Public Health Research Consortium

Economic evaluation: evaluating the short-term impacts of the school food policy and experimental modelling of longer term impacts

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List of abbreviations used

ACS	Acute Coronary Syndrome
BNF	British National Formulary
BMI	Body Mass Index
CEAC	Cost-effectiveness Acceptability Curves
Chr Ang	Chronic Angina
CVD	Cardiovascular Disease
DEM	Discrete Event Model
HCHS	Hospital and Community Health Services
HDL	High density Lipoprotein Cholesterol
LDL	Low density Lipoprotein Cholesterol
MI	Myocardial Infarction
NC	Non-cardiac
NCC	Newcastle City Council
NHS	National Health Service
OECD	Organisation for Economic Co-operation and Development
PSSRU	Personal Social Services Research Unit
QALYs	Quality Adjusted Life Years
WHO	World Health Organization
WTP	Willingness to Pay

1. Executive Summary

Background and project aims

In 2006 a major initiative to improve school food in England was launched. For the first time since 1980 this set out food and nutrient-based requirements for school lunch to which all primary schools had to adhere to by September 2008 and secondary schools by September 2009.

Costs associated directly with change in the school policy were compared to short-term outcomes on a cost-consequence analysis. Further, an exploratory analysis of the changes in the occurrence of future health events, particularly cardiovascular events, resulting from dietary change to estimate longer term impacts on costs and quality adjusted life years (QALYs) was considered.

Methods

To estimate the cost of implementing the new policy, data were collected from one North East council from the period 2005-10 to cover both pre and post-implementation of the school food policy. Data on the cost of staff, premises, food and other services were extracted for each year.

An exploratory model of cardiovascular disease risk was developed to explore the potential to evaluate the longer term impacts in terms of both costs to the NHS and health effects measured in terms of QALYs of the introduction of the school food policy.

Main Findings

A cost-consequence analysis highlighted the trade-offs between the findings for change in diet and the net costs of the school food policy. The net costs per child over their school career are modest when compared to, for instance, the costs of many routine medications prescribed for those at risk of diet-related diseases but a judgement is required as to whether improvement in the nutritional status of those eating school meals, the potential reduction in inequalities, and possible educational benefits are worth the likely increase in net cost and reduced improvement in nutritional intake for those that switch to packed lunches.

The extent that these short-term effects might influence longer term outcomes was explored within an exploratory modelling exercise. This only included the costs and consequences of cardiovascular events and did not include the cost and health effects of other obesity related diseases, nor did it consider the wider societal impact e.g. from educational and employment effects which may arise. This means that the differences in costs and QALYs were smaller than might exist had it been possible to include these other effects in the model. We considered what the size of any additional

health benefits from avoiding other dietary-related disease would need to be so that the incremental cost per QALY was no more than £30,000 (a value which society may be willing to pay to gain additional benefits). The mean difference in cost of school food policy costs was predicted to be on average £524 more over the lifetime of a child. This being the case the school food policy would need to provide an extra 0.017 QALY on average over a lifetime (which is equivalent to an additional 6.37 days in full health over a lifetime).

2. Introduction

School meal provision was introduced in the mid-19th Century as a public health response to under-nutrition of children. In the late 20th Century, the focus for public health shifted as the obesity epidemic in children emerged; and as part of this, the need to improve children's diets was identified.[1] The causes, complexities and adverse health effects of overweight and obesity are well documented[2-4] as are the current and projected economic costs.[5] There has been a major shift in the focus of public health to combating the increasing prevalence of childhood overweight and obesity; and as part of this, to improve children's diets.[6, 7] One such initiative was in 2006 when the Government announced new standards for school food in England. These standards are both food and nutrient-based, crucially, they say what *cannot* be served (for example, confectionery and crisps), and limit the number of times that certain foods can be provided (for example, meat products, starchy foods cooked in fat or oil and deep-fried foods).[8] A change in school food has potential to impact on the diet of children from across the socio-economic spectrum and so impact on inequalities in health.

It is important that the resource impacts and health gains of such initiatives are evaluated in order to ensure that implementation is conducted as efficiently as possible and to help assess the value for money of such programmes in terms of health gains for resources expended. This report will evaluate the short term and longer term economic impacts of the change in school food regulations.

An evaluation of both the process of implementation of the new policy and its effect on the school food and total dietary intake of children were also carried out; the findings of which can be found at http://phrc.lshtm.ac.uk/.

2.1 Aims and objectives

The principal aim of this analysis was to undertake an economic evaluation of the change in school food policy. More specifically, the objectives were to:

- Assess the costs associated directly with the change in food policy itself and compare these to a short-term outcomes in a cost-consequence analysis;
- Analyse the changes in the occurrence of future health events, particularly cardiovascular events, resulting from dietary changes, and from these, to estimate longer-term impacts on costs and QALYs.

The second of these objectives was intended to be exploratory that is to explore the challenges and limitations of undertaking such modelling related to any short change in diet.

3. Economic evaluation: evaluating the short-term impacts of the school food policy

3.1 Method

For the evaluation of the short term impacts of the introduction of the new school food policy in England, data on the costs associated with the implementation of the programme were combined with the short-term nutritional effects.

Costs

To estimate the cost of implementing the new policy, data were collected from Newcastle City Council (NCC) for the period 2005-10 to cover both pre and post policy implementation. NCC supplied accounts data for the school food service which covers 94 schools in the Newcastle upon Tyne area. Data on the cost of staff, premises, food and other services were extracted from the larger data set for each year (more details on what was included in the cost of implementation is included in Appendix 6.1). NCC provided data on the total number of school meals that were supplied each year broken down into paid school meals and free school meals. The data provided by NCC was for all of its school catering and not exclusively to primary schools. As a child may not consume a meal provided by the school each day but instead bring in a packed lunch from home, further information on the cost of a packed lunch was required. The cost of a packed lunch has previously been calculated as being between £1.60 and 1.83 (2008 prices).[9] These data are based on the ingredient costs and time taken to prepare the lunch. The price of a school meal to purchase was £1.85 in 2007. Inflating the values to 2009 prices gives a cost of a packed lunch of £1.86 and a school meal of £1.95; a net decrease in costs of £0.09 per meal borne by the families in which a child has a packed lunch rather than school meal assuming the whole cost of the school meal is borne by the family.

