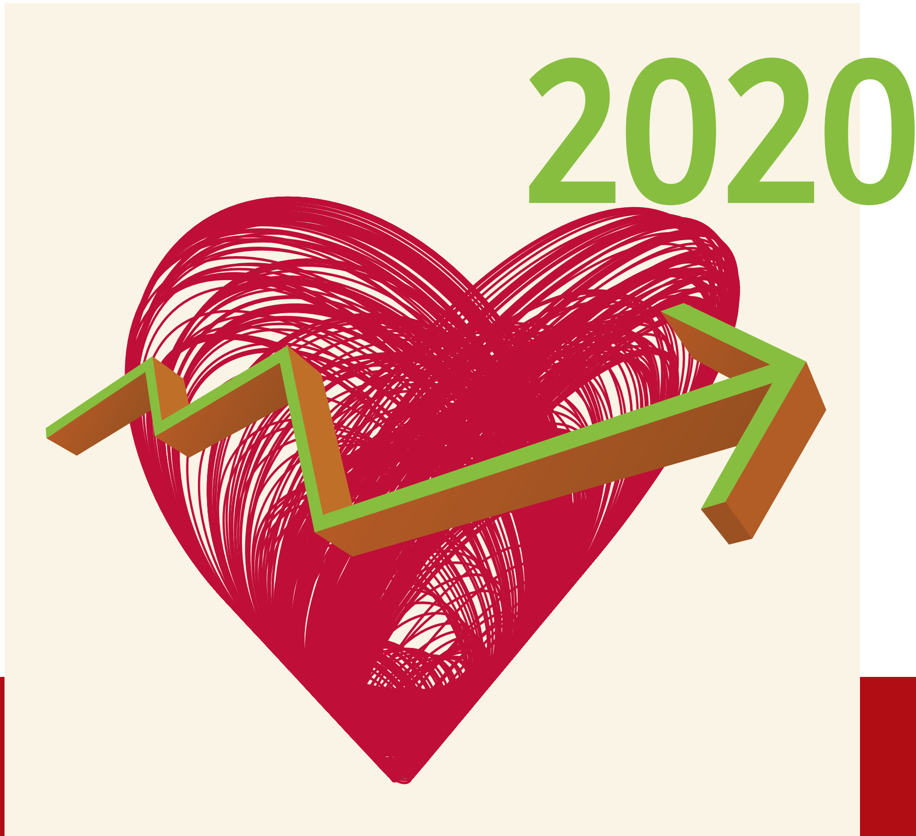
CHD mortality projections to 2020, comparing different policy scenarios

Euroheart II Work Package 6



CHD mortality projections to 2020, comparing different policy scenarios

EuroHeart II Work Package 6

Authors

Karl Andersen, Icelandic Heart Association, Iceland
Thor Aspelund, Icelandic Heart Association, Iceland
Piotr Bandosz, Medical University of Gdansk, Poland
Polly Basak, St George's, University of London, UK
Kathleen Bennett, Trinity College of Dublin, Ireland
Lena Björck, University of Gothenburg, Sweden
Jan Bruthans, Thomayer University Hospital, Czech Republic
Simon Capewell, University of Liverpool, UK
Renata Cifkova, Thomayer University Hospital, Czech Republic
Julia Critchley, St George's, University of London, UK
Carolyn Davies, Medical Research Centre, University of Glasgow, UK
Ruth Dundas, Medical Research Centre, University of Glasgow, UK
Simona Giampaoli, Istituto Superiori de Sanità, Italy
Vilmundur Gudnason, Icelandic Heart Association, Iceland
Maria Guzman-Castillo, University of Liverpool, UK
John Hughes, Queens University, Belfast, UK
Joel Hotchkiss, Medical Research Centre, University of Glasgow, UK
Zubair Kabir, Trinity College of Dublin, UK
Frank Kee, Queens University, Belfast, UK
Sarah Kerry, St George's, University of London, UK
Tiina Laatikainen, National Institute for Health and Welfare, Finland
Esko Levälahti, National Institute for Health and Welfare, Finland
Alastair Leyland, Medical Research Centre, University of Glasgow, UK
Martin O'Flaherty, University of Liverpool, UK
Luigi Palmieri, Istituto Superiori de Sanità, Italy
Fiona Pearson, St George's, University of London, UK
Annika Rosengren, University of Gothenburg, Sweden
Marcin Rutkowski, Medical University of Gdansk, Poland
Rosa Björk Thorolfsdottir, Icelandic Heart Association, Iceland
Erkki Vartiainen, National Institute for Health and Welfare, Finland
Tomek Zdrojewski, Medical University of Gdansk, Poland

Acknowledgements

This study arises from the European Heart Health Strategy II project (EuroHeart II) which has received co-funding from the European Union, in the framework of the Health Programme. The sole responsibility for the text lies with the authors and the Executive Agency for Health and Consumers is not responsible for any use that may be made of the information contained herein. The authors would like to thank the EuroHeart II Steering committee and work package leaders for their support of the project and comments on this report.

Table of Contents

List of Abbreviations

CHD – Coronary Heart Disease

CVC – Cardiovascular Coalition

CVD – Cardiovascular Disease

DPP – Deaths prevented or postponed

FINRISK – National Health Examination Survey taking place in Finland on a 5 yearly basis since 1972

IMPACT – A modelling tool designed to explain trends in CHD mortality

IPAQ – International Physical Activity Questionnaire

NCD – Non-communicable disease

SBP – Systolic blood pressure

Executive Summary

Background

Coronary heart disease (CHD) death rates have been falling across most of Europe in recent decades. However, CHD remains the leading cause of mortality. Furthermore, the burden of CHD may be increasing due to a variety of factors including reductions in case-fatality (resulting in more CHD survivors and increasing prevalence), population ageing, and globalisation. There are also worrying signs that favourable risk factor trends (declines in smoking, blood pressure, and blood cholesterol) may be stalling and that at least in some countries CHD mortality in younger age groups has not declined or has declined more slowly in recent years. Data on regional trends and predictions are available but these may conceal important differences between populations. For all these reasons it is essential to assess the likely future trends in CHD mortality in a range of European populations. It is also important to quantify the potential impact of cost-effective, population wide policy interventions on future trends in the burden of disease. We performed these analyses using a well-known CHD model (IMPACT) which has been widely used to explain past trends in CHD mortality in many European countries.

The key objectives were therefore to:

1. Identify data sources across a range of European countries and populate CHD IMPACT models with the available data up to at least the year 2020.
2. Validate the CHD IMPACT model for forward projection by comparing the model predicted CHD mortality (based on recent trends in CHD risk factors in each country) with recent observed CHD mortality (government statistics).
3. Estimate the future burden of CHD disease (mortality) in each country to at least the year 2020.
4. Identify a series of realistic policy options for appraisal that could be modelled using the CHD IMPACT model, through discussion with stakeholders in each country.
5. Explore the impact of implementing these policy scenarios up to 2020 and beyond using the newly developed and validated IMPACT model in each country.

Methods

1. We developed the previously validated retrospective CHD IMPACT models in nine European populations (*Scotland, Republic of Ireland, Northern Ireland, Sweden, Finland, Iceland, Czech Republic, Poland, and Italy*). In four regions we were able to explicitly validate the model for forward projection by comparing IMPACT model CHD mortality estimates with recently observed CHD mortality trends (*Scotland, Northern Ireland, Republic of Ireland, and Sweden*).
2. We then projected CHD mortality to 2020 and 2030 using national data on population estimates, CHD mortality, and major risk factor trends. Because future trends in CHD mortality are uncertain, we used two counterfactuals (alternative sets of assumptions), one representing the status quo (CHD mortality remaining constant since around the year 2010), and one using a negative exponential distribution to predict future mortality declines.
3. Through discussion with stakeholders we identified a series of policy options for appraisal (such as reductions in dietary salt and saturated fat intakes and reductions in physical inactivity and smoking).
4. Finally, we estimated the effects of possible policy interventions on CHD mortality in 2020 in each country, including drawing lessons about likely impact and generalisability.
5. For pragmatic reasons, medical treatment efficacy and uptake were kept constant in this analysis though in reality significant improvements may be expected by 2020.

Results

The IMPACT Model validation which took place in four countries demonstrated acceptable agreement between predicted future CHD mortality and observed mortality (varying from 80% to 106%). Stakeholders approached were reasonably consistent in prioritising population wide primary prevention interventions (particularly policies to alter dietary nutrient intake, increase physical activity, and reduce smoking). We then modelled feasible policy scenarios to reflect these priorities. The scenarios modelled were reductions in smoking [of 5%, 10% or 15%], and in saturated fat intake [of -1%, -2% or -3% total energy intake] and salt intake [-10%, -20% or -30%], plus increases in physical activity [+5%, +10% or +15%].

Predicting future trends clearly involves uncertainties. However, unless there are substantial improvements in CHD mortality, most countries will see a large increase in the CHD disease burden, mainly due to population ageing.

The most optimistic policy scenarios modelled could reduce CHD mortality substantially, by up to around one third in each country. Roughly 40% of this mortality reduction would be achieved by the proposed alterations in nutrient intakes, 40% from changes in smoking prevalence, and approximately 20% from improvements in physical activity. These results were relatively consistent across diverse populations, under different assumptions about future CHD mortality trends and applying probabilistic sensitivity analyses.

Conclusions

Small and eminently feasible population reductions in cardiovascular risk factors such as cigarette smoking, dietary salt, saturated fat and physical inactivity could substantially decrease future coronary heart disease deaths in Europe, thus consolidating the earlier gains. However, whilst not an original objective, our analyses identified some unfavourable risk factor trends in recent years in several countries (in blood pressure, cholesterol, obesity and diabetes). If these adverse trends continue, future prevention goals might become very challenging.

Background to the project

The CHD IMPACT model

The IMPACT model[1-3] was first developed in the 1990s by Capewell and colleagues and has been widely used in many countries to quantify how much of the recent decline in coronary heart disease (CHD) mortality can be attributed to: (i) medical treatments and (ii) population risk factor changes. In its original formation, it explained past trends in CHD mortality over a period of 10-20 years. The initial model was essentially static and cross-sectional in design, comparing age-specific mortality observed at two time points (a "base year" and a "final year"). It then used indirect standardisation to estimate the number of deaths that would have occurred in the "final" year if age-specific trends had remained constant since the base year. The observed fall in the final year represented the number of deaths prevented or postponed (DPPs) that the model then attempts to explain.

The IMPACT model has now been implemented in over 20 different populations (New Zealand[4,] Scotland[5], England and Wales[6], Iceland[7 8], Northern Ireland[9], Republic of Ireland[10], Finland[11], Sweden[12,] The Netherlands[13], Portugal[14], Spain[15], Italy[16], Czech Republic[17], Poland[18], US[1], Canada[19], Syria[20], Palestine[21], Turkey[22], Tunisia[23]). Most of these are Western populations, where mortality has been falling in recent decades. However, it also includes three populations where CHD mortality was rising (Beijing[24 25], Tunisia[23] and Syria[20).]

Key IMPACT results from most Western industrialised countries over the past few decades are relatively consistent. Some two thirds of the fall in CHD mortality has been explained by risk factor improvements, with the remaining one third being attributed to medical and surgical treatments. The largest mortality decreases have been consistently attributed to reductions in major risk factors, in particular, cholesterol, blood pressure and smoking. The largest medical contributions have come from the increasingly widespread use of cardiology treatments (particularly medications for community-based patients such as secondary prevention after an initial myocardial infarction or cardiac surgery), and anti-hypertensive and statin therapy for high blood pressure and high blood cholesterol among people with no known cardiac problems (primary prevention). The IMPACT model has been previously validated and mostly used to explain falls in mortality in a variety of high income regions or populations including Northern Ireland, Republic of Ireland, Scotland, New Zealand, Finland, England, Canada and the USA[1 4-7.]

In a more limited number of populations, the IMPACT model has been adapted to project into the future[25,] exploring various potential interventions on future disease burdens[25-28]. However, this has only been done over a limited time period (less than 10 years) and by making simple assumptions about the likely trends in CHD mortality over that time period.

A more detailed report was commissioned in 2008 by the Cardio and Vascular Coalition (CVC) to model the future burden of CVD to 2020 in the UK population. This report was prepared by some of the current EuroHeart II WP6 and WP4 team[29]. This report also highlighted the expected increases in CHD burden that might be anticipated in 2020. It was predicted that up to 36,500 excess CHD deaths might be expected in 2020, mainly due to population ageing. Conversely, ensuring that the maximum number of eligible CHD patients received appropriate medications (for primary and secondary prevention) could reduce deaths by approximately 20,000 annually. Policy changes at national and international levels to achieve modest reductions in major CHD risk factors (population cholesterol, blood pressure and smoking) were expected to result in even greater gains in the UK, potentially reducing CHD deaths by about 50,000 annually by 2020[29]. Whilst important, this report considered trends only in the UK, and used a relatively simple and conservative methodology. Since that early analysis, more recent UK data has demonstrated greater than expected falls in mortality[30], and in some key risk factors (such as blood pressure) and hence there was a need to both update this analysis and consider whether the results could be generalised to a range of different European populations.

The CHD IMPACT model itself has also gone through significant refinements over this time period, and now has a number of methodological advancements that were not available at the time of the previous CVC report. These include adjustments for cumulative declines in risk factors, and probabilistic sensitivity analyses (using Monte Carlo methodologies). Further, more sophisticated statistical modelling of future CHD mortality trends was also desirable.

Regional trends in CHD mortality

Age-specific CHD mortality rates have been declining in most European countries over recent years[31]. However, cardiovascular disease (CVD) in general remains the leading cause of mortality in Europe. It is the most common cause of death in women in all European countries, and for men in all but a few countries; accounting for around 47% of total mortality in Europe[32 33]. The Global Burden of Disease project predicts that CVD is likely to remain the leading cause of death for the foreseeable future[34]. Despite the substantial declines in CHD mortality rates that have been observed, the burden of disease may continue to increase due to the ageing of European populations, and also possibly to increases in survival following an initial cardiac event[35 36].

Substantial declines in CHD mortality have been observed in recent years; overall CHD mortality rates are less than half of their levels in the early 1980s in many European countries[31]. For example, CHD mortality declined by about a third in England and Wales between 2000 and 2007[30] – a phenomenal achievement in a short space of time. However, there are doubts as to whether these falls will continue in the future. Recent trends in CHD mortality, as identified in WP4 of the EuroHeart II project, are very variable across EU countries with no clear pattern emerging overall[31]. There is already evidence from some Western countries that the decline in CHD mortality seen among older people is not currently paralleled by falls among younger people (those under 55)[37-39]. Indeed, in some populations, CHD mortality at younger ages appears to have flattened, or may even be increasing[40]. Whilst there is currently little evidence that CHD mortality rates are flattening at younger ages across Europe as a whole[31], it is possible that incidence is increasing at younger ages[31 33]. The underlying causes of this flattening of mortality observed in some countries are still being debated, but are likely to include the substantial increases in obesity and diabetes observed globally[41 42], along with a recent plateauing in the previously falling blood cholesterol levels in some countries[8 43 44]. Furthermore, in some populations, only limited gains in behavioural risk factors (such as reductions in smoking[32], or physical activity[9]) have been achieved. For all these reasons, it is important to update these future projections and compare results across a diverse range of European countries.

Objectives and work tasks

The specific objective was to project future trends in CHD. To do so, we developed a CHD IMPACT model extrapolating CHD mortality across a representative range of European countries up to at least the year 2020, and populated this with contemporary data. Having developed the future IMPACT CHD mortality model in each country, we planned to work with key stakeholders (relevant national and international policy makers) to identify important and realistic policy scenarios to model.

Across all nine country/regional teams, we planned to agree this "core" set of scenarios (or policy options) which we would then model across each of the partner countries involved. Since the IMPACT model had not been extensively used for forward projection, an important secondary objective was to carry out a validation of the forward projection over a short period of time (where possible). In brief, the key work tasks can be summarised as below:

- Identify data sources and future data requirements;
- Populate the IMPACT CHD model with best available data;
- Identify, through discussion with stakeholders, a series of policy options for appraisal;
- Evaluate the potential effect of each policy option chosen

Choice of countries to be included

The choice of countries and regions to be included was largely pragmatic and shortlisted from those that had already completed a CHD IMPACT model explaining past mortality trends. This is because the initial IMPACT model development is very resource-intensive, requiring extensive population based data sources as well as familiarisation with the model methodology and framework. It was therefore not realistic to expect a "new" country team to be able to complete all the initial essential components and also develop future projections within the short timescale of the EuroHeart II project. The countries eventually taking part included three Nordic countries (Iceland, Finland and Sweden); three British Isles countries (Scotland, Northern Ireland, Republic of Ireland), two Central European countries (Czech Republic, Poland) and one Mediterranean country (Italy). Whilst all had completed previous CHD IMPACT models, the model itself had been extensively refined and improved over time, with evidence-based updating of key parameters (including risk factor coefficients and treatment effectiveness) as new data became available. Some countries with "older" versions of the IMPACT model (Finland, Sweden and Italy) were therefore required to update their initial analyses using the newer version of the IMPACT model before generating future projections. This was to ensure that a consistent and comparable version of the model was being used across all the nine populations.

Methods

Validation

In this multi-component project we first validated "original" IMPACT models in nine European regions or countries (Scotland, Republic of Ireland, Northern Ireland, Sweden, Finland, Iceland, Czech Republic, Poland, Italy) by comparing IMPACT model CHD mortality estimates with recently observed CHD mortality trends in each country.

The CHD IMPACT model has mostly been used "retrospectively" to explain past trends in CHD mortality (in terms of risk factor changes, or treatment uptakes). All teams taking part in this project have used (and now published in peer-reviewed journals) "retrospective" versions of the model. In this project, we used the model prospectively. We could therefore take advantage of more recently collected data to validate the performance of the model prospectively against the most recently available observed data (CHD mortality reported in national statistics, generally around the year 2010 in most countries taking part). Our aim was to develop a standard approach for using recent observed data in a predictive validation of the original models. The "base year" for validation was the most recent year of the existing retrospective IMPACT model in each country. The age groups to be included were consistent with those in the previous IMPACT model in that country.

