baseline 2008 average UK diet)

	Current Trends	Less Meat	Fair Less Meat
Total deaths	**+8,412**	**-23,827**	**-61,372**
CHD	+5,116	-17,885	-38,982
Stroke	+1,658	-1,271	-10,619
Cancer	+1,639	-4,671	-11,771
MLP Cancer	+38	-1,297	-1,116
Oesophageal Cancer	+766	-2,960	-4,885
Stomach Cancer	+0	-375	-564
Lung Cancer	+55	-1,869	-1,608
Colon Cancer	+275	+645	-1,269
Gallbladder Cancer	+18	+41	-81
Pancreatic Cancer	+184	+431	-847
Breast Cancer	+68	+159	-312
Endometrial Cancer	+88	+207	-407
Kidney Cancer	+148	+347	-682
Men	+3,893	-15,055	-31,193
Women	+4,520	-8,772	-30,179
Men under 75	+1,921	-6,980	-14,976
Women under 75	+1,268	-1,678	-7,942
Fruit and veg related	+688	-23,399	-20,130
Salt related	-48	-682	-2,091
Fats related	+293	-3,803	-6,228
Obesity related	+7,208	+13,994	-27,362
Fibre related	+271	-9,936	-5,560

Table 5b: Change in mortality by cause, (assumption 2, baseline 2008 average UK diet)

	Current Trends	Less Meat	Fair Less Meat
Total deaths	**+2,509**	**-32,352**	**-45,361**
CHD	+1,817	-22,149	-31,094
Stroke	+202	-4,027	-5,346
Cancer	+490	-6,176	-8,920
MLP Cancer	+102	-1,077	-1,610
Oesophageal Cancer	+292	-3,083	-4,610
Stomach Cancer	-50	-464	-379
Lung Cancer	+147	-1,552	-2,321
Colon Cancer	0	0	0
Gallbladder Cancer	0	0	0
Pancreatic Cancer	0	0	0
Breast Cancer	0	0	0
Endometrial Cancer	0	0	0
Kidney Cancer	0	0	0
Men	+1,421	-18,163	-25,528
Women	+1,088	-14,189	-19,832
Men under 75	+671	-8,564	-12,092
Women under 75	+255	-3,359	-4,724
Fruit and veg related	+1,838	-19,433	-29,059
Salt related	-463	-1,522	-305
Fats related	+294	-3,876	-5,961
Obesity related	0	0	0
Fibre related	+840	-7,521	-10,035

Table 6a: Change in cost to the 2006/07 NHS budget if modelled diets were achieved (Assumption 1, baseline 2007 UK diet)

Disease category	*Current Trends*	*Less Meat*	*Fair Less Meat*
CHD	+£0.13bn	-£0.46bn	-£1.00bn
Stroke	+£0.03bn	-£0.02bn	-£0.19bn
Cancer	+£0.06bn	-£0.13bn	-£0.43bn
Total	**+£0.23bn**	**-£0.62bn**	**-£1.63bn**

Table 6b: Change in cost to the 2006/07 NHS budget if modelled diets were achieved (Assumption 2, baseline 2007 UK diet)

Disease category	*Current Trends*	*Less Meat*	*Fair Less Meat*
CHD	+£0.05bn	-£0.57bn	-£0.80bn
Stroke	+£0.00bn	-£0.07bn	-£0.10bn
Cancer	+£0.02bn	-£0.20bn	-£0.30bn
Total	**+£0.07bn**	**-£0.85bn**	**-£1.20bn**