Outcomes

There were significant and important improvements in the dietary intake of children in the period from pre to post-implementation of the school food policy. There were statistically significant differences found in the mean nutritional intake from school and packed lunch. Post policy lunch time food choice was found to have a significant effect on the total diet in children aged 4-7yrs. In contrast, there was little evidence of an effect of lunch type on total diet in the 11-12yr olds. A full report on the short-term nutritional effects of implementing the school food policy can be found at http://phrc.lshtm.ac.uk/.

3.2 Analysis

The total cost of providing the school meals service was calculated for each year, these data were then combined with the numbers of meals supplied in each year to calculate a cost per meal, inflated to 2009 prices using the Hospital and Community Health Service pay and price inflation index.[10] Food price inflation has been high throughout 2005-09, therefore, the cost per meal was also adjusted using the OECD food price inflation index for the UK.[11] The cost per meal data was used to estimate the total cost of providing school meals to a child across the time that they would spend at school. The costs and outcomes were discounted at 3.5% (the UK Treasury recommended rate).[12] The base case analysis assumes that a child is provided with a school meal five days a week for 39 weeks a year for 12 years but the impact of varying the number of school meals per week was explored in a sensitivity analysis. The incremental cost of providing school meals to a child over their lifetime at school following the introduction of the new school food policy was calculated. This calculation does not adjust for other factors influencing the cost of the school meals such as any diseconomies of scale caused by the reduction in the number of school meals provided. The data on the costs of providing the school meal service and the health outcomes were incorporated into a cost-consequence analysis.

3.3 Results

Costs

The total cost of providing the school meal service in Newcastle upon Tyne and the cost per meal are presented in Table 1.

Table 1: Cost of provision of total school meal service in all age groups (£)

	Cost per Meal	Incremental Cost (HCHS* price index adjusted prices)	Incremental Cost (OECD** food price inflation adjusted prices)	Total Cost	Number of Meals Supplied
2005	1.65	1.90	2.03	5,388,438	3,267,200
2006	1.72	1.91	2.07	5,529,487	3,212,080
2007	1.94	2.07	2.23	5,661,070	2,919,690
2008	2.11	2.19	2.22	6,078,198	2,877,308
2009	2.18	2.18	2.18	5,803,157	2,666,592

*HCHS: Hospital and Community Health Services; **OECD: Organisation for Economic Co-operation and Development

The cost per school meal has increased over the period. This increase is due to a combination of factors; a rise in the price of food, the cost of employing staff and the reduction in the number of meals provided. From 2005 to 2009 the cost of food and the cost of employing staff both increased by 11% for NCC. The number of school meals supplied fell by 600,000, an 18% fall. Over the same period the school role in NCC schools fell by 1,800. This fall in the number of pupils would account for approximately 6% of the reduction in the number of meals supplied. For the specific primary schools included in this study (excluding two primary schools with catering provision not from NCC), there was a 12% reduction in the number of meals supplied, over the same period the number of pupils fell by 4%. This indicates that there has been a substitution of school meals by packed lunches.

Based on the cost per meal presented in Table 1, the total cost of school meals for a child at school per academic year was calculated. Table 2 presents the results based on the cost per meal in 2005 and 2009 to compare before and after the introduction of the new school food policy (See Appendix 6.2 for explanation of how these values were calculated). The number of school meals taken per week by a child may vary; therefore costs were also calculated based on the provision of 1-5 meals per week.

Table 2: Incremental cost per child of school meal service over one academic year (£) pre and post-implementation of school food policy

Number of School Meals Per Week	Incremental Cost (non adjusted prices)	Incremental Cost (HCHS* price index adjusted prices)	Incremental Cost (OECD** food price inflation adjusted prices)
5	103.35	54.60	29.25
4	82.68	43.68	23.40
3	62.01	32.76	17.55
2	41.34	21.84	11.70
1	20.67	10.92	5.85

*HCHS: Hospital and Community Health Services; **OECD: Organisation for Economic Co-operation and Development

For a child entering primary school, accruing 12 years of school meals the incremental cost per child of the school meal service is presented in Table 3.

Table 3: Incremental cost per child of the school meal service over 12 years (£) pre and post-implementation of school food policy

Number of School Meals Per Week	Incremental Cost (non adjusted prices)	Incremental Cost (HCHS* price index adjusted prices)	Incremental Cost (OECD** food price inflation adjusted prices)
5	988.71	527.62	282.65
4	798.96	422.09	226.12
3	599.22	316.57	169.59
2	399.48	211.05	113.06
1	199.74	105.52	56.53

*HCHS: Hospital and Community Health Services; **OECD: Organisation for Economic Co-operation and Development

Cost-consequence analysis

The costs and outcomes of the introduction of the new school meal regulations can be considered together as seen in Table 4.

Table 4: Balance sheet describing the results of the cost consequence analysis

Pros	Cons
• Statistically significant and important reduction for those receiving school dinners in consumption of: fat in both age groups and in saturated fat, non-milk extrinsic sugars, and sodium in primary school children. †	• Increase in cost of providing school lunch of £0.28 per meal over the period 2005-2009 (adjusted using HCHS inflation indices). If a child had 5 school meals per week this would be an increase of £54.60 over the academic year.
• Statistically significant and important increase in consumption of micronutrients. †	• If the prices were adjusted using the OECD food price inflation index the cost of providing the meals increased by £0.15 per meal and £29.25 per child over the academic year.
• Potential narrowing of inequalities as the number of free school meals provided has not fallen at the same rate as paid school meals.	• Over the period 2005-09, the number of school meals provided decreased by 18% (around 6% of this is attributed to reduction in school role).
• Substitution of packed lunch for school lunch is cost saving for parents (assuming all cost of school food is passed to parents); with an annual saving of £17.55 if a child has a packed lunch every day.	• Substitution of school lunches for packed lunches mean nutrition of children eating packed lunches has not improved to the same extent (macronutrient and micronutrient content of packed lunches has also improved over the period, although not to the same extent as school lunches).
• Possible educational benefits – learning behaviours in the classroom, attendance, sickness and possible subsequent educational attainment.	
• Exposure to new foods and tastes.	
• Opportunity for cross curriculum learning on healthy lifestyle behaviours.	
• (Insights into these issues from key stakeholders can be found in the process evaluation report †)	

† A full report on the effect of the new policy on the school food and total dietary intake of children and an evaluation of the process of implementation of the policy can be found at http://phrc.lshtm.ac.uk/

The short-term data presented in the balance sheet highlights the trade-offs that exist when comparing school food since the implementation of the school food policy with previous circumstances. A judgement is required as to whether the improvement in the nutritional status of those eating school meals, the potential reduction in inequalities, and the educational benefits are worth the likely increase in net cost and reduced improvement in nutritional intake for those that switch to packed lunches. An increase in the uptake of school lunch (particularly in primary school) would extend the benefits in nutritional intake to be gained by primary school children.