In those countries that completed validation, we took the original previously completed and published retrospective IMPACT model, and use a standard IMPACT approach (taking current age and sex specific CHD mortality trends and projecting using indirect standardisation) to estimate the CHD mortality that would be expected in the most recent year for which observed CHD mortality data was available (this was generally around the year 2010). We used the most recent risk factor data available for that same final year to derive an epidemiologically based prediction of trends in CHD mortality. In other words, we estimated the expected mortality for that year based on trends in major CVD risk factors. This estimate of the model predicted CHD mortality was then compared with observed CHD mortality for the same year (obtained from government statistics). We hypothesised that the predicted and observed CHD mortality would not be very different and that the precision of prediction would improve with more recent models because they:

- have a shorter time period to predict across,
- are based on more recent and hence more refined versions of the IMPACT model.

Some improvement in treatment uptakes and effectiveness might be expected to have taken place since the final year of the previous retrospective CHD IMPACT mortality models. We therefore considered how best to model these likely changes in treatment effects. After extensive discussions recognising the difficulties in obtaining and inputting recent treatment data, we agreed that recent treatment trends would NOT be explicitly modelled. In other words, a "status quo" assumption was made, assuming that significant increases in treatment uptake or effectiveness had not occurred since the base year. This simplifying assumption was considered reasonable since the time scale for the forward projection was short, and treatment uptakes were already generally high in most populations by the final year of the previous retrospective CHD IMPACT model. In addition, we checked data on prescribing (dispensed) medicines in the population in Ireland, and found limited changes in the uptake of all CVD medicines in recent years (until 2010). Furthermore, the same assumption was consistently applied to all models in all countries.

Clearly, this assumption would be expected to result in the model slightly underestimating the number of DPPs, though the extent of any underestimation may differ by country. For example, in the Czech Republic a substantial increase in heart transplants has recently been observed but the population impact of this increase would be modest. Further, we are aware that there has been a considerable increase in uptake of statins for the primary prevention of CHD in certain populations. It is therefore likely that our validation methodology would not be able to explain all of the observed mortality trends. Pragmatically, we agreed to attribute unexplained mortality reductions to improvements in uptake of these key primary and secondary prevention medications for preventing CHD mortality.

We carried out this validation "blind" i.e. by calculating model predicted CHD mortality rates before obtaining observed rates (or using a separate researcher to obtain observed rates where possible). A detailed methodological proforma was developed and illustrated graphically as a series of powerpoint slides. These proformas were circulated, discussed and agreed in several teleconferences with each of the partners taking part in the project.

Stakeholder consultation

The main objective for consulting with stakeholders was to obtain their views about the most important policy options we should model for our 2020 analyses. Explicitly taking into account stakeholder views and priorities would be expected to increase the likely future use and impact of the 2020 analyses in each country and across Europe. An important secondary objective was therefore to inform these stakeholders about the EuroHeart II 2020 project and also make them aware of previous IMPACT model publications.

Via the European Heart Network (EHN) and through consultation with national leads in each of the 9 partner countries, we identified key national and international stakeholders to consult in order to obtain views on which potential policy options we should attempt to model using the IMPACT methodology. We developed an initial, preliminary list of potential policy options based on that tested and published in another EU funded modelling study, MedCHAMPS (http://research.ncl.ac.uk/medchamps/)[45-48]. This agrees closely with the list of dietary policy options developed as part of WP5 of the EuroHeart II project[49] and reviewed in stakeholder meetings taking place as part of WP7 of EuroHeart II. We developed a detailed questionnaire using this initial list and piloted this approach with 6-7 participants from a broad background (public health specialists, GPs, cardiologists, and a clinical pharmacologist) from the Republic of Ireland at a meeting of the Irish Heart Foundation Council for Cardiovascular Prevention in February 2012. This pilot study was conducted in order to establish the best ways of approaching stakeholders and providing them with background information (in order to elicit informed and consistent responses). Following this feedback, we made minor changes to the proforma (including adding a more detailed description of likely policy content for each policy). We then rolled out the policy questionnaire across the other eight countries taking part in the project. Our target groups for interview thus included senior policy makers from Ministries of Health, Public Health Departments of local health service organisations and providers, senior public health academics in Universities, and NGOs (e.g. charitable organisations) concerned with preventing cardiovascular diseases. Ethical permission for this was required for this study in some countries.

Choice of policy scenarios to model

Our final choice of policy scenarios was strongly based on the stakeholder consultations which prioritised population-based primary prevention initiatives (such as policies to control tobacco, improve diet and increase physical activity). We explicitly included some relatively simple scenarios that were easy to measure across all partner countries (e.g. falls in population smoking prevalence) and also included more complex scenarios (such as policies to reduce the salt content in processed foods). Work Package 5 of the EuroHeart II project also identified that policies to reduce salt intake (particularly taxes, mandatory product reformulation, and multi-component interventions) appear to have been effective in reducing salt intake in some European countries, although population wide policies to reduce fat intakes have been less widely evaluated[49]. Although it is difficult to find comparable data on physical activity and trends in activity levels across Europe[50], it is thought that about two-thirds of adults in Europe do not take sufficient physical activity. Leisure time physical activity appears to have been increasing in recent years, but physical activity at work and for transport has generally been declining[50]. For these reasons, reducing levels of physical inactivity is also an important target.

The prioritisation of the different policies by stakeholders in the different countries is detailed in the "Results" section. The most popular policies were then reviewed in a consensus approach involving discussion and finalisation by group teleconference.

As a result of this process, the final CVD risk factor policy scenarios to be modelled were:

- Reductions in smoking prevalence
- Reductions in salt consumption
- Alterations in type of fats consumed (a reduction in intake of saturated fats, replaced with unsaturated fats)
- Increase in physical activity

For each of these risk factor changes, we devised three scenarios with small, moderate and larger reductions in the risk factor prevalence (conservative, intermediate and optimistic respectively, see Table 1 below).

Table 1. Policy scenarios modelled in the IMPACT analyses

Scenario	Decrease in energy from saturated fats	Relative decrease in salt	Decrease in prevalence of physical inactivity	Decrease in smoking prevalence
Conservative	1% E	10%	5%	5%
Intermediate	2% E	20%	10%	10%
Optimistic	3% E	30%	15%	15%

Mortality Projections

We projected CHD mortality to 2020 and 2030 using national data on population, mortality and major risk factor trends. We then estimated the effects of possible policy interventions (such as reductions in salt and saturated fat intakes, reductions in physical inactivity and smoking) on CHD mortality in 2020 and 2030 in each country, drawing lessons about likely impact and generalisability. This report focuses on the 2020 projections as specified in the original study protocol.

CHD IMPACT Model Methods

The updated IMPACT CHD Policy Model was used to forecast the number of deaths expected in 2020 and also the number of deaths that could be prevented or postponed in this year (DPPs) if effective policies to reduce lifestyle-related risk factors could be introduced and implemented. The basic methodology of the IMPACT model which is used to translate changes in biological risk factors (systolic blood pressure [SBP], cholesterol, physical activity and smoking) has been described in detail elsewhere. Here we present the methodology we used to extend the model to explore further policies around altering specific nutrients (salt and saturated fat intake).

Translating decreases in salt and saturated fat intakes into CHD mortality reductions

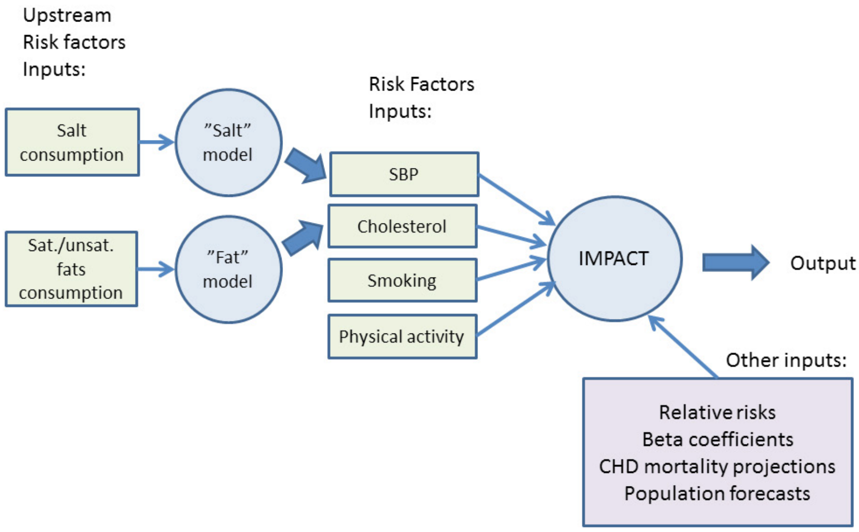
The original IMPACT model had no functionality to calculate the DPPs which might result from changes in salt consumption and saturated/unsaturated fatty acids intake. For this project, we extended the model with two additional layers to translate the effects of changes in these risk factors to changes in blood pressure and total cholesterol levels, and hence to CHD mortality. Translating the effect of salt consumption to changes in blood pressure was based on data published in a Cochrane systematic review[51] which quantified the effect of salt reduction on blood pressure in both hypertensive and normotensive individuals. According to this extensive meta-regression, a 6g/d reduction in salt intake would result in a 7.2 mmHg (95%CI 5.6-8.8 mmHg) reduction in SBP in hypertensives and 3.6 mmHg reduction in SBP (95%CI 1.9-5.2 mmHg) in normotensive individuals. Smaller reductions in salt intake were modelled proportionately so that more realistic reductions in salt intake chosen in these scenarios could be expected to reduce SBP by around 1-2 mmHg in practice. We then used the established IMPACT methodology to translate this expected change in SBP levels into expected CHD mortality reductions.

In order to model the effect of changing saturated fats intake on serum cholesterol level we used the Clarke equations which were obtained from meta-regression of over 90 metabolic ward studies[52] to translate a change in saturated fat intake into a change in total cholesterol levels, with replacement with poly and mono-unsaturated fats to maintain caloric balance (assuming that each 1% reduction in saturated fat is replaced by 0.5% mono and 0.5% poly-unsaturated fat). These equations imply that:

- a 5% decrease in consumed saturated fats which are replaced by poly-unsaturated fats results in decrease in total cholesterol level by 0.39 mmol/L
- a 5% decrease in consumed saturated fats which are replaced by monounsaturated fats results in decrease in total cholesterol level by 0.24 mmol/L

The structure of the updated model is presented in Figure 1.

Figure 1 : Structure of updated IMPACT CHD model used in this analysis



Selecting an appropriate mortality counterfactual (baseline for comparison)

In previous IMPACT forward projections, we have used only very simple assumptions to project CHD mortality into the future. These can essentially be described as "no change" (assuming age-specific CHD mortality rates remain constant from the most recent data observed into the future i.e. simple indirect standardisation of mortality rates) or a linear extrapolation (assuming that age-sex specific CHD mortality rates continue to decline at the same annual rate as observed over the most recent decade, for example). Clearly, neither of these assumptions are particularly realistic since the first assumes that the substantial falls observed in CHD mortality would suddenly level off, and the second that mortality can continue to decline at the current rapid rates (eventually achieving impossible negative mortality rates).

In order to develop more realistic estimates of future mortality to be used as a baseline for the policy scenarios, we explored the use of a range of non-linear models in a variety of datasets. We chose a negative exponential model as the best fit model to the data we had available. This allows us to capture both population structural change and more realistic trends in the risk of future mortality. CHD mortality trends and population projections were obtained from each country's statistical offices. For comparison, we included in our analysis both the negative exponential model counterfactual (continuing decline in mortality) and the indirect standardised one (no change in mortality).

Modelled scenarios

Three scenarios were modelled taking into account different degrees in changes of lifestyle related risk factors (see Table 1). The first, **conservative scenario** assumed a decrease in dietary energy from saturated fats by 1% (and replacing it with energy from mono- and polyunsaturates), reduction in salt intake by 10%, and reduction in absolute percentage of smokers and decrease in physically inactive people by 5%.

Two other scenarios, **intermediate** and **optimistic**, assumed slightly greater changes in the same risk factors.

The provisional values for the three scenarios were chosen pragmatically by the EuroHeart II WP6 modelling team, based on previous published analyses, and then tested, refined and finalised by discussion in a series of teleconferences. The values were chosen to be realistic and feasible compared with reductions in risk factors achieved elsewhere[53 54], and in relation to national or international targets[27]. However, they were not necessarily equivalent in terms of costs or political feasibility.

Relative Risks and Beta Coefficients used in the model

Relative risk values and regression beta coefficients used in the IMPACT model used in this analysis are presented in tables 3-6 below with their sources and a brief critical appraisal in the footnotes. In all cases, we have attempted to use the most robust and up to date data available. These generally come from either the Prospective Studies Cohort Collaboration (a large prospective meta-epidemiological study pooling data from over 60 prospective studies carried out globally) or from recent reviews carried out by the Global Burden of Disease Project.

Table 2: Beta coefficients for blood pressure change in population

Systolic blood pressure	Age group (years)				
	25-44	45-54	55-64	65-74	75+
Men (hazard ratio per 20 mmHg)	0.49	0.49	0.52	0.58	0.65
Men (log hazard ratio per 1 mmHg)	-0.036	-0.035	-0.032	-0.027	-0.021
Minimum	*-0.029*	*-0.028*	*-0.026*	*-0.022*	*-0.017*
Maximum	*-0.043*	*-0.042*	*-0.039*	*-0.032*	*-0.025*
Women (hazard ratio per 20 mmHg)	0.40	0.40	0.49	0.52	0.59
Women (log hazard ratio per 1 mmHg)	-0.046	-0.046	-0.035	-0.032	-0.026
Minimum	*-0.037*	*-0.037*	*-0.028*	*-0.026*	*-0.021*
Maximum	*-0.055*	*-0.055*	*-0.042*	*-0.039*	*-0.031*

Source: Prospective studies collaborative meta-analysis, Lancet 2002[55]
Units: Can be interpreted as percentage change in CHD mortality per 20 mmHg change in systolic blood pressure
Strengths: Large dataset, includes US data, adjusted for regression dilution bias, consistent with randomised controlled trials, results stratified by age and sex, with 95% confidence intervals
Limitations: Some publication bias still possible

Table 3: Beta coefficients for total cholesterol change in population

Cholesterol	Age groups (years)					
	25-44	45-54	55-64	65-74	75-84	85+
	Mortality reduction per 1 mmol/l					
Men	0.55	0.53	0.36	0.21	0.21	0.21
Women	0.57	0.52	0.35	0.23	0.23	0.23
	Log coefficient					
Men	**-0.799**	**-0.755**	**-0.446**	**-0.236**	**-0.117**	**-0.083**
Minimum	*-0.639*	*-0.604*	*-0.357*	*-0.189*	*-0.093*	*-0.067*
Maximum	*-0.958*	*-0.906*	*-0.536*	*-0.283*	*-0.140*	*-0.100*
Women	**-0.844**	**-0.734**	**-0.431**	**-0.261**	**-0.174**	**-0.051**
Minimum	*-0.675*	*-0.587*	*-0.345*	*-0.209*	*-0.139*	*-0.041*
Maximum	*-1.013*	*-0.881*	*-0.517*	*-0.314*	*-0.209*	*-0.062*

Source: Prospective studies collaborative meta-analysis, Lancet 2007[56]
Units: Percentage change in CHD mortality per 1 mmol/l change in total cholesterol
Strengths: Includes US data, adjusted for regression dilution bias, includes randomised controlled trials, RCT values consistent with observational data, results stratified by age and sex, with 95% confidence intervals
Limitations: Some publication bias still possible

Table 4: Relative risk of mortality from Ischaemic Heart Disease for current smokers relative to non-smokers (95% CIs in parentheses), from the American Cancer Society's Cancer Prevention Study (CPS-II)

Age	Men	Women
30-44	5.51 (2.47-12.25)	2.26 (0.83-6.14)
45-59	3.04 (2.66-3.48)	3.78 (3.10-4.62)
60-69	1.88 (1.70-2.08)	2.53 (2.22-2.87)
70-79	1.44 (1.27-1.63)	1.68 (1.46-1.93)
>=80 years	1.05 (0.78-1.43)	1.38 (1.08-1.77)

Notes: CPS-II is an ongoing prospective study of mortality in 1.2 million Americans aged 30 years or more when they completed a questionnaire on tobacco and alcohol use, diet, and multiple other factors affecting health and mortality in 1982. Relative Risks (RRs) were estimated from Cox proportional-hazard models, with non-smokers as the reference group (RR=1.0 for non-smokers). Risks were adjusted for age, race, education, marital status, "blue collar" employment in most recent or current job, weekly consumption of vegetables and citrus fruit, vitamin (A, C, and E) use, alcohol use, aspirin use, body mass index, exercise, dietary fat consumption and for hypertension and diabetes (both at baseline). Analyses of the hazards associated with smoking were based on the first six years of follow-up (1982 through 1988). Source: Ezzati et al (2005)[57]

Table 5: Relative risk of Ischaemic Heart Disease from physical (in)activity levels from WHO Global Burden of Disease Study (95% CIs in parentheses), relative to those considered physically active

Age	Inactive level	Insufficiently active level
15-69	1.71 (1.58-1.85)	1.44 (1.28-1.62)
70-79	1.50 (1.38-1.61)	1.31 (1.17-1.48)
80+ years	1.30 (1.21-1.41)	1.20 (1.07-1.35)

Notes: Physical (in)activity in the WHO GBD study was treated as a categorical variable with three categories: Level 1: Inactive: doing no or very little physical activity at work, at home, for transport, or during discretionary time. Level 2: Insufficiently active: doing some physical activity but less than 150 minutes of moderate-intensity physical activity or 60 minutes of vigorous-intensity physical activity a week accumulated across work, home, transport or discretionary domains. Level 3: Sufficiently active (unexposed): at least 150 minutes of moderate-intensity physical activity or 60 minutes of vigorous-intensity physical activity a week accumulated across work, home, transport or discretionary domains, which approximately corresponds to current recommendations in many countries. RR estimates were adjusted for confounding variables, measurement error associated with self-report, and attenuated over age (25% of the excess risk for the 70-79 year age-group and 50% of the excess risk for the oldest age group, 80+), but not adjusted for blood pressure and cholesterol.
Sources: Bull et al (2004)[58]; Joubert et al (2007)[59].