4. Estimating the longer term impacts of the school food policy

A model of cardiovascular disease (CVD) risk was developed to evaluate the potential longer term impacts in terms of both costs to the NHS and health effects measured in terms of QALYs of the introduction of the school food policy. This model includes only CVD and does not include cost and outcomes of other diet related disease such as obesity, diabetes, cancer and dental caries neither is it possible for such a model to take account of any improvement in educational attainment and subsequent employment benefits which may accrue through improved nutrition and attention. As such this analysis should be treated as a proof of concept rather than a definite analysis of longer term impacts of the school food policy.

4.1 Lifecourse model of cardiovascular disease risk

Purpose and Description

The model was a discrete event simulation model. The model examined a cohort of children, and extrapolated their body mass index to early adulthood (age 32 yrs). The yearly probability of a cardiovascular event was calculated for every year for the next forty years. For those individuals having a cardiovascular event, the nature of that event was determined, and the subsequent health states were simulated until death. The NHS costs of medical interventions and QALYs were calculated for each individual undergoing an event.

States and Variables

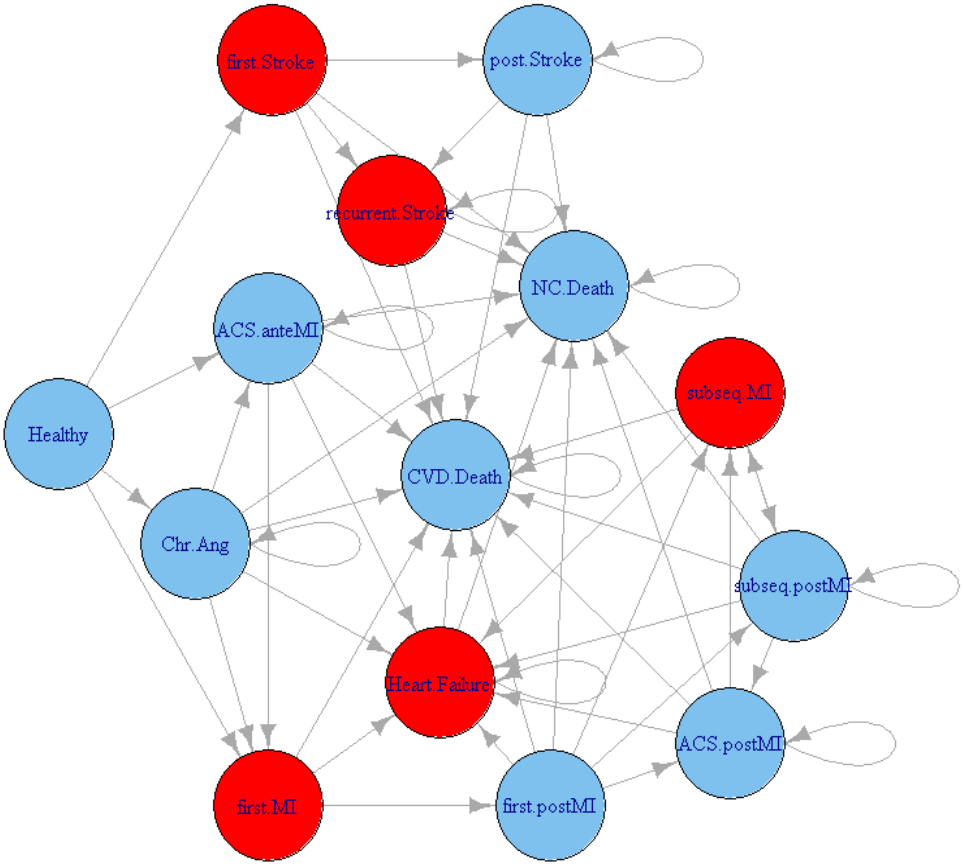
Each individual in the model was characterised by eight state variables: Age (discrete); Sex (cardinal); Body mass index, or BMI (continuous); Systolic blood pressure (continuous); cholesterol/HDL ratio (continuous); Smoking status (binary); Treatment for Hypertension (binary); Diabetes (binary). The QRISK algorithm[13] was used to estimate the risk of cardiac events. This algorithm considered six other state variables, but we either lacked information on these for the cohort of interest, or lacked

data on how they were correlated with other covariates. Consequently, these were omitted from the calculation or considered absent. These state variables were: Townsend score (continuous); Family history of heart disease (binary); Atrial Fibulation (binary); Rheumatoid arthritis (binary); Chronic renal disease (binary); Ethnicity (cardinal).

Details about how a simulated cohort of people from age 12 to 72 yrs was produced are described in detail in Appendix 7.3. The QRISK algorithm was used to predict the yearly probability of a CVD event of the cohort of healthy 32yr olds (described in detail in Appendix 7.4: Simulation to first CVD event). Incidence of CVD events resulting from the model was 60.2 (95% CI: 49.6 – 71.8) per 10,000 individuals.

Transitions from first event

Individuals experiencing a CVD event pass from a healthy state to one of four initial states: first stroke, acute coronary syndrome ('unstable angina'), chronic angina, and first myocardial infarction, or MI (Figure 1). The probability of each of these events was derived from national rates of incidence of each of these conditions.



ACS = acute coronary syndrome; Chr. Ang. = Chronic angina; MI = Myocardial infarction; NC = Non cardiac. Events lasting less than a year are shown in red. ACS = acute coronary syndrome, MI = myocardial infarction.

Figure 1: Transition pathways following first cardiovascular disease event

Following the initial condition, each individual had a probability of passing into subsequent states (details of the probability parameters are presented in Appendix 7.5) indicated in Figure 1. Change in state was assessed on a yearly time-step. The MI, heart failure, and stroke events lasted for less than a year; these were combined into the subsequent event to determine yearly status. Thus 'first stroke + post stroke' was considered to be a single year's events, as was 'MI + heart failure + CVD death'. The states of 'post MI' and 'post stroke' represented time spent following a stroke or MI with no further CVD events.