Sensitivity Analyses

To assess the robustness of the model to uncertain parameters we carried out probabilistic sensitivity analyses using Monte Carlo methodology in R software. We repeated random draws from specified distributions for input variables that are used to iteratively recalculate the model.

Input variables taken from external sources (e.g. beta coefficients and relative risk reductions) were randomly drawn from specified distributions. We then calculated the 95% uncertainty intervals from the realised values of the output variable. We calculated the uncertainty intervals based on 10,000 draws taking the 95% uncertainty intervals as the 2.5th and 97.5th percentiles. Distributions used for main input parameters are listed in Table 6.

Table 6 : distributions used for main input parameters in the model

Group	Parameters	Distribution	Distribution parameters
Population counts in base year and CHD deaths stratified by age and sex	Population counts (no error) CHD mortality (no error)	No error (uniform distribution) No error (uniform distribution)	
Population counts in final year and CHD deaths stratified by age and sex	Population counts CHD deaths	Poisson Normal (mean, sd)	 Mean = point estimate Sd = standard error of the mean
Prevalence/mean estimates	Prevalence estimates (smoking, physical activity, diabetes) (Beta distribution: cases, sample-size minus cases) Continuous variables (SBP, total cholesterol, total salt intake)	Beta (alpha, beta) Normal (mean, sd)	Alpha = cases Beta = sample size minus non cases Mean = point estimate Sd = standard error of the mean
Relative risks	Relative risk distribution(60)	RelRisk(RR, SE ln(RR)):	RR= relative risk; SE in (RR) standard error
Beta coefficients	Normal distribution	Normal (mean, sd)	Mean = point estimate Sd = standard error of the mean

Key Methodological Developments of the CHD IMPACT model carried out as part of EuroHeart II WP6 project

Several major developments have been implemented in this project compared with previous IMPACT model projects; the most notable of these are summarised below:

- Forward prediction of CHD mortality trends (to 2020 and beyond – in some cases up to 2040[8])
- Validation of future predictions in a sub-set of countries with available data
- More realistic mortality counterfactuals (using a statistical model – the negative exponential model)
- Explicit inclusion of "upstream" nutritional risk factors (salt and saturated fat intakes) rather than just biological risk factors (cholesterol, blood pressure) for the first time
- Probabilistic sensitivity analyses using Monte Carlo Methodology (rather than the more simplistic "Analysis of Extremes" approach)
- Explicit consideration of stakeholder priorities to determine policy options to model

Results

Validation

The validation component of the project was completed in four populations – **Northern Ireland, Republic of Ireland, Scotland,** and **Sweden** (see summary Table 7). In all four of these populations, the agreement between the epidemiological model estimate (IMPACT – projecting deaths to 2010 or so based on risk factor changes in the model and comparing with observed official statistics) varied from good to very good. This is reassuring, as the IMPACT model has not been extensively used prospectively. In two cases, the published IMPACT models are "recent" (from 1985 to 2005 in the Republic of Ireland, and from 1987-2007 in Northern Ireland) where we would expect closer agreement. But there were longer periods for Sweden (1986 to 2002) and for the much "older" model for Scotland (1975-1999). Hence the level of agreement between the model estimates and the observed 2010 data is particularly reassuring. The model appears to be slightly underestimating the numbers of deaths prevented or postponed by secular trends in risk factor levels. However, this is reasonable since we assumed treatment uptakes to be constant over this time period (when in reality they probably improved). The model would therefore be expected to slightly underestimate the number of deaths prevented or postponed. (Table 7).

It was not possible to complete this validation component in every population (for Poland, the Czech Republic and Italy, there are no risk factor surveys more recent than those used in the previously published retrospective CHD IMPACT model). Furthermore, it was not essential to validate the model in every population to demonstrate that the CHD IMPACT model is generally acceptable for forward projection. One other population (Finland) is still working towards validation.

Table 7. Summary of IMPACT Model validation results/agreement

Country	Base year of original model	End year of original model	Model Estimate of fall in 2010 deaths	Observed estimate of fall in 2010 deaths	% agreement
Republic of Ireland	1985	2000	3,150	2,966	106%
Northern Ireland	1987	2007	1,360	1,492	91%
Scotland	1975	1999	6,243	7,835	80%
Sweden	1986	2002	3,359	4,800	70%

Stakeholder analyses

We categorised the policies, treatments and suggestions listed in the original questionnaire (see appendix 1) into groups as shown in Table 8 (policies for either the primary or secondary prevention of CHD). In order to calculate the category totals objectively for each country a grading system was used where each stakeholder's first choice was given 5 points, their second choice 4 points, their third choice 3 points, their fourth choice 2 points and their fifth and final choice 1 point. The answers were categorised and the total points for each group were then calculated.

We present here the top five priorities overall with individual results from each country in appendix 1:

Table 8. Top five policy priorities for each country:

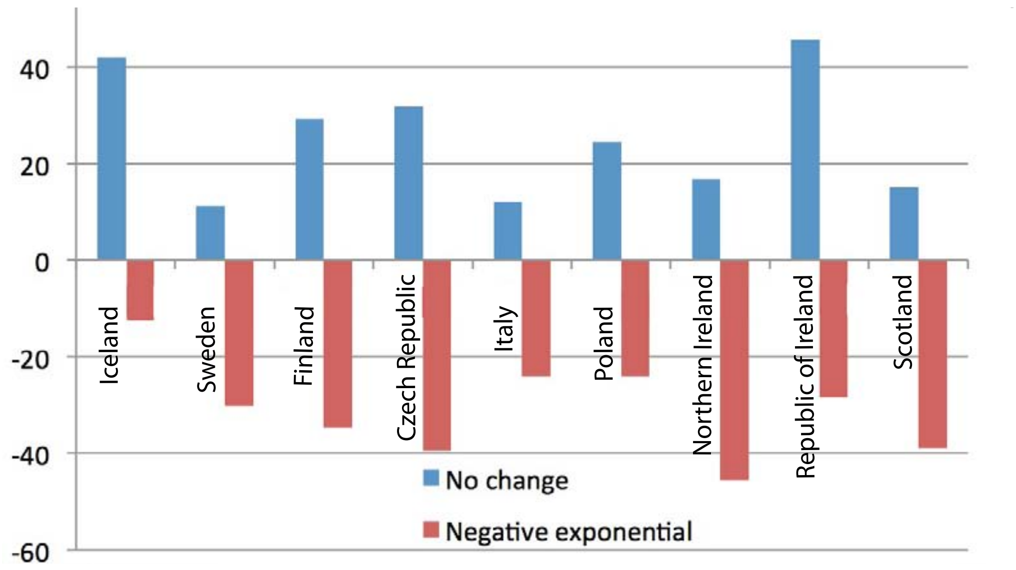
Category	Questionnaire number/s	Primary or Secondary prevention
Legislation/fiscal policies relating to food	1-5, 10	Primary
Increasing public awareness of need to reduced saturated fat and salt intakes	6, 11	Primary
The prescription of drugs for those at risk at heart disease	7-9	Primary
Reformulation work with all sectors of the food industry to reduce levels of saturated fats, sugars and salt in processed foods	12, 13	Primary
Legislation/fiscal policies relating to tobacco/smoking	14-17	Primary
Standalone – Education campaigns on smoking	18	Primary
Standalone – Smoking cessation initiatives	19	Primary
Healthy lifestyle initiatives	20-26	Primary
Initial treatments for heart attacks/acute treatments	1-3	Secondary
Secondary Prevention	4-6	Secondary
Increasing expertise/clinical needs	7, 8	Secondary
Improving communication/mentoring	9-12	Secondary
Equality issues	Additional category	

The legislation/fiscal policies relating to food were very highly ranked in all four countries: first in Poland, Italy and Northern Ireland and second in Scotland and the Republic of Ireland. Legislation/fiscal policies relating to tobacco/smoking were also high: first in Scotland and third in Poland, Italy, Northern Ireland and the Republic of Ireland. The healthy lifestyle initiatives were the Republic of Ireland's top priority and came second in Northern Ireland, third in Scotland and fourth in Poland. Interestingly in all five countries each had only one secondary prevention policy in their top five categories (see appendix 2 for more details of country results).

IMPACT model CHD mortality projections to 2020

As expected the actual trends in CHD mortality predicted in each country was quite variable, under both the "no change" and "negative exponential" mortality counterfactuals. This variability reflected both the demographic changes (degree of ageing of the population) and the level of previous reduction in CHD risk factor trends. The variation predicted assuming the "no mortality change" counterfactual ranged from +12% (Sweden) to +45% (Republic of Ireland) (Figure 2). The actual reductions in CHD mortality predicted using the negative exponential mortality counterfactual 2020 varied from -12% (Iceland) to -45% (Northern Ireland) compared with the baseline (around 2010) value (Figure 2).

Figure 2. Percentage change in CHD mortality under both the "no mortality change" and "negative exponential" models, by country, in 2020 compared with base year (approximately 2010):



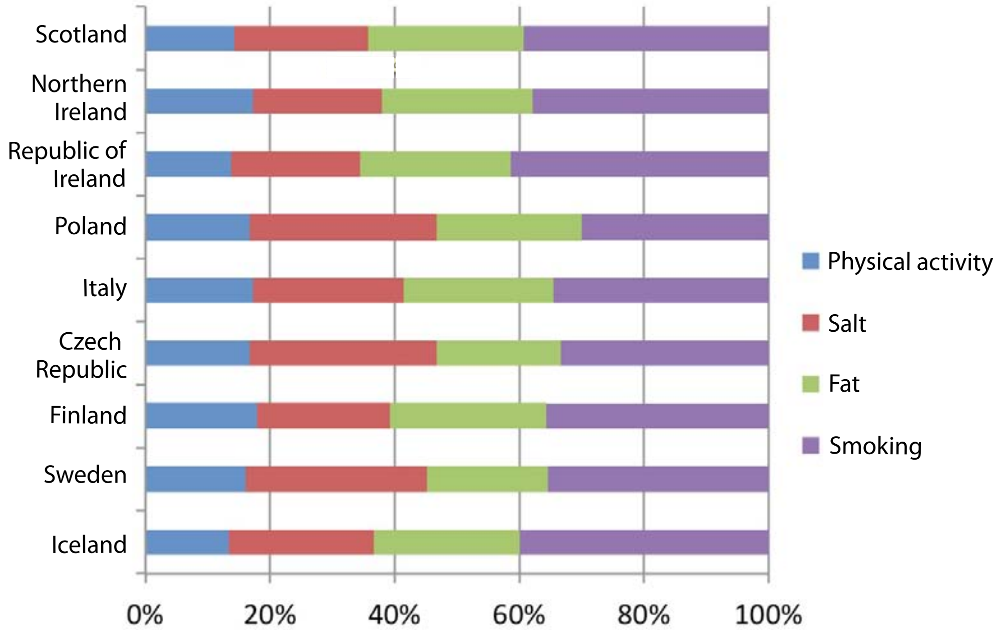
IMPACT model policy projections to 2020

Overall, the optimistic dietary, physical activity and smoking policy changes we envisaged could together reduce CHD mortality by up to around 30% (see appendix 2). Whilst the absolute number of deaths prevented or postponed varies substantially due to population size, this percentage reduction is very consistent across the 9 countries modelled (varying from 27% to 32% - see appendix 2).

Broadly, the analyses suggest that the (15%) reductions in smoking prevalence modelled would account for up to 40% of the overall mortality declines predicted. The modest changes in salt (-30%) and saturated fat consumption (-3% of total energy intake) would be expected to account for just over 40% of the predicted overall decline in CHD mortality.

Increases in physical activity (maximum 15%) would contribute less than 20% of the overall mortality trend (Figure 3 next page).

Figure 3. Percentage of total modelled CHD mortality reduction contribued by each policy scenario



There was remarkably little variation between the nine countries in the potential benefits that could be achieved from each of these modelled scenarios. Figure 3 shows the most optimistic scenario, but there is little relative difference between this and the intermediate or most conservative scenarios, though the absolute benefits were proportionately smaller (Appendix 2).

Figure 4 presents the maximum possible fall in DPPs from reductions in smoking and physical inactivity prevalence in each of the 9 countries. This demonstrated the amount of mortality fall theoretically possible if optimal levels of these risk factors could be achieved - idealistically assuming no-one smokes in the population and that there are no physically inactive individuals in the population. The clear differences across populations are more apparent with this presentation – demonstrating that countries where risk factor levels and mortality remain high (such as Scotland and Northern Ireland) have the greatest potential for future benefit from population wide policies to reduce these major risk factors.

Figure 4a. Maximum reduction in DPPs theoretically achievable by decreasing smoking prevalence

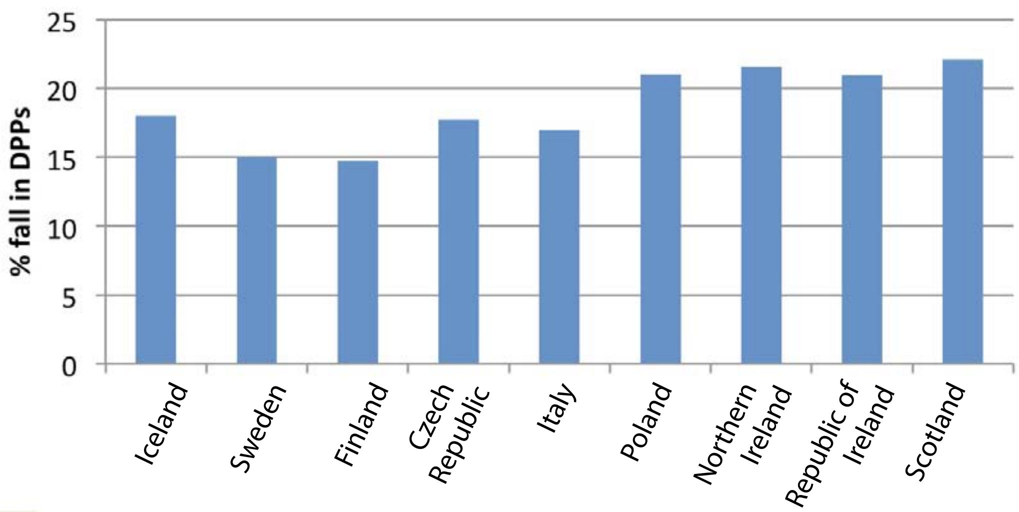
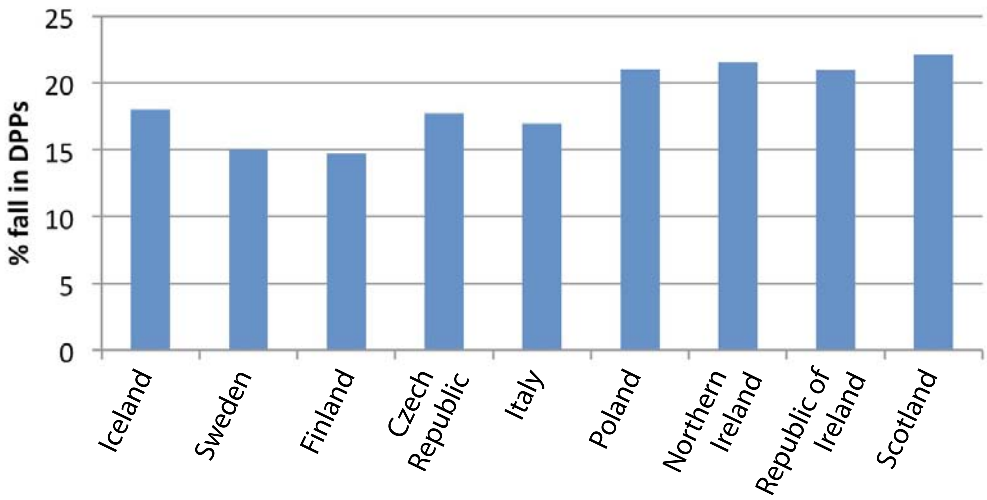


Figure 4b. Maximum reduction in DPPs theoretically achievable by increasing physical activity



Appendix 2 presents the detailed individual results (tables and figures) for each country included in the EuroHeart II country analyses.

Comparability of physical activity across different populations

Physical activity is difficult to report and record objectively, and a myriad of different questionnaires and reporting systems have been used in an attempt to survey physical activity levels in different populations. Many existing instruments are not truly comparable in the ways that physical activity is recorded. For example, many only record leisure time physical activity ignoring physical activity in the workplace or through routine activities[61]. Similarly, some questionnaires include questions about being "out of breath" or "sweaty[62]", in an attempt to measure the intensity of activities performed, but others do not.

However, there have been attempts to standardise physical activity instruments and the International Physical Activity Questionnaire (IPAQ questionnaire)[63 64] is a good example of a standardised instrument which is being widely adopted and used globally. Global recommendations for physical activity for health and NCD primary prevention currently focus on a minimum recommended level of 150 minutes of moderate intensity activities (such as walking) per week[65]. This is often recommended as 30 minutes daily, on at least 5 days per week, though there are other ways of meeting the 150 minutes total. The 30 minutes daily can be accumulated in shorter bursts of at least 10 minutes duration[65]. Higher levels of activity are also beneficial but the greatest health gain at a population level may come from encouraging those who are completely inactive to start some activity, rather than from encouraging those who are already active to do more[66].

Since physical activity is one of the hardest risk factors to measure and standardise cross-nationally, it was likely that the nine countries involved in WP6 were using slightly different definitions (from national or sub-national level surveys) to record this variable. This was acceptable, when analysing trends within just one country. However, it might potentially affect the interpretation of our potential policy to increase physical activity levels in different countries. The CHD IMPACT model relies on secondary data sources, and thus our ability to retrospectively standardise definitions on physical activity is limited. However, it is important to fully understand the magnitude of differences between populations involved, hence highlighting this potential limitation.

In table 9 below, we therefore summarised the definitions that have been used. Most countries (apart from Finland, Iceland and the Republic of Ireland) were using an IPAQ questionnaire and definition of at least 30 minutes of moderate physical activity daily (or 150 minutes per week). This review has acted as a potentially useful tool to standardise physical activity measurements across the EuroHeart II countries, since the Republic of Ireland team have already re-calculated their physical activity data to align with the IPAQ definitions used elsewhere, and the Iceland team are considering doing the same.

There is evidence from some countries that self-reported physical activity levels may be substantially above actual levels, particularly when compared with activity levels obtained from objective measurements such as accelerometers[67], though this has not been a consistent finding[68]. Furthermore, objective measurements of physical activity are not suitable for large scale epidemiological surveys and hence self-reported physical activity measurements will always have a degree of inherent misclassification. The imprecise measurement of physical activity, however, is likely to attenuate relationships between physical activity and key cardiometabolic risk factors that are included in the IMPACT model such as cholesterol levels and BMI (obesity)[69].

Table 9. Descriptions of the definitions of physical activity used in the individual country CHD IMPACT models

COUNTRY	DEFINITION
Czech Republic	No population information on physical activity considered sufficiently reliable to use. There is EUROASPIRE data (mostly for secondary prevention patients) which uses the IPAQ questionnaire (i.e. 30 minutes a day, 5 times a week).
Finland	Someone who at work walks and lifts a lot, or climbs a lot of stairs etc. (construction workers, builders, farmers etc.) OR the work is physically very heavy (heavy farming, forestry etc.) AND/OR 2) During leisure time the person actively goes jogging, skiing, playing ball games etc. OR is competing in some sports AND/OR 3) Every day walks, cycles etc. to work and back at least 30 min AND/OR 4) 3 times per week or more has leisure time physical activity at least 20 min so that is out of breath or sweating. Persons meeting any of these criteria are regarded as physically active and the rest are regarded as physically inactive
Iceland	Do you exercise regularly?
Italy	Separate question about physical activity at work (4 categories including sedentary, some light standing and walking, some standing and walking with light weights, hard manual labour). 4 categories of leisure (sedentary, walk or ride a bicycle etc. 4+hours per week, regular sport, competitive sport). Someone was defined as “physically inactive” if they answered in both the lowest (sedentary) category on both questions
Northern Ireland	IPAQ questionnaire used. Definition of at least 150 minutes moderate activity per week or 60 minutes vigorous activity per week (or a combination of the two)
Poland	Physically active at least for 30 minutes, at least two or three times a week i.e. 60 to 90 minutes of activity
Republic of Ireland	No exercise over the last 7 days. Currently updating this in our projections to coincide with the definition from Northern Ireland (see above).

COUNTRY	DEFINITION
Scotland	IPAQ questionnaire used. Definition based on global physical activity recommendations ≥5 occasions/week of at least moderate activity (for a total of at least thirty minutes per day) is recorded. Contributing activities included those performed at home (housework, gardening, DIY etc) and at work, as well as sport, exercise and walking. Activities performed for longer than fifteen minutes contributed to the total.
Sweden	Sweden has changed the way they defined physical activity so the data is hard to compare over time. From 1998 to 2005 the question was: "I would like to know how much you exercise during your leisure time?" Physical inactivity=Practically not at all From 2008 and onwards: "How often are you exercising at least 30 minutes (including walking)?" Physical inactivity= Practically never

Discussion

Our policy scenario results to 2020 were broadly consistent across the 9 participating countries. They suggest that structural population-wide policies, aiming to improve cardiovascular risk factor profiles, could substantially reduce the number of deaths otherwise occurring in 2020 (by up to one third). This is true even though important reductions in CHD mortality have already been achieved in recent years in all these populations, and even though age-specific mortality rates are set to reduce further, according to our negative exponential mortality counterfactual model projections.

We have focused on CHD mortality as the primary outcome. However, the reductions in CHD prevalence and disease burden would be expected to be substantially greater. These results were broadly consistent across the nine countries, and occurred whichever mortality counterfactual was assumed, and regardless of the precise percentage change in the lifestyle risk factor modelled. Our findings therefore essentially highlight the consistently powerful effects of even small population wide changes in nutrient intakes (saturated fats, salt consumption), physical activity and smoking prevalence at a population wide level.

We did not model possible changes in other important risk factors (such as obesity and diabetes) which have been increasing in recent years because as yet there are no successful population wide policies that have led to consistent and sustained decreases in these risk factors.

Whilst there are no substantial differences between populations, it is clear that this is partly due to the relatively modest reductions in risk factors that have been assessed, even in the most optimistic scenarios. Whether or not the risk factor changes modelled are truly comparable is hard to assess, since the intervention effort required to achieve them may not be equal. Furthermore, the appropriate counterfactual (the theoretically optimum level of each of these risk factors) remains open to discussion. Figure 4 shows the maximum DPPs that could be achieved in each country from reductions in just two categorical CHD risk factors, assuming a "perfect" risk factor counterfactual (i.e. no smoking, and everyone meeting recommended global physical activity targets) could be achieved. The benefits from achieving a healthy diet would be substantially greater. This initial analysis essentially demonstrates the potential for policies only targeted at population wide risk factors to reduce CHD mortality and appears most limited in Sweden (because substantial reductions in these two risk factors have already been achieved) and greatest in Scotland (where these risk factors remain relatively high at a population level).

Strengths and limitations of this study

Strengths

Modelling studies have a number of potential strengths, providing integration and simultaneous consideration of large amounts of data. The IMPACT Model has been widely used to explain CHD mortality trends, and has now been validated in over 20 high and middle income populations[30]. However, the EuroHeart II WP6 study is one of the first analyses of the model to make consistent and comparable forward projections across a range of countries. We attempted to validate the model for forward projection over a short period of time in half the countries taking part. In this validation exercise, the model predicted between 70% to 106% of the observed trend in CHD mortality. In three out of four populations reporting results, the model under-estimated the observed trends slightly and this may be expected given that we chose to project model based estimates of CHD mortality using only observed trends in major CVD risk factors. In reality treatment uptake and effectiveness will probably have increased in most countries over the validation time period[70].

Limitations of data and methodology

We acknowledge several limitations. All models are dependent on the quality and extent of data available and the outcome data (CHD mortality) is particularly important. In general, high quality data for population projections, CHD risk factors, and cause specific mortality were available from these nine European populations taking part in EuroHeart II WP6. However, projecting CHD mortality trends into the future is very uncertain. We therefore modelled all scenarios under two different assumptions about mortality trends – the conventional conservative (no change) scenario and the more optimistic negative exponential scenario. The latter model provided a very good fit to the observed trends in CHD mortality in each of the 9 countries taking part but this does not necessarily mean it will provide accurate predictions for the future. This statistical model generally takes information over a longer time period (around 10 -20 years, a time period where mortality has generally been falling significantly in most EuroHeart II populations) to project future rates. However, there are concerns that recent CHD mortality trends have flattened in some countries, particularly in younger age groups[37-40], though this does not yet appear to be a Europe-wide phenomenon[31]. If this recent flattening is continued, the statistical model may over-estimate the reduction in CHD mortality that will be observed, and hence could become "too optimistic" over time. Epidemiological models, which take into account age, period and cohort effects, may be preferable to simple statistical models to project future CHD mortality trends[71] but are much more time consuming to model across multiple populations.

The current analysis considers only a limited number of policy scenarios, and only one outcome measure (CHD mortality). Other outcomes (incidence, life years gained[72-74] or lost, and cost-effectiveness[75]) though potentially valuable[76] would require further data which is not readily available. It would clearly be useful to measure other potential policies, particularly to reduce risk factors showing adverse trends, such as obesity and diabetes. The potential benefits of the individual policies evaluated cannot simply be summed to estimate a total benefit, if it were possible to implement all policy changes at once. This is because any one CHD death could be prevented in more than one way (the "causal complement" model[77]). Hence the reductions in mortality from reducing smoking, or reducing dietary salt consumption, cannot be assumed to be independent of each other. Lag times (between a change in the nutrient intake or risk factor, and a change in CHD mortality) were ignored, although there is good evidence suggesting that these can be very short in practice[24 78]. However this merits attention in future work. Future model refinements are planned for example to produce more accurate breakdowns of salt consumption and the effects of changes in salt consumption for men and women separately, and also to improve (and standardise) the way physical activity is defined and implemented across the 9 countries.

Policy Implications

Our results may be generalisable to similar countries in Europe and beyond, particularly considering the relative consistency of the results across the 9 countries taking part in this analysis.

Our findings highlight the consistently powerful effects of even small changes in the major cardiovascular risk factors such as smoking, physical activity, and nutrient intakes such as salt and saturated fat. However, current risk factor trends are not universally favourable across Europe. There have been dramatic global rises in diabetes[41], including in Europe, mainly reflecting marked increases in BMI and adverse trends in diet (particularly increases in sugar, saturated fat and calorie intakes)[79], as well as modest physical activity levels. Neither are recent trends in blood pressure and total cholesterol levels universally favourable, with some countries demonstrating increases in blood cholesterol or blood pressure among the entire population or in certain age–sex groups[8 43 44]. Furthermore, the current popularity of low carbohydrate diets may be having adverse effects on blood cholesterol levels in some populations. Thus in Finland, total cholesterol levels rose in the population between 2007 and 2012 – and this is the first time that a population level rise in cholesterol has been seen since 1982 FINRISK surveys[43]. Similarly worrying increases in consumption of dietary saturated fats have been observed in Sweden[44], and there is also recent evidence of increased sales of products such as butter in the UK[80], the US[81], and elsewhere in Europe[82]. Therefore even the modest risk factor changes we have modelled could not necessarily be achieved without rigorous population-wide policy interventions. Future projects using this modelling approach therefore include plans to comprehensively assess the effect of these adverse risk factor trends on future CHD mortality rates.

These recent adverse risk factor trends are very worrying and represent a clear wake-up call. They justify stronger regional and global policy responses targeting smoking, unhealthy diet, and physical inactivity. Effective interventions exist[83 84 85-87]; but their implementation can often be politically challenging[49]. The evidence base for interventions to reduce obesity and diabetes globally is sparse. However, evidence from many countries suggests that tobacco control and dietary policies can be powerful, rapid and cost saving.[83 84 88, 89-91] These evidence-based policy interventions should therefore be strongly recommended for the prevention of both CHD and other non-communicable diseases in Europe, and possibly beyond.

References

1. Ford ES, Ajani UA, Croft JB, Critchley JA, Labarthe DR, Kottke TE, et al. Explaining the decrease in U.S. *deaths from coronary disease, 1980-2000. N Engl J Med* 2007;356(23):2388-98.

2. Critchley JA, Capewell S, Reeve J. Is 'Saving Lives' Feasible? Estimating the potential for further reductions in UK coronary heart disease deaths [Abstract]. *Journal of Epidemiology and Community Health* 2001;54:774.

3. Kabir Z, Bennett K, Shelley E, Unal B, Critchley J, Feely J, et al. Life-years-gained from population risk factor changes and modern cardiology treatments in Ireland. *European journal of public health* 2007;17(2):193-8.

4. Capewell S, Beaglehole R, Seddon M, McMurray J. Explanation for the decline in coronary heart disease mortality rates in Auckland, New Zealand, between 1982 and 1993. *Circulation* 2000;102(13):1511-6.

5. Capewell S, Morrison CE, McMurray JJ. Contribution of modern cardiovascular treatment and risk factor changes to the decline in coronary heart disease mortality in Scotland between 1975 and 1994. *Heart* 1999;81(4):380-86.

6. Unal B, Critchley J, Capewell S. Explaining the decline in coronary heart disease mortality in England and Wales, 1981-2000. *Circulation* 2004;109:1101-07.

7. Aspelund T, Gudnason V, Magnusdottir BT, Andersen K, Sigurdsson G, Thorsson B, et al. Analysing the large decline in coronary heart disease mortality in the Icelandic population aged 25-74 between the years 1981 and 2006. *PloS one* 2010;5(11):e13957.

8. Thorolfsdottir RB, Aspelund T, Capewell S, Critchley J, Gudnason V, Andersen K. Population assessment of future trajectories in coronary heart disease mortality in Iceland. *PloS one* 2014;9(1):e85800.

9. Hughes J, Kee F, O'Flaherty M, Critchley J, Cupples M, Capewell S, et al. Modelling coronary heart disease mortality in Northern Ireland between 1987 and 2007: broader lessons for prevention. *European journal of preventive cardiology* 2013;20(2):310-21.

10. Bennett K, Kabir Z, Unal B, Shelley E, Critchley J, Perry I, et al. Explaining the recent decrease in coronary heart disease mortality rates in Ireland, 1985-2000. *J Epidemiol Community Health* 2006;60(4):322-7.

11. Laatikainen T, Critchley J, Vartiainen E, Salomaa V, Ketonen M, Capewell S. Explaining the decline in coronary heart disease mortality in Finland between 1982 and 1997. *Am J Epidemiol* 2005;162(8):764-73.

12. Bjorck L, Rosengren A, Bennett K, Lappas G, Capewell S. Modelling the decreasing coronary heart disease mortality in Sweden between 1986 and 2002. *Eur Heart J* 2009;30(9):1046-56.

13. Vaartjes I, O'Flaherty M, Grobbee DE, Bots ML, Capewell S. Coronary heart disease mortality trends in the Netherlands 1972-2007. *Heart* 2011;97(7):569-73.

14. Pereira M, Azevedo A, Lunet N, Carreira H, O'Flaherty M, Capewell S, et al. Explaining the decline in coronary heart disease mortality in Portugal between 1995 and 2008. *Circ Cardiovasc Qual Outcomes* 2013;6(6):634-42.

15. Flores-Mateo G, Grau M, O'Flaherty M, Ramos R, Elosua R, Violan-Fors C, et al. [Analyzing the coronary heart disease mortality decline in a Mediterranean population: Spain 1988-2005]. *Rev Esp Cardiol* 2011;64(11):988-96.

16. Palmieri L, Bennett K, Giampaoli S, Capewell S. Explaining the decrease in coronary heart disease mortality in Italy between 1980 and 2000. *Am J Public Health* 2010;100(4):684-92.

17. Bruthans J, Cifkova R, Lanska V, O'Flaherty M, Critchley JA, Holub J, et al. Explaining the decline in coronary heart disease mortality in the Czech Republic between 1985 and 2007. *European journal of preventive cardiology* 2012.

18. Bandosz P, O'Flaherty M, Drygas W, Rutkowski M, Koziarek J, Wyrzykowski B, et al. Decline in mortality from coronary heart disease in Poland after socioeconomic transformation: modelling study. *BMJ* 2012;344.

19. Wijeysundera HC, Machado M, Farahati F, Wang X, Witteman W, van der Velde G, et al. Association of temporal trends in risk factors and treatment uptake with coronary heart disease mortality, 1994-2005. *JAMA* 2010;303(18):1841-7.

20. Rastam S, Al Ali R, Maziak W, Mzayek F, Fouad FM, O'Flaherty M, et al. Explaining the increase in coronary heart disease mortality in Syria between 1996 and 2006. *BMC Public Health* 2012;12:754.

21. Abu-Rmeileh NME, Shoaibi A, O'Flaherty M, Capewell S, Husseini A. Analysing falls in coronary heart disease mortality in the West Bank between 1998 and 2009. *BMJ Open* 2012;2(4).

22. Unal B, Sozmen K, Arik H, Gerceklioglu G, Altun D, Simsek H, et al. Explaining the decline in coronary heart disease mortality in Turkey between 1995 and 2008. *BMC Public Health* 2013;accepted 21/11/2013.

23. Saidi O, Ben Mansour N, O'Flaherty M, Capewell S, Critchley JA, Ben Romdhane H. Analyzing recent coronary heart disease mortality trends in Tunisia between 1997 and 2009. *PloS one* 2013;8(5):e63202.

24. Critchley J, Liu J, Zhao D, Wei W, Capewell S. Explaining the increase in coronary heart disease mortality in Beijing between 1984 and 1999. *Circulation* 2004;110(10):1236-44.

25. Cheng J, Zhao D, Zeng Z, Critchley JA, Liu J, Wang W, et al. The impact of demographic and risk factor changes on coronary heart disease deaths in Beijing, 1999-2010. *BMC Public Health* 2009;9:30.

26. Critchley JA, Capewell S. Substantial potential for reductions in coronary heart disease mortality in the UK through changes in risk factor levels. *Journal of Epidemiology and Community Health* 2002.

27. Capewell S, Ford ES, Croft JB, Critchley JA, Greenlund KJ, Labarthe DR. Cardiovascular risk factor trends and potential for reducing coronary heart disease mortality in the United States of America. *Bulletin of the World Health Organization* 2010;88(2):120-30.

28. Capewell S, O'Flaherty M, Ford ES, Critchley JA. Potential reductions in United States coronary heart disease mortality by treating more patients. *The American journal of cardiology* 2009;103(12):1703-9.

29. Capewell S, Allender S, Critchley J, Lloyd-Williams F, O'Flaherty M, Rayner M, et al. Modelling the UK burden of Cardiovascular Disease to 2020. www.cardiovascularcoalition.org.uk. London: British Heart Foundation, 2008.

30. Bajekal M, Scholes S, Love H, Hawkins N, O'Flaherty M, Raine R, et al. Analysing recent socioeconomic trends in coronary heart disease mortality in England, 2000-2007: a population modelling study. *PLoS Medicine* 2012;9(6):e1001237.

31. Nichols M, Townsend N, Scarborough P, Rayner M. Trends in age-specific coronary heart disease mortality in the European Union over three decades: 1980–2009. *European Heart Journal* 2013.

32. Nichols M, Townsend N, Scarborough O, Luengo-Fernandez R, Leal J, Gray A, Rayner M (2012). European Cardiovascular Disease Statistics 2012, European Heart Network, Brussels, European Society of Cardiology, Sophia Antipolis.