The transition probabilities between each of these states were derived from the literature.[14] Some probabilities were predicated on whether they preceded or followed other events, thus the presence of states for acute coronary syndrome pre- and post-MI, and the distinction between first MI and subsequent MI. The 'first post MI' state represents the short-term following an MI (a year or less);

individuals pass from this into the 'subsequent post MI' state to indicate the long-term (greater than a year) survival following an MI.

Intervention

Intervention in this discrete event model was simulated by changing the state variables of the 12yr old population. This was in terms of BMI, systolic blood pressure (as change in school food was shown to result in reduced sodium intake); and cholesterol (as change in school foods was shown to result in reduced % energy and absolute amounts of dietary fat, and saturated fat in primary schools only). It was not possible to use any other dietary change variables. Tracking of reduced sodium and fat intake from childhood to adulthood was initially taken to be 100% although this is unlikely to be true. A systematic review of the evidence for tracking in studies that tracked plasma lipids from childhood to at least age 25yrs is reported in Appendix 7.6. For example the correlation coefficients reported for total plasma cholesterol ranged from 0.35 to 0.71. The discrete event model therefore represents a best-case scenario of the extrapolation of the effects, with respect to CVD, of the school food policy intervention to early adulthood. Variability of the model proved very high under the best-case scenario; an effect that would have only been amplified if less perfect tracking was included.

Costs

The perspective was the NHS and for each event in the model a NHS treatment package was developed. This treatment package took into account the procedures and medications a patient experiencing an event would receive. The treatment packages were constructed following a review of relevant clinical guidelines outlining recommended evidence based care for these events.[15-21] Quantities of resources used and their costs were developed from these guidelines supplemented by evidence from relevant health technology assessments.[22] Further details of medical treatments for each event were based on the British National Formulary 60 (BNF 60)[23] on standard treatment for the relevant event. The treatment packages were presented to the project research advisory committee to check for any omissions before being finalised. The final treatment packages for each event are presented in Appendix 7.7.

Costs were attached to each item within each treatment package using data from either the Department of Health Reference Costs 2008-09, the Personal Social Services Research Unit (PSSRU) Unit Cost of Health and Social Care 2010,[10] and the BNF 60[23] as appropriate. The cost attached to each item and the source of the data is presented in Appendix 7.8. Drug costs were taken from the BNF. It was assumed that the costs of a recurrent event would be the same as the first event and that there were no additional costs incurred for the transition into death. The constructed annual costs for each treatment package are presented in Appendix 7.9.

Health state utilities

Health outcomes are presented in terms of QALYs. To calculate QALYs a health state utility value was required for each event (including remaining healthy). A literature review was undertaken to identify utility values for each event within the model. Studies were identified through a search of the CEA registry[24] and the NHS Economic Evaluation Database[25] and from a prior review reported as part of a health technology assessment conducted by Ward et al (2007).[26] Ward et al conducted a literature review for studies up to 2004 which was judged to be reasonably comprehensive and relevant to the NHS. The review provided utility values for stable angina, unstable angina, MI and stroke. Therefore, further data on relevant utility values was sought from the literature from 2004 onwards. A separate search was conducted for utility values associated with Heart Failure using the CEA registry and NHS EED for studies published between 2000 and 2010. Appendix 7.8 presents the studies identified from the literature review to identify the most appropriate data for the model. The derived annual utility values used in the CVD model are presented in Appendix 7.9.

4.2 Costs and outcomes between age 4 and 32 yrs

For each individual in the simulated cohort costs and QALYs were estimated between age 4 and 32 yrs. The cost between age 4 and 16 yrs were assumed to be equal to the cost of meals, thereafter annual costs were assumed to be 0 until age 32 yrs. Annual QALYs were assumed to be 1 between 4 and 32 yrs.

Analysis

The output of the model consists of the eventual fates of the simulated cohorts of individuals (one cohort who received the school food intervention and one that did not).

The results are also presented in terms of cumulative mean costs and QALYs. Both costs and QALYs are discounted at 3.5%.[27] The results of the analysis are also presented as numerical descriptions of cost-effectiveness acceptability curves (CEAC) which illustrate the likelihood that a strategy is cost-effective at various threshold values for society's willingness to pay for an additional QALY.

Results

The mean estimates of QALYs and costs pre and post-implementation of the school food policy are shown in Table 5. Post-implementation appears to be more costly than pre-implementation whereas there are no significant differences in QALYs between the two groups. The costs post-implementation are mainly driven up by the higher school food price post-implementation relative to the school food

price pre-implementation of school food policy; however, due to the low incidence rates of the CVD events, QALYs of the control group have not been greatly affected, which leads to the average QALY values being nearly identical for the two groups. Furthermore, the analysis is run as two separate models – one for pre-implementation and one for post-implementation; therefore, death and other events are random events which are probabilistically determined. Since the models are run separately, the random numbers generated in the programme software (R) for the event cases in the post-implementation model are not identical to those in the pre-implementation model and as a result of this there are small imbalances that may affect the mean estimates of costs and QALYs.

Table 5: Mean estimates of quality adjusted life years and costs

Group	**QALYs***	**Costs***
Post-implementation of school food policy	25.76	£4117
Pre-implementation of school food policy	25.77	£3593

* Data based on middle school data

A sensitivity analysis examining the cost-effectiveness of the school food policy is performed in order to address uncertainty presented as the numerical descriptions of the CEAC in Table 6. The probability of the intervention being cost-effective increases as the society's willingness to pay (WTP) for a QALY rises. When WTP for a QALY is 0, there is little chance of the school food policy intervention being cost-effective, thus the intervention would not be recommended. As the WTP for a QALY increases up to above £5000, the two programmes will have nearly equal probability to be cost-effective. Considering the current NICE recommended threshold for the value per QALY is £30000,[28] in which case the school food service after the introduction of the school food policy and the service prior to the introduction of the school food policy will be nearly equally cost-effective, the decision on the choices between the two may then lie on considerations of other short-term effects as presented in Table 4.

Table 6: Probability of cost-effective at different threshold values for society's willingness to pay for a quality adjusted life year

Group | WTP (£)	0	5000	10000	20000	30000	50000
Post school food policy	0.5%	46.5%	48.5%	48.7%	48.7%	48.7%
Pre school food policy	99.5%	53.5%	51.5%	51.3%	51.3%	51.3%

5. Summary and brief discussion

The cost-consequence analysis presented, provides a means of highlighting the trade-offs between the outcomes and findings from the report on the short-term nutritional effects of the school food policy and the net costs of the school food policy. The net costs per child over their school career are modest when compared to, for instance, the costs of many routine medications prescribed for those at risk of obesity related diseases, but, a judgement is required as to whether improvement in the nutritional status of those eating school meals, the potential reduction in inequalities, and the educational benefits are worth the likely increase in net cost and reduced improvement in nutritional intake for those that switch to packed lunches.