33. Danchin N, Puymirat E, Simon T. The (possibly) deceptive figures of decreased coronary heart disease mortality in Europe. *European Heart Journal* 2013.

34. Lozano R, Naghavi M, Foreman K, Lim S, Shibuya K, Aboyans V, et al. Global and regional mortality from 235 causes of death for 20 age groups in 1990 and 2010: a systematic analysis for the Global Burden of Disease Study 2010. *Lancet* 2012;380(9859):2095-128.

35. Davies AR, Smeeth L, Grundy EM. Contribution of changes in incidence and mortality to trends in the prevalence of coronary heart disease in the UK: 1996 2005. *Eur Heart J* 2007;28(17):2142-7.

36. Bennett K, Johnson H, Dack P, Shelley E, Feely J. Changes in prevalence of and prescribing for ischaemic heart disease in Ireland 1990-2002. *Ir J Med Sci* 2005;174(3):4-8.

37. O'Flaherty M, Allender S, Taylor R, Stevenson C, Peeters A, Capewell S. The decline in coronary heart disease mortality is slowing in young adults (Australia 1976-2006): A time trend analysis. *Int J Cardiol* 2011.

38. O'Flaherty M, Bishop J, Redpath A, McLaughlin T, Murphy D, Chalmers J, et al. Coronary heart disease mortality among young adults in Scotland in relation to social inequalities: time trend study. *BMJ* 2009;339:b2613.

39. O'Flaherty M, Ford E, Allender S, Scarborough P, Capewell S. Coronary heart disease trends in England and Wales from 1984 to 2004: concealed levelling of mortality rates among young adults. *Heart* 2008;94(2):178-81.

40. Ford ES, Capewell S. Coronary heart disease mortality among young adults in the U.S. from 1980 through 2002: concealed leveling of mortality rates. *J Am Coll Cardiol* 2007;50: 2128-32.

41. International Diabetes Federation. IDF Diabetes Atlas, 6th edn. Brussels, Belgium, 2013.

42. Whiting DR, Guariguata L, Weil C, Shaw J. IDF diabetes atlas: global estimates of the prevalence of diabetes for 2011 and 2030. *Diabetes research and clinical practice* 2011;94(3):311-21.

43. National Institute for Health and Welfare. FINRISK 2012 Study: Population cholesterol levels on the rise after decades of decline. http://www.thl.fi/en_US/web/en/pressrelease?id=30737 (last accessed 23/12/2013), 2012.

44. Johansson I, Nilsson LM, Stegmayr B, Boman K, Hallmans G, Winkvist A. Associations among 25-year trends in diet, cholesterol and BMI from 140,000 observations in men and women in Northern Sweden. Nutr J 2012;11:40.

45. Ghandour R, Khatib R, Shoaibi A, Capewell S, Critchley J, Ahmad B, et al. Priority setting for prevention and control of coronary heart disease in the occupied Palestinian territory: a pilot study. *The Lancet* 2013;382(S11).

46. Bowman S, Unwin N, Critchley J, Capewell S, Husseini A, Maziak W, et al. Use of evidence to support healthy public policy: a policy effectiveness-feasibility loop. *Bulletin of the World Health Organization* 2012;90(11):847-53.

47. Maziak W, Critchley J, Zaman S, Unwin N, Capewell S, Bennett K, et al. Mediterranean studies of cardiovascular disease and hyperglycemia: analytical modeling of population socio-economic transitions (MedCHAMPS)--rationale and methods. International journal of public health 2013;58(4):547-53.

48.Ghandour R, Shoaibi A, Khatib R, Abu Rmeileh N, Unal B, Sözmen K, et al. Priority setting for the prevention and control of cardiovascular diseases: Multi-criteria decision analysis (MCDA) in four eastern Mediterranean countriesInt J Pub Health (submitted) 2013.

49. Bromley H, Lloyd Williams F, Orton L, O'Flaherty M, Capewell S. Identifying the most effective and cost effective public health nutrition policy options for CVD prevention. *EuroHeart II Work Package 5. Liverpool University of Liverpool*, 2013.

50. European Heart Network. Diet, Physical activity and cardiovascular disease prevention in Europe. Brussels, 2011.

51. He FJ, MacGregor GA. How far should salt intake be reduced? *Hypertension* 2003;42(6):1093-99.

52. Clarke R, Frost C, Collins R, Appleby P, Peto R. Dietary lipids and blood cholesterol: quantitative meta-analysis of metabolic ward studies. *BMJ* 1997;314(7074):112-6.

53. Unal B, Critchley JA, Capewell S. Small changes in United Kingdom cardiovascular risk factors could halve coronary heart disease mortality. *J Clin Epidemiol* 2005;58(7):733-40.

54. Critchley JA, Capewell S. Substantial potential for reductions in coronary heart disease mortality in the UK through changes in risk factor levels. *J Epidemiol Community Health* 2003;57(4):243-7.

55. Lewington S, Clarke R, Qizilbash N, Peto R, Collins R. Age-specific relevance of usual blood pressure to vascular mortality: a meta-analysis of individual data for one million adults in 61 prospective studies. *Lancet* 2002;360(9349):1903-13.

56. Lewington S, Whitlock G, Clarke R, Sherliker P, Emberson J, Halsey J, et al. Prospective Studies Collaboration. Blood cholesterol and vascular mortality by age, sex, and blood pressure: a meta-analysis of individual data from 61 prospective studies with 55,000 vascular deaths. *Lancet* 2007;370(9602):1829-39.

57. Ezzati M, Henley SJ, Thun MJ, Lopez AD. Role of smoking in global and regional cardiovascular mortality. *Circulation* 2005;112(4):489-97.

58. Bull F, Armstrong TP, Dixon T, Ham S, Neiman A. Physical inactivity. In: Ezzati M, Lopez AD, Rodgers A, Murray CJL, editors. *Comparative quantification of risk. Global and regional burden of disease attributable to selected major risk factors*. Geneva: World Health Organization. pp, 2004:729-881.

59. Joubert J, Norman R, Lambert EV, Groenewald P, Schneider M. Estimating the burden of disease attributable to physical inactivity in South Africa in 2000. S *Afr Med J* 2007;97:725-31.

60. Ezatti M, Lopez AD, Rodgers A, Murray CJL. *Comparative quantification of risk. Global and regional burden of disease attributable to selected major risk factors*. Geneva: World Health Organization, 2004.

61. Taylor HL, Jacobs Jr DR, Schucker B, Knudsen J, Leon AS, Debacker G. A questionnaire for the assessment of leisure time physical activities. *Journal of Chronic Diseases* 1978;31(12):741-55.

62. Stamatakis E, Ekelund U, Wareham N. *Temporal trends in physical activity in England: the Health Survey for England,* 1991-2004.

63. http://www.ipaq.ki.se/ipaq.htm. International Physical Activity Questionnaire, 2013 (*last accessed* 22/12/13).

64. Fogelholm M, et al. International Physical Activity Questionnaire: Validity against fitness. *Med Sci Sports Exerc* 2006;38:753-60.

65. World Health Organization. Global Recommendations on Physical Activity for Health. http://www.who.int/dietphysicalactivity/leaflet-physical-activity-recommendations.pdf (last accessed 23/12/2013), 2011.

66. Naidoo B, Thorogood M, McPherson K, LJ G-S. Modelling the effects of increased physical activity on coronary heart disease in England and Wales. *J Epidemiol Community Health* 1997;51(2):144-50.

67. Joint Health Surveys Unit. *Health Survey for England 2008: Physical activity and fitness*. Leeds: The Information Centre, 2010.

68. Prince SA, Adamo KB, Hamel ME, Hardt J, Gorber SC, Tremblay M. A comparison of direct versus self-report measures for assessing physical activity in adults: a systematic review. *Int J Behav Nutr Phys Act.* 2008; 5: 56. 2008.

69. Celis-Morales CA, Perez-Bravo F, Ibañez L, Salas C, Bailey MES, Gill JMR. Objective vs. Self-Reported Physical Activity and Sedentary Time: Effects of Measurement Method on Relationships with Risk Biomarkers. . *PloS one* 2012;7(5): e36345. doi:10.1371/journal.pone.0036345.

70. Chung S-C, Gedeborg R, Nicholas O, James S, Jeppsson A, Wolfe C, et al. Acute myocardial infarction: a comparison of short-term survival in national outcome registries in Sweden and the UK. *The Lancet* 2014.

71. Castillo MG, O'Flaherty M, Bandosz P, Capewell S. PPO1 Predicting Future Coronary Heart Disease Mortality trends in England and Wales in 2020: a Bayesian age Period Cohort Approach. *J Epidemiol Community Health* 2013;67(Suppl 1):A49.

72. Unal B, Critchley JA, Fidan D, Capewell S. Life-years gained from modern cardiological treatments and population risk factor changes in England and Wales, 1981-2000. *Am J Public Health* 2005;95(1):103-8.

73. Capewell S, Hayes DK, Ford ES, Critchley JA, Croft JB, Greenlund KJ, et al. Life-years gained among US adults from modern treatments and changes in the prevalence of 6 coronary heart disease risk factors between 1980 and 2000. *Am J Epidemiol* 2009;170(2):229-36.

74. Critchley JA, Capewell S, Unal B. Life-years gained from coronary heart disease mortality reduction in Scotland: prevention or treatment? *J Clin Epidemiol* 2003;56(6):583-90.

75. Fidan D, Unal B, Critchley J, Capewell S. Economic analysis of treatments reducing coronary heart disease mortality in England and Wales, 2000-2010. *Qjm* 2007;100(5):277-89.

76. Gouda HN, Critchley J, Powles J, Capewell S. Why choice of metric matters in public health analyses: a case study of the attribution of credit for the decline in coronary heart disease mortality in the US and other populations. *BMC Public Health* 2012;12:88.

77. Rothman K, Greenland S. Causation and causal inference. Modern Epidemiology: *Lippincott*, 1998.

78. Capewell S, O'Flaherty M. Rapid mortality falls after risk-factor changes in populations. *The Lancet* 2011;378:752-53.

79. Hu F. Globalization of diabetes: the role of diet, lifestyle, and genes. *Diabetes Care* 2011;34(6):1249 - 57.

80.The Grocer. Butter Booms but total spreads sector slides: http://www.thegrocer.co.uk/fmcg/fresh/butter-booms-but-total-spreads-sector-slides/344913.article (*last accessed* 23/12/2013), 2013.

81. Farnham A. Slather It, Baby! Butter Consumption Hits 40-Year High. ABC News 2014.

82. Butler J. Spanish Eating More Butter, Less Olive Oil. *Olive Oil Times* 2011.

83. IOM (Institute of Medicine). Promoting Cardiovascular Health in the Developing World. A Critical Challenge to Achieve Global Health. In: Fuster V, Kelly B, editors. Washington DC: The National Academies Press, 2010.

84. National Institute for Health and Clinical Excellence. Prevention of cardiovascular disease at population level. NICE Public Health Guidance. London: National Institute for Health and Clinical Excellence, 2010.

85. Beaglehole R, Bonita R, Horton R, Adams C, Alleyne G, Asaria P, et al. Priority actions for the non-communicable disease crisis. *The Lancet* 2011;377(9775):1438-47.

86. El Awa F. The WHO Framework Convention on Tobacco Control as a tool for advancing health promotion: perspective from the Eastern Mediterranean Region. Glob Health Promot 2010;17(1 Suppl):60-6.

87. Fong GT, Cummings KM, Shopland DR. Building the evidence base for effective tobacco control policies: the International Tobacco Control Policy Evaluation Project (the ITC Project). *Tob Control* 2006;15 Suppl 3:iii1-2.

88. Sassi F. Obesity and the Economics of Prevention. Fit not Fat: Organisation for Economic Co-operation and Development (OECD), 2010.

89. Murray CJL, Lauer JA, Hutubessy RCW, Niessen L, Tomijima N, Rodgers A, et al. Effectiveness and costs of interventions to lower systolic blood pressure and cholesterol: a global and regional analysis on reduction of cardiovascular-disease risk. *The Lancet* 2003;361(9359):717-25.

90. Gaziano T, et al. Tax on salt and voluntary industry reductions in salt content could reduce deaths from cardiovascular disease by 3 percent in developing countries. Preliminary data from new Harvard report. *World Congress of Cardiology*. Dubai: World Heart Federation, 2012.

91. Mason H, Shoaibi A, Ghandour R, O'Flaherty M, Capewell S, Khatib R, et al. A Cost Effectiveness Analysis of Salt Reduction Policies to Reduce Coronary Heart Disease in Four Eastern Mediterranean Countries. *PLoS ONE* 2014;9(1):e84445.

Appendix 1

Work Package 6 - Stakeholder Consultation

This appendix provides further information on the information and questionnaire provided to stakeholders during the stakeholder consultation phase. Stakeholders were provided with significant background information including a detailed description of the policy options proposed and results from a previous country specific IMPACT model, to help guide their ranking.

Below as an example we show a summary of results from the previous Northern Ireland IMPACT model, which was distributed to the Northern Ireland stakeholders approached along with the policy options list questionnaire and the detailed descriptions of policy content and results from each country.

Results from Northern Ireland IMPACT model 87 – 07

Table 1 Summary results (% mortality CHD decline between 1987 & 2007) by model subcategory

Policy Option / target	Target Group	IMPACT Category	Impact from previous model (1987- 2007)	Impact to 2020 Estimate from new model
Acute Treatment	Myocardial Infarction	**T1**	-3%	?
	Heart Failure	**T2**	-4%	?
	Angina	**T3**	-1%	?
Secondary prevention	Following Acute myocardial Infarction	**T4**	-14%	?
	Following CABG/ angioplasty	**T5**	-1%	?
	Community Angina	**T6**	-3%	?
	Community Heart failure	**T7**	-3%	?
Primary preventative medications	Statins	**T8**	-4%	?
	Anti-hypertensive medications	**T9**	-3%	?
Risk factor changes	Cholesterol (diet)	**RF1**	-26%	?
	Blood pressure	**RF2**	-28%	?
	Smoking	**RF3**	-20%	?
	Diabetes	**RF4**	8%	?
	Obesity	**RF5**	1%	?
	Physical inactivity	**RF6**	5%	?

Policy options list questionnaire

Policy option categories listed below are consistent with categorisation within the IMPACT model. Following your input and feedback from other stakeholders, the IMPACT model will be used to predict future CHD mortality estimates to 2020 based on a range of viable policy scenarios.

Please indicate on a scale of 1- 5 (1 = lowest priority, 5 = highest priority) the importance of each policy option in the primary prevention (Table 2) and secondary prevention (Table 3) of cardiovascular diseases in Northern Ireland over the next decade.

Please take into account how appropriate, feasible and effective each option is likely to be. More detail on policy options for primary prevention was included in an appendix (copied on page 5 of this technical appendix).

Table 2 – Policy Options for Primary Prevention of Heart disease

		Priority (1= lowest, 5 = highest)					
Policy Option	**IMPACT category**	**1**	**2**	**3**	**4**	**5**	**N/A**
1. Consistent approach to front of pack food labelling (salts, sugars, fats & calories)	**RF1, RF 2**						
2. Higher taxes for processed foods	**RF1, RF2**						
3. Higher taxes for foods with high levels of saturated fats	**RF1**						
4. Restrictions on marketing of fizzy drinks or junk food in or adjacent to programmes which have a particular appeal to children under 16	**RF1**						
5. Transfats reductions/bans	**RF1**						
6. Increase consumer awareness of the impact of saturated fats on health/heart disease	**RF1**						
7. Increase uptake of statins to reduce cholesterol levels	**T8**						
8. Increase uptake of antihypertensive therapies to reduce blood pressure levels	**T9**						
9. Investment in polypill (statin & anti-hypertensive)	**RF1,RF2**						
10. Subsidies for fruit & vegetables/promote healthier food products	**RF1**						
11. Public awareness campaign to reduce discretionary salt intake (cooking and/or at table)	**RF2**						
12. Reformulation work working with all sectors of the food industry to reduce levels of saturated fats and sugars in processed foods.	**RF1**						
13. Reformulation work working with all sectors of the food industry to reduce the salt content of processed foods.	**RF2**						
14. Further increases in tax for tobacco/cigarettes	**RF3**						
15. Increasing selling price on tobacco/cigarettes	**RF3**						
16. Enforce existing laws regarding smokefree areas	**RF3**						
17. Create more smokefree areas (cars)	**RF3**						
18. More education campaigns for children on dangers of smoking	**RF3**						
19. Maintain or increase smoking cessation initiatives for disadvantaged groups/persons in disadvantaged areas	**RF3**						
20. Promoting active travel	**RF4,RF5,RF6**						
21. Initiatives to promote PA in workplace/school	**RF4,RF5,RF6**						
22. Initiatives to promote PA at home	**RF4,RF5,RF6**						
23. Local authorities to make it easier and safer for walking and cycling	**RF4,RF5,RF6**						
24. Employers to encourage employees to walk/cycle to work	**RF4,RF5,RF6**						
25. Physician advice on increasing PA levels	**RF4,RF5,RF6**						
26. More media campaigns to promote healthier lifestyle interventions (changes in diet & increase levels of physical activity)	**RF4,RF5,RF6**						

Other suggestions/comments

Table 3 – Policy Options for Secondary Prevention of Heart Disease

		Priority (1= lowest, 5 = highest)					
Policy Option	**IMPACT category**	**1**	**2**	**3**	**4**	**5**	**N/A**
1. Acute treatment – Improving initial treatment following admission for MI/UA	**T1, T3**						
2. Roll out primary angioplasty provision across NI	**T1**						
3. Acute treatment – Improving treatment following admission for heart failure	**T2**						
4. Increase availability of secondary preventative drugs (MI, HF & Angina)	**T4 –T7**						
5. Patient groups – importance of compliance with secondary preventative drugs.	**T4 – T7**						
6. Secondary prevention – follow up on cardiac rehab	**T4 –T7**						
7. Patient groups – improved psychology services required	**T4 –T7**						
8. Increase levels of expert clinical staff	**T1 –T7**						
9. More training opportunities for staff	**T1-T7**						
10. More structured integrated approach to secondary prevention (secondary care – primary care)	**T1-T7**						
11. Improved electronic communication between hospital and community	**T1-T7**						
12. Improve resources to monitor and analyse data. e.g. collection of MINAP audit data in all HSC trusts	**T1-T7**						

Other suggestions/comments

Overall what are your top five priorities in order of importance (either primary or secondary prevention)

1.