The extent that these short-term effects might influence longer term outcomes was explored within a modelling exercise. This was a discrete event simulation model that simulated the impact of changes in school food policy on cardiovascular events, survival, quality of life and costs. These were combined to estimate the cumulative costs and QALYs following the implementation of a school food policy compared with those following the previous policy. This modelling exercise was exploratory as there were relatively few data to enable the extrapolation from the short-term data. The estimated number of cardiac events was very low and hence the opportunity for a school food policy to demonstrate a benefit was limited. Therefore, the mean costs and QALYs for both the post and pre school policies were very similar. Indeed the mean QALYs for the post school food policy are slightly lower but this is purely a modelling artefact. The modelling exercise would have been improved with individual-level rather than population-level covariates; data on correlation between covariates was not available in many cases; which would have improved the predictive power of the model. Importantly, the modelling exercise shows that it is possible to link up interventions at childhood to survival, QALYs, and costs in later life.

The modelling exercise only included the costs and consequences of cardiovascular events and did not include the cost and health effects of other obesity related diseases, nor did it consider the wider societal impact e.g. from educational and employment effects. This means that the differences in costs and QALYs presented in Table 5 and Table 6 are smaller than might exist had these other effects been modelled. It is possible to consider what the size of any additional health benefits from avoiding other obesity related disease would need to be so that the incremental cost per QALY was no more than £30,000 (a value which society may be willing to pay to gain additional benefits). Given the mean difference in cost reported in Table 5 (school food policy costs on average £524 more over the life time of the child), the school food policy would need to provide an extra 0.017 QALYs on average over a lifetime (which is equivalent to an additional 6.37 days in full health over a lifetime).

Strengths

The main strength of the economic evaluation based on the short-term data is that the principles of cost-benefit analysis have been followed, which valued all relevant costs and outcomes that we were able to; for those that we could not value we have measured them in natural units (e.g. change in micronutrients) and where we cannot quantify an effect we have identified a potential impact (e.g. educational benefits of a school food policy).

Limitations

With reference to the health economic analysis the main limitation was that these different outcomes could not be combined into a single measure of relative efficiency as would be expected from a full cost-benefit analysis. With respect to the costs of providing school lunch sufficiently disaggregated data to estimate the costs came from just one local authority area. This potentially limits the generalisability of the data. A further limitation of the short-term economic model was that it did not consider the longer term impact of the school food policy. This is especially important as the costs of providing more costly school meals may be compensated by improved health and lower use of health services in the future. The extrapolation of the short term outcomes to longer term outcomes was limited by the ability to model the linkages between short-term surrogate measures of nutritional status and long term events. Despite a systematic review, only limited data were available to inform the model and, as a consequence, the model should best be considered as exploratory. The model concentrated on predicting and modelling the consequences (in terms of survival, quality of life and costs) of cardiovascular events. Other potential effects (e.g. the impact on other obesity related diseases) were not included. The informational demands of such a model are, however, considerable and it is not known whether sufficient data to populate such a model are available. Nevertheless, the modelling exercise has illustrated the feasibility of such a modelling exercise and shown the need for further data to link short and long-term data.

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7. Appendices

7.1 Items included in cost of school food intervention

The total cost of the provision of the school food service presented in section 2 is based on accounts provided from Newcastle City Council. The items included in the cost of the school food intervention are presented in the table below.

Items	
Staff	Payroll including superannuation and overtime allowances Retirement Allowances
	Meal Allowances
	Training
Food/Drink	Re-saleable Items
	Milk (not in 2009)
Premises	Equipment leasing, purchase and maintenance
	Cleaning materials
	Refuse Collection
	Pest Control
Supplies	Medical Equipment/First Aid
	Clothing and Uniforms
	Laundry
	Animal Feed
	Consumable Materials
Other	External Security and Cash Collection
	Public Liability
	Employers Liability
	Personal Accident Insurance
	Other Expenses
	Promotions/Advertising

7.2 Calculation of incremental cost per child of school meal service

The incremental cost per child of the school meal service presented in Table 2 was calculated as:

$$\text{Incremental Cost per child} = C^{2009} - C^{2005}$$

Where:

C^{2009} = (Cost per meal in 2009 *Number of meals per week)*number of weeks per academic year

C^{2005} = (Cost per meal in 2005 *Number of meals per week)*number of weeks per academic year

The number of weeks per academic year is 39

Example:

Cost per child 2009 = (£2.18*5)*39 = £425.10

Cost per child 2005 = (£1.65*5)*39 = £321.75

Incremental cost per child = 425.10 – 321.75

= £103.35

7.3 Extrapolation from childhood to middle age

A dataset from a previous study[29, 30] was used to determine the relationship between the state variables at age 12 and 32. A significant relationship was found between BMI at age 12 and BMI at age 32, with gender as a significant covariant. This analysis was used to generate a simulated cohort of 32-year olds.

Table 7: Results of Generalised linear model: Response variable = log (BMI age 32)

Variable	mean coefficient	Standard deviation of coefficient	F-value	P
(intercept)	1.51934	0.19958	7.613	1.06×10^{-12}
log (BMI age 12)	0.64385	0.06756	9.531	$<2.00 \times 10^{-16}$
gender: female	–0.07310	0.01933	–3.782	0.000206

First, gender and BMI of a cohort of 12-year olds was simulated: gender was randomly divided into male (1) and female (0) with equal probability, and BMI was determined by drawing a random deviate from a normal distribution with the mean and standard deviation of the 12-year old BMI. Random deviates for each coefficient were generated by drawing random deviates using the mean and standard deviation listed in Table 7. The BMI at age 32 could then be predicted using the regression equation:

$$BMI_{32} = e^{a+b.\log(BMI_{12})+c.SEX}$$

Where *a*, *b*, and *c* are the random deviates for the intercept, coefficient for log (BMI_{12}) and gender, respectively.

Values for cholesterol ratio at age 32 were taken from the age-specific population means of these measurements[13]. Smoking status was assigned independently of other variables according to the incidence in the Health Survey for England 2007.[31] Diabetes was assigned independently based on incidence of diabetes in the general UK population.[32] The effect on systolic blood pressure was estimated from changes in salt intake simulated using regression equations.[33] It was assumed that there was 100% tracking between salt reduction at school and salt reduction in adult life. The effect of dietary fat on blood cholesterol: HDL ratio was simulated in the same fashion[34]. The initial cohort for the post data sets were generated assuming a 345 mg/day reduction in salt intake for juniors and a 1112 mg/day reduction in salt intake for middle schoolers. Furthermore, the post data sets derived fewer of their daily calories from fat: a 2.2% decrease in total fat and a 1% decrease in saturated fats for the junior cohort; and a 3.5% decrease in total fat but no reduction in saturated fat for the middle

school cohort. Once again, 100% tracking between reduction in dietary fat at school and in adult life was assumed.

A GLM of all individuals greater than 32 was constructed using BMI, smoking status, sex, and age as predictors (Table 8). Incidence of individuals undergoing treatment for hypertension was randomly determined based on the incidence observed in the Health Survey for England 2007.[31] This incidence was decade-specific, and divided into those with a systolic blood pressure of less than 140 mmHg, and those with equal or greater than 140mmHg (Table 9).

Table 8: Results of Generalised linear model: Response variable = log (Systolic Blood Pressure)

Variable	**mean coefficient**	**Standard deviation of coefficient**	**F-value**	**P**
(intercept)	4.1401	0.0372	111.2750	$<2.00 \times 10^{-16}$
age	0.0036	0.0001	27.1360	$<2.00 \times 10^{-16}$
log (BMI)	0.1519	0.0111	13.6980	$<2.00 \times 10^{-16}$
gender: male	0.0317	0.0039	8.1380	0.0000
Smoking: yes	0.0189	0.0049	3.8290	0.0001

Table 9: Incidence of treatment for hypertension

Decade	**Incidence of treatment for hypertension (systolic BP >= 140 mmHg)**	**Incidence of treatment for hypertension (systolic BP < 140 mmHg)**
(30,40]	0.082	0.007
(40,50]	0.163	0.060
(50,60]	0.263	0.160
(60,70]	0.348	0.254
(70,80]	0.498	0.408
(80,90]	0.480	0.443
(90,100]	0.429	0.625

7.4 Simulation to first cardiovascular disease event

QRISK predicts the ten-year likelihood of a CVD event, this was converted to a standard base of one year as follows:

$$P_{1year} = 1 - \left(1 - P_{10\,year}\right)^{1/10}$$

This probability was calculated individually for each member of the cohort. A random deviate between 0 and 1 was drawn from a uniform distribution for each individual; if this deviate was lower than the calculated probability of a CVD event, then the individual was deemed to have had a CVD event. Once an event had occurred, that individual was excluded from any further iterations of the QRISK algorithm.

Simulation of events continued for forty years. Each year, prior to testing for CVD events, the population's age was incremented by one, and systolic blood pressure and cholesterol ratio were updated according to population averages for the new age. BMI was recalculated every decade using a correlation matrix of BMI by decade derived from.[35, 36] New values for BMI were generated through Cholesky decomposition of the correlation matrix multiplied by normal random deviates. Systolic blood pressure and hypertension were updated at the same time, using the method described above.

7.5 Parameter values used in the discrete event model

Variable	Value	Reference
Stroke		
Stroke incidence	B[0.241, 0.286, 0.398, 0.542]	[37]
Recurrent stroke incidence	0.507	[38]
Stroke mortality	0.331	[38]
Myocardial infarction		
MI incidence (%)	M[0.225, 0.359, 0.710, 1.010] F[0.030, 0.165, 0.236, 0.590]	[14]
Short term MI recurrence, at age **t**, **b**+exp (**at**) (%)	**a**=0.0337, **b**=0.0325	[14]
Long term MI recurrence, at age **t**, **b**+exp (**at**) (%)	**a**=0.030, **b**=0.0159	[14]
Annual probability of progression from angina/ACS to MI, at age **t**, exp (**at**+**b**) (%)	**a**=0.0458, **b**=–6.574	[14]
MI mortality (%)	B[4, 15, 25, 46]	[14]
Angina		
Chronic angina incidence (%)	M[0.238, 0.548, 0.655, 0.300] F[0.098, 0.357, 0.333, 0.600]	[14]
Acute coronary syndrome incidence (%)	M[0.043, 0.080, 0.190, 0.210] F[0.029, 0.030, 0.039, 0.048]	[14]
Annual probability of progression from chronic angina to ACS, at age **t**, exp (**at**+**b**) (%)	**a**=0.0458, **b**=–6.574	[14]
ACS mortality (%)	3.9	[14]
Other coronary events		
heart failure rate (%)	B[0.001, 0.009, 0.015, 0.036, 0.087]	[14]
death due to heart failure	B[0.05, 0.09, 0.10, 0.20, 0.64]	[14]
Baseline mortality rate, at age **t** for sex **s** (0=F, 1=M), exp(**c**+**at** +**bs**)	**a**=0.0534, **b**=0.4342, **c**=–9.7059	Office for National Statistics

Transition Probabilities. For variables where vectors are provided, these are for males (M), females (F), or both (B), and are for the age ranges [45–54, 55–64, 65–74, 75–84]

7.6 Systematic review of tracking of lipids from childhood to adulthood

Background

A systematic search of the literature was initially conducted in order to identify existing systematic reviews of tracking of cardiovascular disease risk factors from childhood to adulthood that could provide appropriate parameters for the lifecourse model of CVD risk for the school food policy and to identify where there were gaps in the literature and data available. The initial systematic literature search found two systematic reviews on tracking of blood pressure.[39, 40] Three systematic reviews relevant to tracking of obesity were found and one review of systematic reviews of obesity tracking.[41]

Reviews (not systematic) were found relating to tracking of obesity[42] cardiometabolic risk factors[43] and reporting lipids data at different lifestages, (but not tracking parameters) using mainly cross-sectional analyses.[44] As no systematic reviews on tracking of lipids were found, it was decided to focus work on a systematic review of tracking of lipids from childhood to adulthood in order to provide data for the lifecourse model.

Objectives

To identify, collate, critically appraise and extract data from longitudinal studies that have collected data on 'tracking' of lipids from childhood into adulthood. To extract details of tracking parameters measured in order to expand the lifecourse model for CVD risk.