2.

3.

4.

5

Description of policy options for prevention of CVD

1. Consistent approach to front of pack food labelling (e.g. of salts, sugars, fats and calories)

More visible labels on the front of packets – not the back or side. These should be clearly presented, using "traffic lights" guide to tell the consumer at a glance if the food has high, medium or low amounts of fat, saturated fat, sugars and salt.

2. Higher taxes for processed foods

Increased taxation on foods that are high in sugar, salt or saturated fats.

3. Higher taxes for foods with high levels of saturated fats

As above, but aimed particularly at foods high in saturated fats. Such a tax was implemented in Denmark in October 2011.

4. Restrictions on marketing of fizzy drinks or junk food in or adjacent to programmes which have a particular appeal to children under 16

Statutory regulation to prevent the marketing of "energy dense, nutrient poor" foods during programmes with a particular appeal to children and during programmes specifically aimed at children.

5. Transfats reductions/bans

Total ban of transfats (which represent approximately 1% of UK diets, and have no nutritional value) from food.

6. Increase consumer awareness of the impact of saturated fats on health/heart disease

Media campaigns, advertising,

7. Increased uptake of statins to reduce cholesterol levels

Among individuals deemed to be at "high risk" of cardiovascular disease e.g. 20% in the next 10 years

8. Increased uptake of anti-hypertensive therapies to reduce blood pressure levels

As above, among individuals deemed to be at "high risk" of cardiovascular disease e.g. 20% in the next 10 years

9. Investment in polypill (statin and anti-hypertensive)

As above, to be given to individuals deemed to be at "high risk" of cardiovascular disease e.g. 20% in the next 10 years.

10. Subsidies for fruit and vegetables/promote healthier food products

For example, discounted food vouchers, possibly targeted at people with low incomes. Could possibly be combined with taxes on saturated fats / processed foods.

11. Public awareness campaign to reduce discretionary salt intake (cooking or at table)

E.g. media campaigns, advertising

12. Reformulation work working with all sectors of the food industry to reduce the levels of saturated fats and sugars in processed foods.

13. Reformulation work working with all sectors of the food industry to reduce the salt content of processed foods

14. Further increases in tax for tobacco/cigarettes

15. Increase selling prices on tobacco/cigarettes

16. Enforce existing laws regarding smokefree areas

17. Create more smokefree areas (cars)

E.g. ban on smoking in cars carrying children (<16)

18. More education campaigns for children on dangers of smoking Media campaigns, advertising.

19. Maintain or increase smoking cessation initiatives for disadvantaged groups/personal in disadvantaged areas

Increase access to effective smoking cessation strategies (NRTs, support, leaflets etc) for disadvantaged groups with high smoking prevalence such as those with mental health problems, prisoners.

20. Promoting active travel

Walking, cycling and public transport information, tailor-made travel packs.

21. Initiatives to promote physical activity in the workplace/school

Promoting walking and cycling to work. Signs encouraging use of stairs rather than lifts. Workplace screening and counselling.

22. Initiatives to promote physical activity in the home

23. Local authorities to make it easier and safer for walking and cycling

Traffic calming measures including reductions in speed limits. Better infrastructure such as cycle lanes, tracks and paths.

24. Employers to encourage employees to walk/ cycle to work

A range of possible strategies such as installing showers, bike / locker storage, including cycling miles in mileage allowances.

25. Physician advice on increasing PA levels

Brief counselling and advice, possibly related to barriers to change.

26. More media campaigns to promote healthier lifestyle interventions (changes in diet and increased levels of physical activity)

RESULTS: Top five priorities by country and category (%)

Poland

Legislation/fiscal policies relating to food	31%	Primary
Relating to healthier foods	16%	Primary
Legislation/fiscal policies relating to tobacco/smoking	15%	Primary
Healthy lifestyle initiatives	10%	Primary
Improving communication/mentoring	8%	Secondary

Scotland

Legislation/fiscal policies relating to tobacco/smoking	28%	Primary
Legislation/fiscal policies relating to food	18%	Primary
Healthy lifestyle initiatives	16%	Primary
Equality issues *	10%	
Initial treatments for heart attacks/acute treatments	7%	Secondary

*Note: Some answers referred to equality that wasn't on the original questionnaire, so a new category was created.

Northern Ireland

Legislation/fiscal policies relating to food	28%	Primary
Healthy lifestyle initiatives	20%	Primary
Legislation/fiscal policies relating to tobacco/smoking	10%	Primary
Secondary Prevention	10%	Secondary
Standalone - Education campaigns on smoking	10%	Primary

Republic of Ireland

Healthy lifestyle initiatives	25%	Primary
Legislation/fiscal policies relating to food	21%	Primary
Legislation/fiscal policies relating to tobacco/smoking	21%	Primary
Relating to healthier foods	10%	Primary
Secondary Prevention	10%	Secondary

Italy

Legislation/fiscal policies relating to food	32%	Primary
Healthy lifestyle initiatives	28%	Primary
Legislation/fiscal policies relating to tobacco/smoking	25%	Primary
Food industry	11%	Primary
Improving communication/mentoring	4%	Secondary

Appendix 2.

Technical report on predicted decrease in CHD mortality, due to changes in risk factors. Results from individual populations taking part.

The aim of this analysis is to assess the number of deaths due to coronary heart disease (CHD) preventable by population wide structural interventions aiming to modify the main lifestyle-related cardiovascular risk factors (smoking, salt consumption, saturated fat and physical activity) .

Changes of following four risk factors were modelled:

- Smoking
- Salt consumption
- Proportion of consumed saturated fats to unsaturated ones
- Physical Activity

This analysis was done for following nine EU populations:

- Czech Republic
- Finland
- Iceland
- Ireland
- Italy
- Northern Ireland
- Poland
- Scotland
- Sweden

1. Czech Republic

The age range of the analysis was 25-74 years. The size of the population of the Czech Republic in this age range was 6.8 million in 2007. According to population forecast, in year 2020 the number of subjects aged 25-74 years will be 7.3 million.

During the base year of the analysis (2007) the number of CHD deaths was 8 039. Assuming no future changes in mortality, the number of CHD deaths in the final year (2020) will be 10 598, which is a 31.8% increase. Decrease in predicted number of deaths in 2020 under assumption of no mortality change in future is shown in Fig. 1.1 and Table 1.1.

If mortality will change according to the forecast based on current trends, we will observe 4 890 CHD deaths in 2020, which is 39.2% decrease (Fig. 1.2 and Table 1.2).

The relative effect of changes in different risk factors is presented on Fig. 1.3. This figure shows also maximum effect for changes in smoking (assuming no smoking in population) and physical activity (assuming no inactive subjects in population).

Figure 1.1: Czech: Forecasted change in number of deaths due to changes in risk factors, assumed no changes in future mortality.

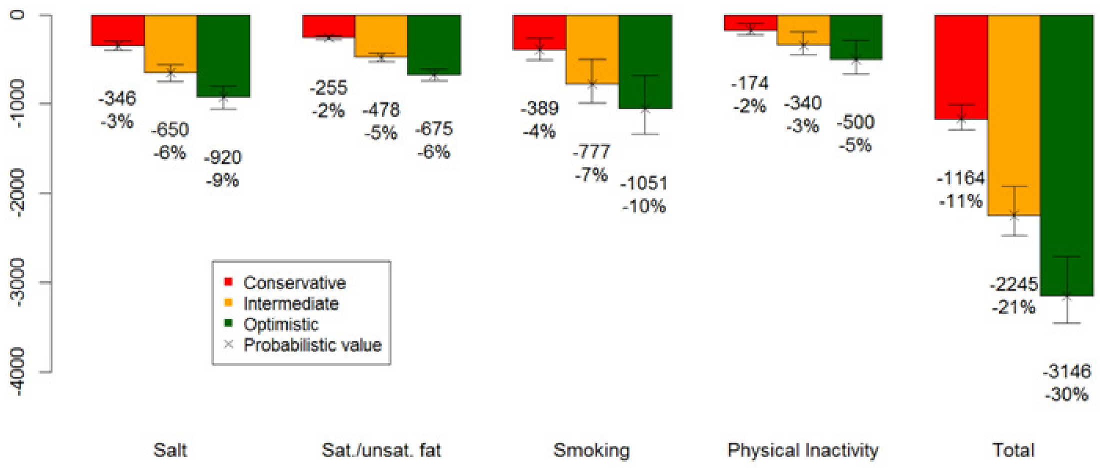


Table 1.1: Czech Republic: Forecasted change in number of deaths due to changes in risk factors, assumed no changes in future mortality

	Scenario											
	Conservative				Intermediate				Optimistic			
Risk Factor	N	%	LCL	UCL	N	%	LCL	UCL	N	%	LCL	UCL
All	1164	11%	1001	1289	2245	21%	1916	2473	3146	30%	2704	3447
Phys. activity	174	2%	99	226	340	3%	193	445	500	5%	283	661
Salt intake	346	3%	298	399	650	6%	562	748	920	9%	799	1057
Sat. fats	255	2%	231	280	478	5%	434	525	675	6%	615	742
Smoking	389	4%	257	506	777	7%	496	991	1051	10%	677	1342

Table 1.2: Czech Republic: Forecasted change in number of deaths due to changes in risk factors, assumed changes in future mortality according to current trend

	Scenario											
	Conservative				Intermediate				Optimistic			
Risk Factor	N	%	LCL	UCL	N	%	LCL	UCL	N	%	LCL	UCL
All	535	11%	418	642	1033	21%	802	1232	1452	30%	1130	1735
Phys. activity	81	2%	44	111	157	3%	85	218	231	5%	125	323
Salt intake	159	3%	124	198	299	6%	234	373	424	9%	332	527
Sat. fats	118	2%	96	142	221	5%	180	266	312	6%	256	376
Smoking	178	4%	112	241	355	7%	217	474	484	10%	296	650

Figure 1.2: Czech Republic: Forecasted change in number of deaths due to changes in risk factors, assumed changes in future mortality according to current trend

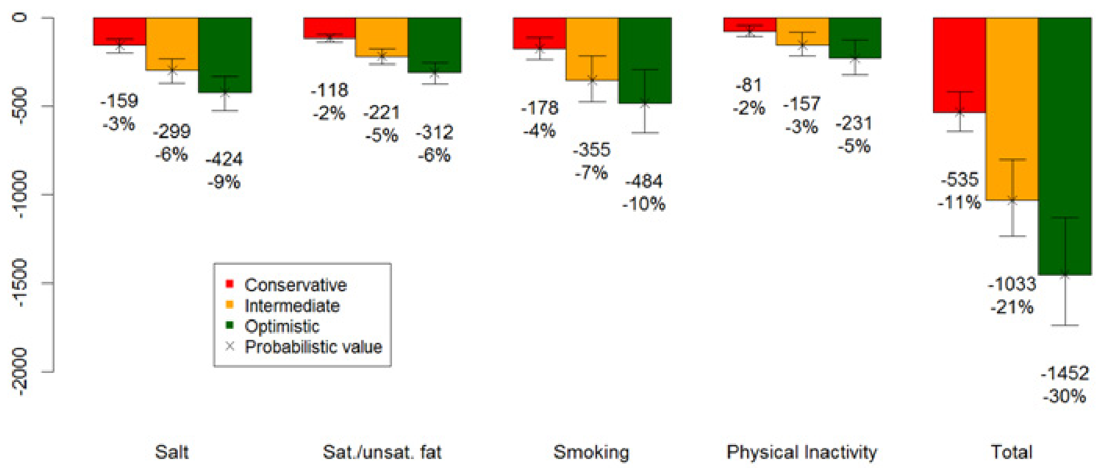
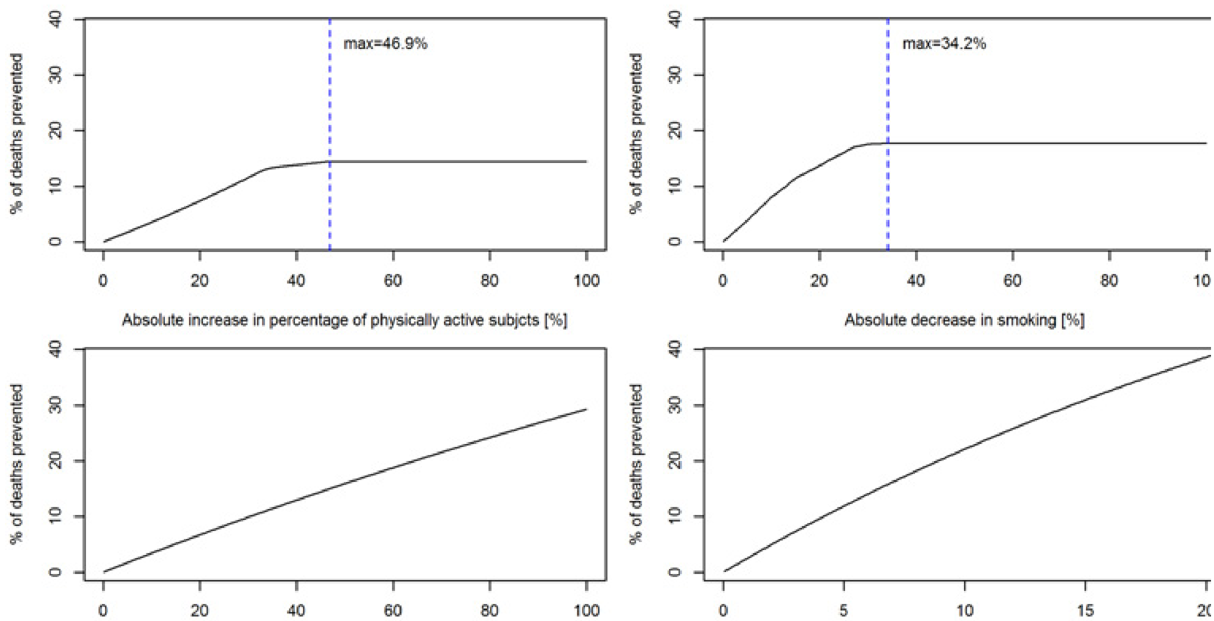


Figure 1.3: Czech Republic: Forecasted effects of changes in four behavioural risk factors, and maximum effect for smoking and physical activity interventions



2. Finland

The age range of the analysis was 25-74 years. The size of the population of Finland in this age range was 3.3 million in 2007. According to population forecast, in year 2020 the number of subjects aged 25-74 years will be 3.5 million.

During the base year of the analysis (2007) the number of CHD deaths was 3 442. Assuming no future changes in mortality, the number of CHD deaths in final year (2020) will be 4 443, which is 29.1% increase. Decrease in predicted number of deaths in 2020 under assumption of no mortality change in future is shown in Fig. 2.1 and Table 2.1.

If mortality will change according to the forecast based on current trends, we will observe 2 247 CHD deaths in 2020, which is 34.7% decrease (Fig. 2.2 and Table 2.2).

The relative effect of changes in different risk factors is presented on Fig. 2.3. This figure shows also maximum effect for changes in smoking (assuming no smoking in population) and physical activity (assuming no inactive subjects in population).