The term 'tracking' is used to describe the longitudinal development of a variable.[45] There is no agreed single definition but the term is usually taken to imply correlation between measurements over a lifetime[45] or the 'preservation of relative position.[46]

Methods

The systematic review was conducted according to a pre-defined protocol.

Search methods for identification of studies

Searching was conducted on MEDLINE, EMBASE, CINAHL, PSYCInfo, Google and Google Scholar. A full search strategy combining both MeSH headings and textwords as appropriate was developed (for MEDLINE on Ovid) and adapted for each of the other databases as appropriate. A standard filter for finding cohort studies was used for MEDLINE and EMBASE. All studies were searched for regardless of language of publication.

The reference lists of all included studies were also checked to identify any other relevant studies. A list of all prospective cohort studies presented by WHO at a meeting on lifecourse epidemiology was also screened[47]. We also attempted to identify additional studies through identification of cohort studies by discussion within our team and other experts and searched websites for any relevant publications.

Inclusion criteria for the review

Studies searched for were cohort studies (prospective, retrospective) and controlled trials with longitudinal follow-up of a cohort from at least one arm of the study, with follow-up from childhood (<18 years) to adulthood (>18 years) of at least 5 years. For the lifecourse model studies that tracked from childhood and followed participants to at least age 30 years were of most interest but to provide a complete picture of the data available all studies that tracked from childhood to adulthood as defined above were included. Studies that reported male or female participants of any ethnic origin, aged less than or equal to 18 years at baseline and followed up for at least 5 years to any age over 18 years were included. Participants needed to have at least one measure of lipids (total cholesterol, HDL cholesterol, LDL cholesterol or triglycerides) measured at baseline and measured at follow-up and to report any parameter used to measure tracking (for example a correlation coefficient, regression coefficient, or a measure of agreement such as Cohen's kappa).

Data collection and analysis

The abstract, title or both sections of every record retrieved were screened by one reviewer and all potentially relevant articles were obtained as full text. Potentially relevant full-text articles were fully screened for inclusion using a purpose-designed IN/OUT form.

For studies that fulfilled the inclusion criteria, data on type of study, country, number in cohort, drop-outs, recruitment, age of participants, sex, ethnicity, socioeconomic position, length of follow-up, method of assessment of lipids at baseline and follow-up, lipids outcome at baseline and follow-up, tracking parameters measured and statistical methods used to assess tracking were extracted. Tracking parameters were extracted at all points available in the follow-up in order to maximise the information available about the tracking profile.

In the case of duplicate publications and companion papers of a primary study, yield of information was maximised by evaluation of all available data.

Assessment of trial quality/risk of bias

Trial quality (cohort studies) was assessed according to the Newcastle-Ottawa scale (NOS).[48] The Newcastle-Ottawa scale covers 3 main domains (Selection, Comparability and Outcome).

Studies were additionally appraised in relation to their methods of measurement of chronic disease risk factors e.g. training and supervision of assessors, whether risk factor estimates were based on a single measurement or took means from separate estimates, use of fasting or non-fasting blood samples. Furthermore we appraised the statistical methods used to calculate tracking parameters, following a previously reported framework.[45]

Main findings

Searches

MEDLINE, EMBASE and PSYCInfo were searched through Ovid. CINAHL was searched through EBSCO Host. The MEDLINE, EMBASE, PSYCInfo and CINAHL searches found 3574, 3397, 534 and 47 search hits respectively. After importing into Endnote, combining and removal of duplicates, there were 5690 search hits. After screening by title and/or abstract, 89 potentially relevant papers were identified and full papers obtained. After screening the full papers, 62 papers were excluded because they did not meet the inclusion criteria and 1 paper was not available (via inter-library loan) within the timescale of the review. In total, 28 papers from 13 separate studies with data on tracking of lipids from childhood to adulthood, were included. Some studies reported data at successive timepoints over several different papers, or reported the data in duplicate publications or different tracking analyses in different papers.

Description of included studies

The 13 included studies (28 papers) were the Cardiovascular Risk in Young Finns Study;[49-53] the Bogalusa Heart Study;[54-57] the Amsterdam Growth and Health Study;[58-61] Childhood Determinants of Adult Health Study;[62] Beaver County Lipid Study;[63-65] the 'Danish' Study;[66, 67] the Muscatine Study;[68, 69] the Quebec family Study;[70] the Busselton Study;[71] the Aerobics Centre Longitudinal Study;[72] the Fels Longitudinal Study;[73, 74] Salonen et al[75] and Mellies et al.[76] Of the 13 included studies, 6 were conducted in the US, 2 in Australia, 2 in Finland, and one each in the Netherlands, Denmark and Canada. Eleven of the studies were conducted in representative, general populations of children at baseline. One study followed a birth cohort of children born 'appropriate for gestational age' compared to those who were 'small for gestational age'[75]. One study followed relatives with familial hypercholesterolaemia.[76] The study has been included for comparison but data are reported separately as tracking may be greater because of the hereditary link.

Three studies in general populations tracked children until they were adults aged over 30 years (the Cardiovascular Risk in Young Finns study; Childhood Determinants of Adult Health study; the Busselton study) and 6 studies in general populations tracked from childhood to adult ages 25 to 30 years (the Bogalusa Heart Study; the Amsterdam Growth and Health Study; Beaver County Lipid Study; the Muscatine study; the Quebec Family Study; the Aerobics Centre Longitudinal Study and the one study in those with familial hypercholesterolaemia.[76] The remaining studies tracked to ages less than 25 years.

Data synthesis

As there was heterogeneity of the tracking data for lipids in terms of length of follow-up, ages of children at baseline and, the statistical methods used and reported for tracking, formal statistical pooling of results was not attempted. However, key study characteristics and tracking outcomes were fully tabulated. In most of the studies, data are reported separately by gender. Some studies also reported data by ethnicity.

A range of tracking analyses were reported in the studies. The majority of studies reported correlation coefficients or partial correlation coefficients. Other tracking data reported were odds ratios, persistence in an extreme e.g. highest tertile, quintile. The data has been fully extracted and tabulated by baseline age, length of follow-up, type of lipids reported, study characteristics and quality assessment but is not reported here due to space restrictions (> 80 pages of data). The full data were supplied to the team working on the lifecourse model for CVD risk.
In the studies that tracked to at least 25 years of age, the range of tracking correlation coefficients reported (including both males and females, and all ethnicity data) were as follows:-

Total cholesterol 0.35 – 0.71
LDL-cholesterol 0.32 – 0.67
HDL cholesterol 0.26 -0.65
Triglycerides 0.20 – 0.58.