Figure 2.1: Finland: Forecasted change in number of deaths due to changes in risk factors, assumed no changes in future mortality

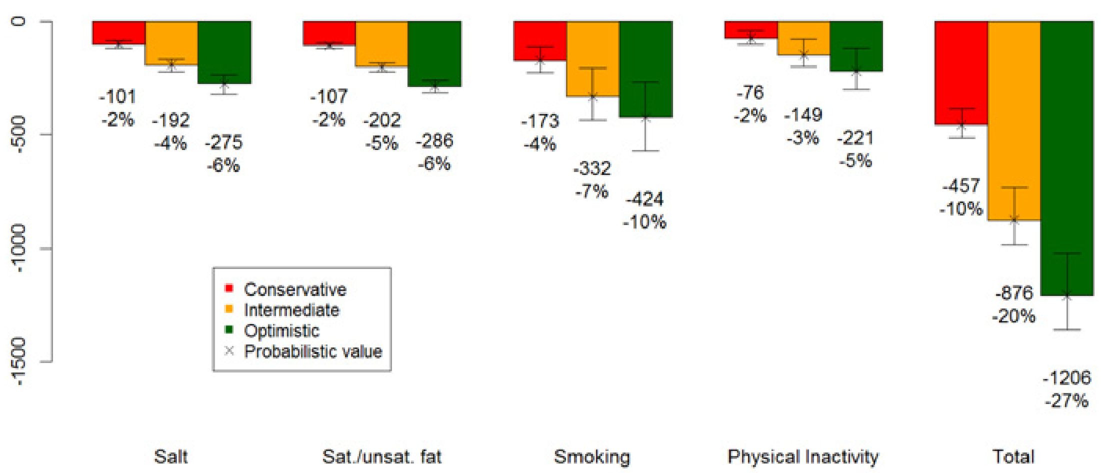


Table 2.1: Finland: Forecasted change in number of deaths due to changes in risk factors, assumed no changes in future mortality

	Scenario											
	Conservative				Intermediate				Optimistic			
Risk Factor	N	%	LCL	UCL	N	%	LCL	UCL	N	%	LCL	UCL
All	457	10%	384	514	876	20%	732	984	1206	27%	1021	1357
Phys. activity	76	2%	41	102	149	3%	80	201	221	5%	118	301
Salt intake	101	2%	87	118	192	4%	166	224	275	6%	238	320
Sat. fats	107	2%	97	118	202	5%	183	222	286	6%	260	316
Smoking	173	4%	112	226	332	7%	207	435	424	10%	266	571

Table 2.2: Finland: Forecasted change in number of deaths due to changes in risk factors, assumed changes in future mortality according to current trend

	Scenario											
	Conservative				Intermediate				Optimistic			
Risk Factor	N	%	LCL	UCL	N	%	LCL	UCL	N	%	LCL	UCL
All	231	10%	183	273	443	20%	349	523	612	27%	488	726
Phys. activity	38	2%	20	53	75	3%	40	106	112	5%	58	158
Salt intake	51	2%	41	62	97	4%	78	118	139	6%	112	169
Sat. fats	55	2%	46	65	103	5%	87	121	146	7%	123	172
Smoking	86	4%	54	117	167	7%	101	224	215	10%	131	298

Figure 2.2: Finland: Forecasted change in number of deaths due to changes in risk factors, assumed changes in future mortality according to current trend

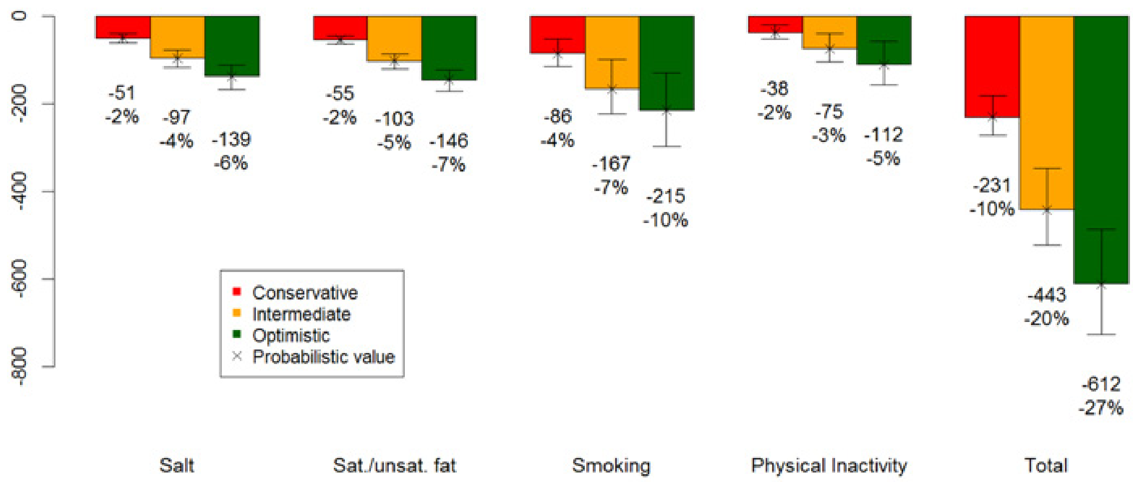
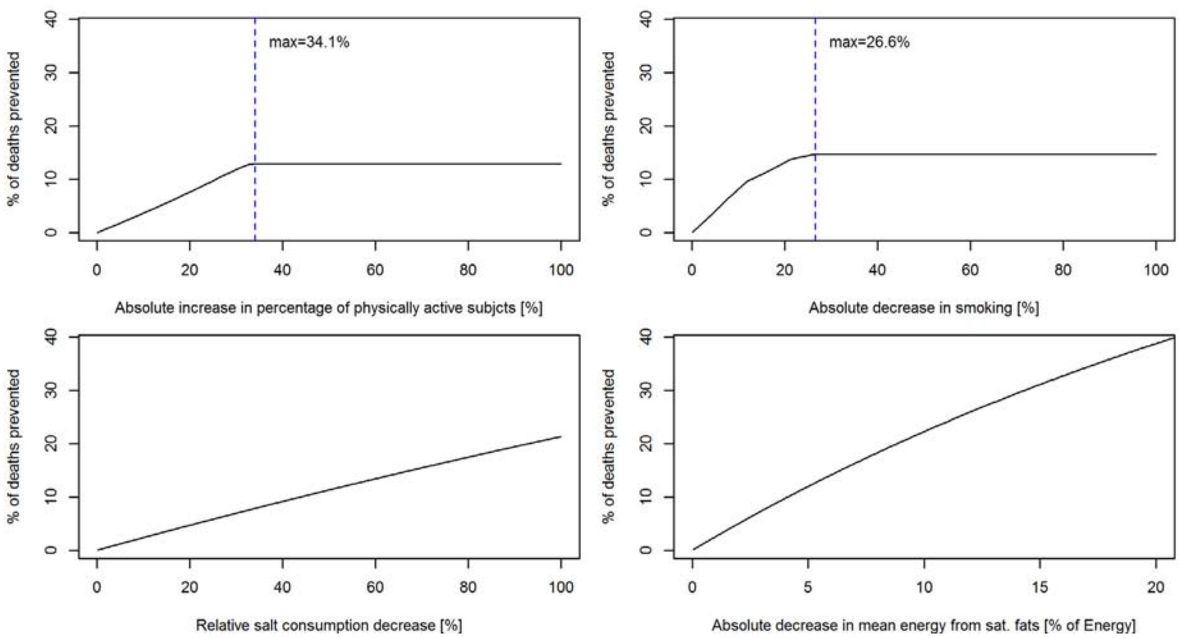


Figure 2.3: Finland: Forecasted effects of changes in four behavioural risk factors, and maximum effect for smoking and physical activity interventions



3 Iceland

The age range of the analysis was 25-74 years. The size of the population of Iceland in this age range was 0.2 million in 2009. According to population forecast, in year 2020 the number of subjects aged 25-74 years will be 0.2 million.

During the base year of the analysis (2009) the number of CHD deaths was 75. Assuming no future changes in mortality, the number of CHD deaths in final year (2020) will be 106, which is a 41.9% increase. Decrease in predicted number of deaths in 2020 under assumption of no mortality change in future is shown in Fig. 3.1 and Table 3.1.

If mortality will change according to the forecast based on current trends, we will observe 65 CHD deaths in 2020, which is 12.5% decrease (Fig. 3.2 and Table 3.2).

The relative effect of changes in different risk factors is presented on Fig. 3.3. This figure shows also maximum effect for changes in smoking (assuming no smoking in population) and physical activity (assuming no inactive subjects in population).

Figure 3.1: Iceland: Forecasted change in number of deaths due to changes in risk factors, assumed no changes in future mortality

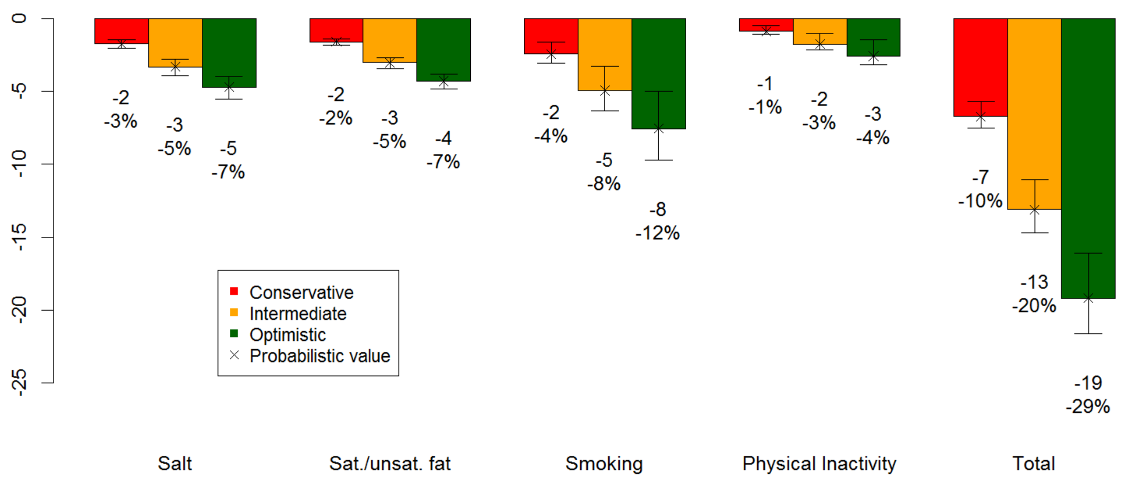


Table 3.1: Iceland: Forecasted change in number of deaths due to changes in risk factors, assumed no changes in future mortality

	Scenario											
	Conservative				**Intermediate**				**Optimistic**			
Risk Factor	N	%	LCL	UCL	N	%	LCL	UCL	N	%	LCL	UCL
All	11	10%	9	12	21	20%	18	23	31	29%	26	34
Phys. activity	1	1%	1	2	3	3%	2	3	4	4%	2	5
Salt intake	3	3%	2	3	5	5%	5	6	8	7%	7	9
Sat. fats	3	2%	2	3	5	5%	4	5	7	7%	6	8
Smoking	4	4%	3	5	8	7%	5	10	12	11%	8	15

Table 3.2: Iceland: Forecasted change in number of deaths due to changes in risk factors, assumed changes in future mortality according to current trend

	Scenario											
	Conservative				Intermediate				Optimistic			
Risk Factor	N	%	LCL	UCL	N	%	LCL	UCL	N	%	LCL	UCL
All	7	10%	6	8	13	20%	11	15	19	29%	16	22
Phys. activity	1	1%	1	1	2	3%	1	2	3	4%	1	3
Salt intake	2	3%	1	2	3	5%	3	4	5	7%	4	6
Sat. fats	2	2%	1	2	3	5%	3	3	4	7%	4	5
Smoking	2	4%	2	3	5	8%	3	6	8	12%	5	10

Figure 3.2: Iceland: Forecasted change in number of deaths due to changes in risk factors, assumed changes in future mortality according to current trend

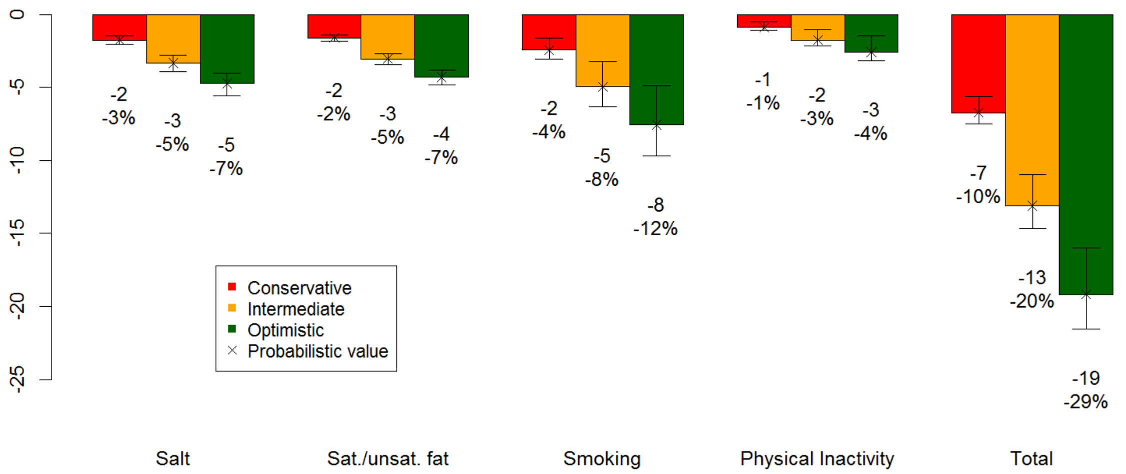
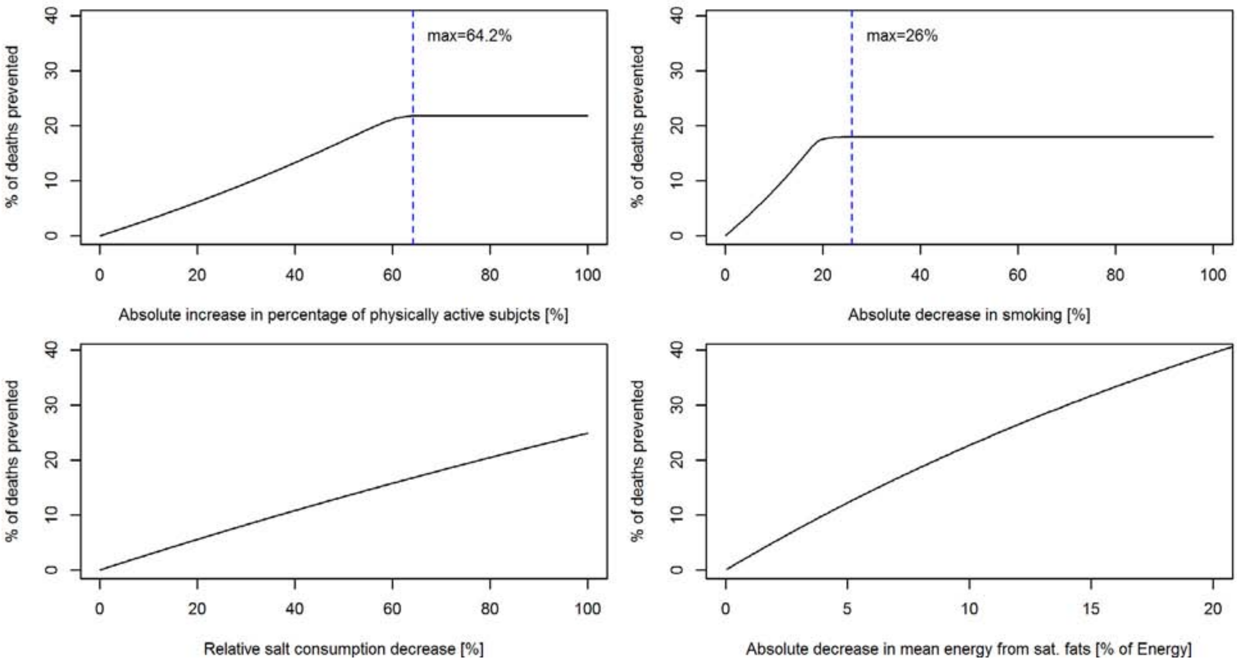


Figure 3.3: Iceland: Forecasted effects of changes in four behavioural risk factors, and maximum effect for smoking and physical activity interventions



4. Ireland

The age range of the analysis was 25-74 years. The size of the population of Ireland in this age range was 2.7 million in 2010. According to population forecast, in year 2020 the number of subjects aged 25-74 years will be 3.6 million.

During the base year of the analysis (2010) the number of CHD deaths was 1 464. Assuming no future changes in mortality, the number of CHD deaths in final year (2020) will be 2 130, which is a 45.5% increase. Decrease in predicted number of deaths in 2020 under assumption of no mortality change in future is shown in Fig. 4.1 and Table 4.1.

If mortality will change according to the forecast based on current trends, we will observe 1 047 CHD deaths in 2020, which is 28.5% decrease (Fig. 4.2 and Table 4.2).

The relative effect of changes in different risk factors is presented on Fig. 4.3. This figure shows also maximum effect for changes in smoking (assuming no smoking in population) and physical activity (assuming no inactive subjects in population).

Figure 4.1: Ireland: Forecasted change in number of deaths due to changes in risk factors, assumed no changes in future mortality

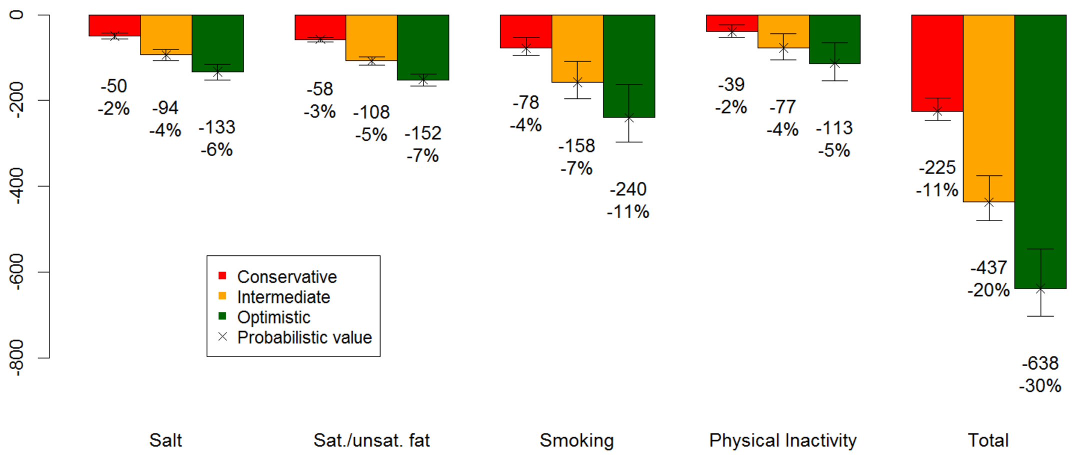


Table 4.1: Ireland: Forecasted change in number of deaths due to changes in risk factors, assumed no changes in future mortality

	Scenario											
	Conservative				Intermediate				Optimistic			
Risk Factor	N	%	LCL	UCL	N	%	LCL	UCL	N	%	LCL	UCL
All	225	11%	194	247	437	20%	377	481	638	30%	548	703
Phys. activity	39	2%	23	53	77	4%	45	104	113	5%	65	154
Salt intake	50	2%	43	57	94	4%	81	107	133	6%	116	152
Sat. fats	58	3%	52	63	108	5%	98	118	152	7%	139	166
Smoking	78	4%	54	96	158	7%	108	196	240	11%	162	299

Table 4.2: Ireland: Forecasted change in number of deaths due to changes in risk factors, assumed changes in future mortality according to current trend

	Scenario											
	Conservative				Intermediate				Optimistic			
Risk Factor	N	%	LCL	UCL	N	%	LCL	UCL	N	%	LCL	UCL
All	111	11%	95	124	216	21%	184	242	316	30%	266	353
Phys. activity	20	2%	11	26	38	4%	22	52	56	5%	32	77
Salt intake	24	2%	21	28	46	4%	39	53	65	6%	56	76
Sat. fats	29	3%	26	33	55	5%	49	61	77	7%	69	86
Smoking	38	4%	26	47	77	7%	53	97	118	11%	79	148

Figure 4.2: Ireland: Forecasted change in number of deaths due to changes in risk factors, assumed changes in future mortality according to current trend