Further assessment of the data will be conducted to determine if there is scope for conducting meta-regression and to determine if there are trends in the data e.g. by baseline age, length of follow-up, gender, ethnicity.

7.7 Treatment packages used in the cardiovascular disease risk model

First Angina

Resource	Cost (lower quartile, upper quartile) 2010 prices	Reference
GP first Attendance	36	PSSRU[10]
Outpatient first attendance	163 (106, 201)	NHS Reference Costs 2008-09[77]
ECG monitoring and stress test – outpatients	131 (93,150)	NHS Reference Costs 2008-09[77]
Total cost	**330 (235,387)**	

Management of Stable Angina

Resource	Cost (lower quartile, upper quartile) 2010 prices	Reference
Glycerol trinitrate spray	3.13	BNF 60[23]
Propanalol (beta blocker)	22.16	BNF 60[23]
Simvastatin (statin)	19.70	BNF 60[23]
GP appointment	36	PSSRU[10]
Nurse appointment	12	PSSRU[10]
Total Cost per year	**141***	
Total Cost per quarter	**35.25***	

* Figures may not be exact due to rounding

First MI/Recurrent MI

Resource	Cost (lower quartile, upper quartile) 2010 prices	Reference
Ambulance	244	PSSRU[10]
A&E	282 (144,453)	NHS Reference Costs 2008-09[77]
MI Admission	1701 (1278, 1935)	NHS Reference Costs 2008-09[77]
Thrombolysis	600	BNF 60[23]
Angiography	2454 (1414, 2974)	NHS Reference Costs 2008-09[77]
Outpatient x 3 appointments	387 (106,201)	NHS Reference Costs 2008-09[77]
Cardiac Rehabilitation	595	[22]
Total Cost	**6263 (4551,7266)**	

Management following MI

Resource	Cost , 2010 prices	Reference
Aspirin	8	BNF 60[23]
Clopidogrel (anti-platelet therapy)	433**	BNF 60[23]
Propranalol (beta blocker)	22.16	BNF 60[23]
Perindopril Erbumine (ACE inhibitor)	29.80	BNF 60[23]
Pravastatin (statin)	47.32	BNF 60[23]
GP x 3 visits per year	108	PSSRU[10]
Nurse	12	PSSRU[10]
Total Cost per year	**661***	
Total cost per quarter	**165***	

*Figures may not be exact due to rounding
**Based on treatment for STEMI which requires Clopidogrel for 12 months

First Stroke/Recurrent Stroke

Resource	Cost (lower quartile, upper quartile) 2010 prices	Reference
Ambulance	244	PSSRU[10]
A&E	282 (144,453)	NHS Reference Costs 2008-09[77]
Stroke Admission	2772 (2040,3221)	NHS Reference Costs 2008-09[77]
Thrombolysis	600	BNF 60[23]
Outpatient x 2 appointments	332 (253,380)	NHS Reference Costs 2008-09[77]
Total Cost	**4230 (3281,4898)**	

Stroke Rehabilitation

Resource	Number of Sessions	Cost (lower quartile, upper quartile) 2010 prices	Reference
Physiotherapy	12	636 (408,732)	NHS Reference Costs 2008-09[77]
Occupational Therapy	12	744 (312,1032)	NHS Reference Costs 2008-09[77]
Speech and Language Therapy	12	636 (264,720)	NHS Reference Costs 2008-09[77]
Dietician	1	29	PSSRU[10]
Ophthalmology (outpatient attendance)	1	73 (59,90)	NHS Reference Costs 2008-09[77]
Total Cost		**2118 (1072, 2603)**	

Management following Stroke

Resource	Cost	Reference
Aspirin	8	BNF 60[23]
Dipyridamole (anti-platlet)	91	BNF 60[23]
Atorvastatin (statin)	368	BNF 60[23]
GP x 3 per year	108	PSSRU[10]
Total Cost per year	575	
Total Cost per quarter	144	

Chronic Heart Failure

Resource	Cost	Reference
Lisinopril (ACEI)	18	BNF 60[23]
Carvedilol (beta blocker)	29	BNF 60[23]
Spironolactone	23	BNF 60[23]
Digoxin	26	BNF 60[23]
Furosemide (diuretic)	12	BNF 60[23]
Outpatient (Cardiology) x1 per year	112 (85,132)	NHS Reference Costs 2008-09[77]
Total Cost per year	**207**	
Total Cost per quarter	**52**	

7.8 Cost of treatment package and utility values for each event

Event	Total Cost (range) £	Reference
First Angina	330 (235-387)	Costs data are constructed from reference sources including: NHS reference costs 2008/2009,[77] PSSRU 2010[10] and BNF 60[23]
First MI	6263 (4551-7266)	
First Stroke	4230 (3281-4898)	
Unstable Angina	3809 (3137-4292)	
Chronic CHD – Angina (per quarter)	35	
Chronic CHD – MI (per quarter)	165	
Chronic CHD – Stroke Rehabilitation	2118 (1072-2603)	
Chronic CHD – Stroke Drug Therapy (per quarter)	144	
Recurrent MI	3809 (3137-4292)	
Recurrent Stroke	4230 (3281-4898)	
Heart Failure (per quarter)	52	

Event	Utility value (range)	Reference
Angina	0.75 (0.6-0.808)	[78,79]
Unstable Angina	0.77 (0.714-0.77)	[80, 81, 82]
MI	0.75 (0.683-0.91)	[83, 84, 85]
Stroke	0.65 (0.629-0.74)	[86, 84]
Recurrent Stroke	0.38 (0.334-0.426)	[84]
Heart Failure	0.63 (0.508-0.815)	[87, 88]
Post stroke	0.612 (0.15-0.74)	[89, 90]
Post MI	0.88 (0.718-0.949)	[91, 92, 93]

7.9 Derived annual total cost and total utility of each state in cardiovascular disease model

State	Total cost	Total utility
First MI	6758	0.75
First Stroke	6780	0.62*
First Angina	435	0.75
Unstable Angina	3914	0.77
Heart failure	208	0.63
Subsequent MI	6758	0.75
Recurrent Stroke	6780	0.55
First post MI	660	0.88
Subsequent post MI	660	0.88
Unstable Angina post MI	660	0.88
Post stroke	576	0.612
CVD death	0	0
Non CVD death	0	0