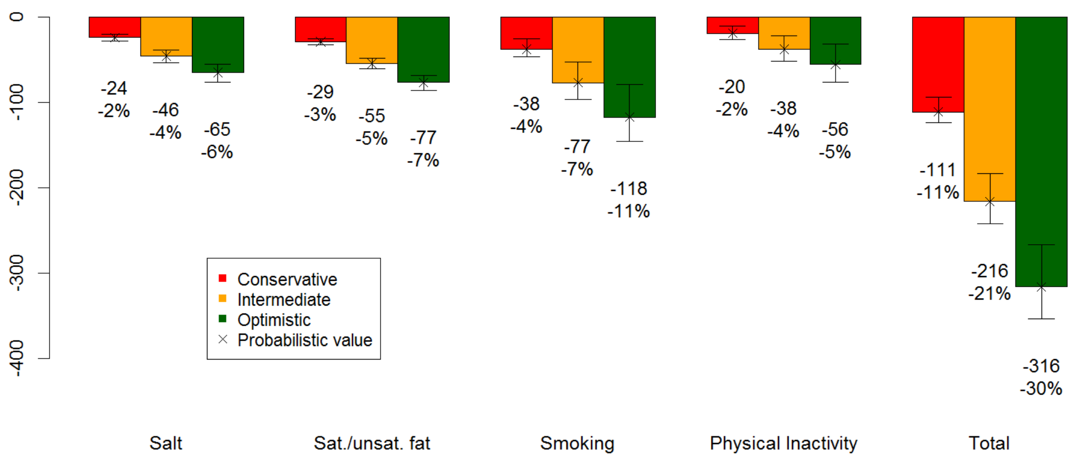
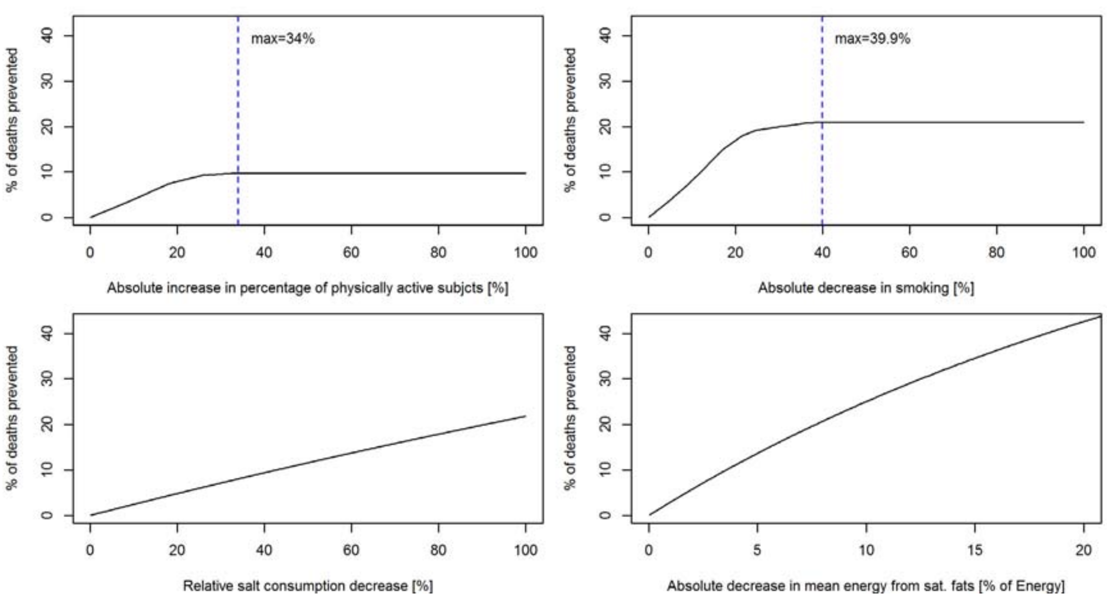


Figure 4.3: Ireland: Forecasted effects of changes in four behavioural risk factors, and maximum effect for smoking and physical activity interventions



5. Italy

The age range of the analysis was 25-74 years. The size of the population of Italy in this age range was 38.6 million in 2010. According to population forecast, in year 2020 the number of subjects aged 25-74 years will be 38 million.

During the base year of the analysis (2010) the number of CHD deaths was 14 674. Assuming no future changes in mortality, the number of CHD deaths in final year (2020) will be 16 193, which is a 10.4% increase. Decrease in predicted number of deaths in 2020 under assumption of no mortality change in future is shown in Fig. 5.1 and Table 5.1.

If mortality will change according to the forecast based on current trends, we will observe 11 002 CHD deaths in 2020, which is 25% decrease (Fig. 5.2 and Table 5.2).

The relative effect of changes in different risk factors is presented on Fig. 5.3. This figure shows also maximum effect for changes in smoking (assuming no smoking in population) and physical activity (assuming no inactive subjects in population).

Figure 5.1: Italy: Forecasted change in number of deaths due to changes in risk factors, assumed no changes in future mortality

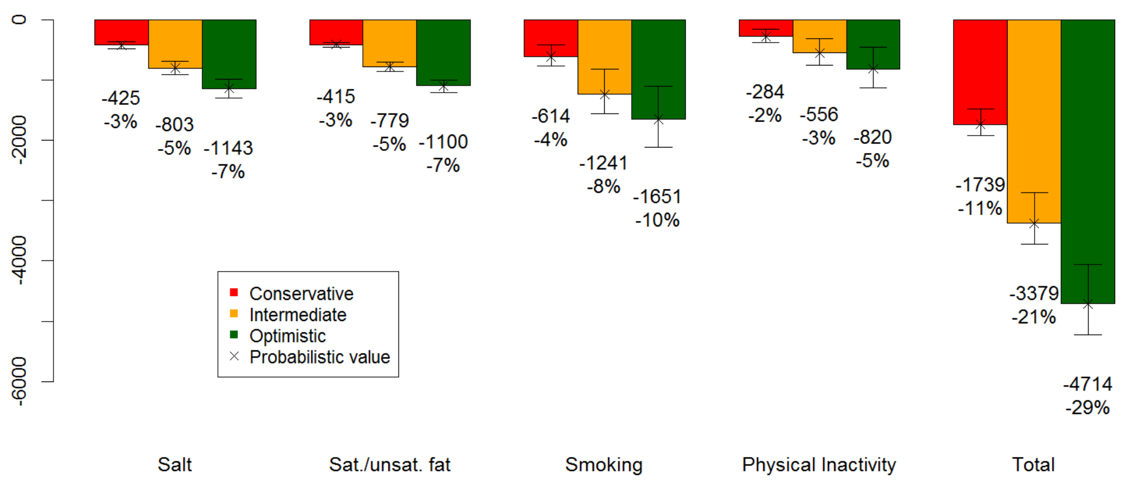


Table 5.1: Italy: Forecasted change in number of deaths due to changes in risk factors, assumed no changes in future mortality

	Scenario											
	Conservative				Intermediate				Optimistic			
Risk Factor	N	%	LCL	UCL	N	%	LCL	UCL	N	%	LCL	UCL
All	1739	11%	1487	1926	3379	21%	2872	3724	4714	29%	4056	5221
Phys. activity	284	2%	160	385	556	3%	312	761	820	5%	459	1135
Salt intake	425	3%	368	487	803	5%	698	919	1143	7%	995	1307
Sat. fats	415	3%	376	456	779	5%	710	856	1100	7%	1004	1210
Smoking	614	4%	415	777	1241	8%	817	1554	1651	10%	1103	2114

Table 5.2: Italy: Forecasted change in number of deaths due to changes in risk factors, assumed changes in future mortality according to current trend

	Scenario											
	Conservative				Intermediate				Optimistic			
Risk Factor	N	%	LCL	UCL	N	%	LCL	UCL	N	%	LCL	UCL
All	1171	11%	928	1401	2277	21%	1789	2711	3166	29%	2526	3776
Phys. activity	193	2%	104	275	377	3%	204	543	556	5%	299	813
Salt intake	289	3%	228	358	546	5%	430	676	778	7%	613	964
Sat. fats	274	2%	232	322	515	5%	436	605	729	7%	617	856
Smoking	415	4%	269	553	839	8%	526	1097	1103	10%	713	1470

Figure 5.2: Italy: Forecasted change in number of deaths due to changes in risk factors, assumed changes in future mortality according to current trend

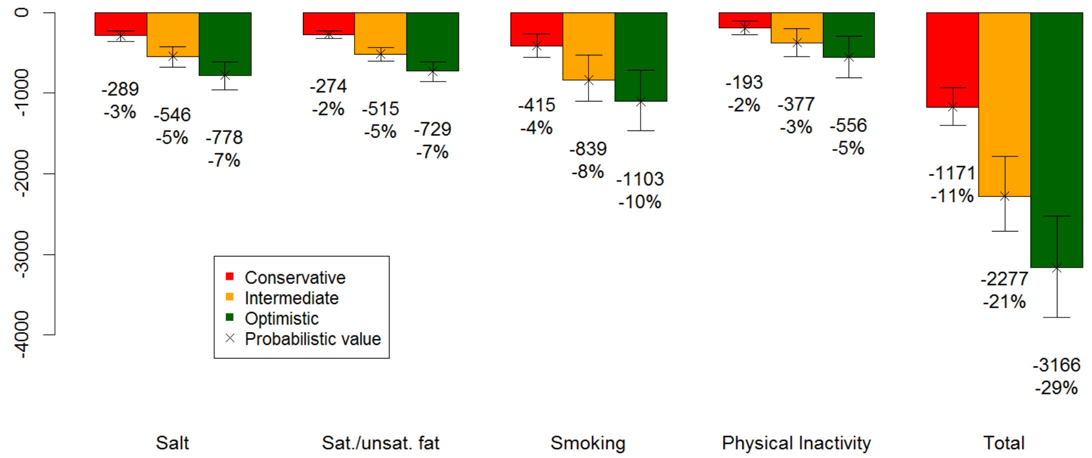
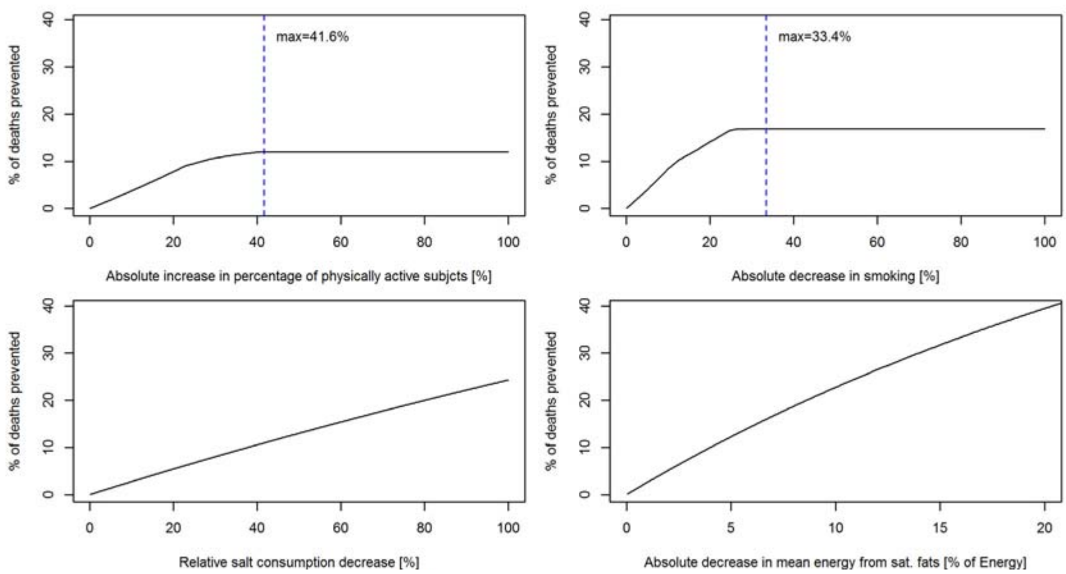


Figure 5.3: Italy: Forecasted effects of changes in four behavioural risk factors, and maximum effect for smoking and physical activity interventions



6. Northern Ireland

The age range of the analysis was 25-74 years. The size of the population of Northern Ireland in this age range was 1.1 million in 2010. According to population forecast, in year the 2020 number of subjects aged 25-74 years will be 1.2 million.

During the base year of the analysis (2010) the number of CHD deaths was 761. Assuming no future changes in mortality, the number of CHD deaths in final year (2020) will be 889, which is a 16.8% increase. Decrease in predicted number of deaths in 2020 under assumption of no mortality change in future is shown in Fig. 6.1and Table 6.1.

If mortality will change according to the forecast based on current trends, we will observe 415 CHD deaths in 2020, which is 45.5% decrease (Fig. 6.2and Table 6.2).

The relative effect of changes in different risk factors is presented on Fig. 6.3. This figure shows also maximum effect for changes in smoking (assuming no smoking in population) and physical activity (assuming no inactive subjects in population).

Figure 6.1: Northern Ireland: Forecasted change in number of deaths due to changes in risk factors, assumed no changes in future mortality

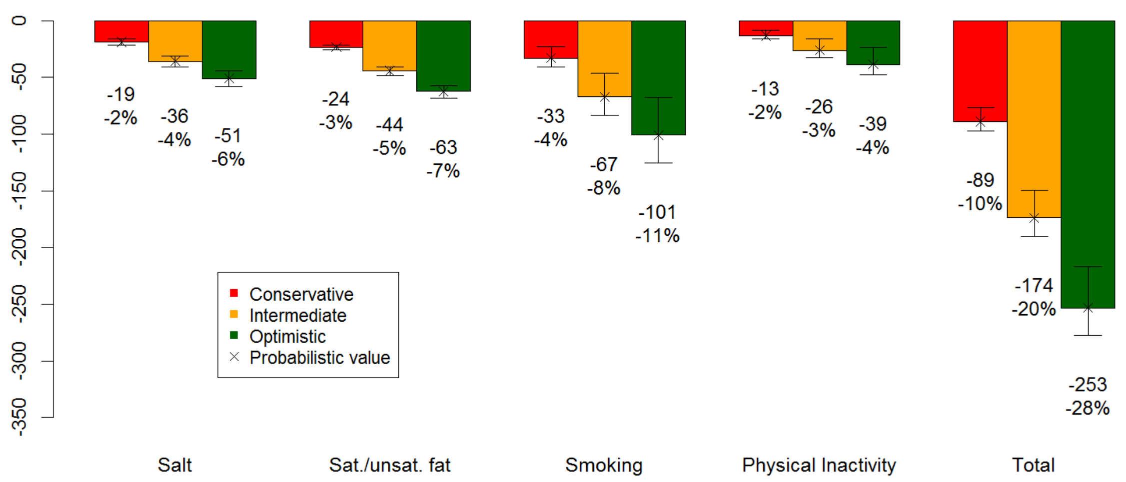


Table 6.1: Northern Ireland: Forecasted change in number of deaths due to changes in risk factors, assumed no changes in future mortality

	Scenario											
	Conservative				Intermediate				Optimistic			
Risk Factor	N	%	LCL	UCL	N	%	LCL	UCL	N	%	LCL	UCL
All	89	10%	77	97	174	20%	150	190	253	28%	217	277
Phys. activity	13	2%	8	16	26	3%	16	32	39	4%	24	48
Salt intake	19	2%	16	22	36	4%	31	41	51	6%	44	58
Sat. fats	24	3%	22	26	44	5%	41	48	63	7%	57	68
Smoking	33	4%	23	41	67	8%	46	84	101	11%	68	126

Table 6.2: Northern Ireland: Forecasted change in number of deaths due to changes in risk factors, assumed changes in future mortality according to current trend

	Scenario											
	Conservative				Intermediate				Optimistic			
Risk Factor	N	%	LCL	UCL	N	%	LCL	UCL	N	%	LCL	UCL
All	42	10%	36	47	83	20%	70	92	121	29%	102	134
Phys. activity	6	2%	4	8	12	3%	8	15	18	4%	11	23
Salt intake	9	2%	8	10	17	4%	14	19	24	6%	20	27
Sat. fats	12	3%	10	13	22	5%	20	25	31	7%	28	35
Smoking	16	4%	11	19	32	8%	22	39	48	12%	32	59

Figure 6.2: Northern Ireland: Forecasted change in number of deaths due to changes in risk factors, assumed changes in future mortality according to current trend

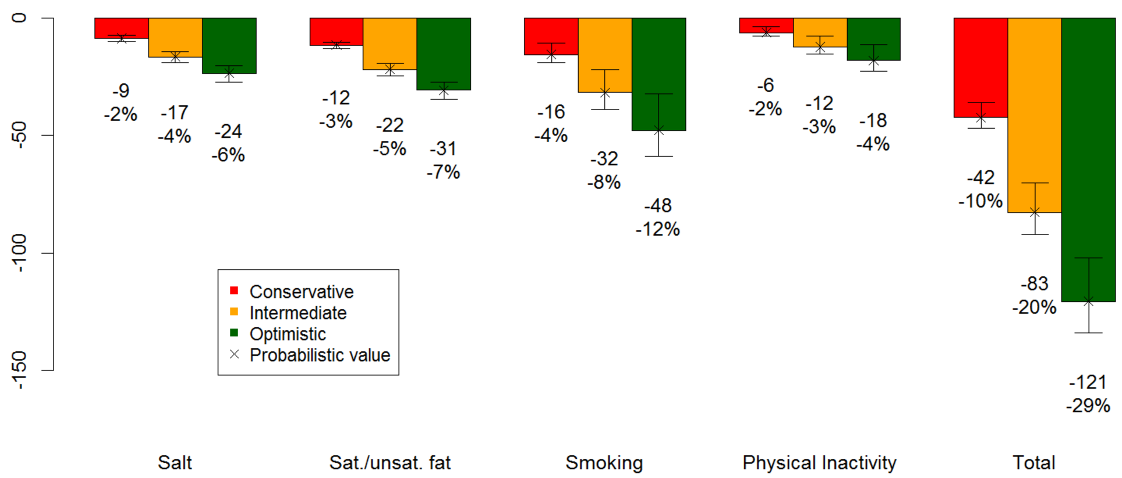
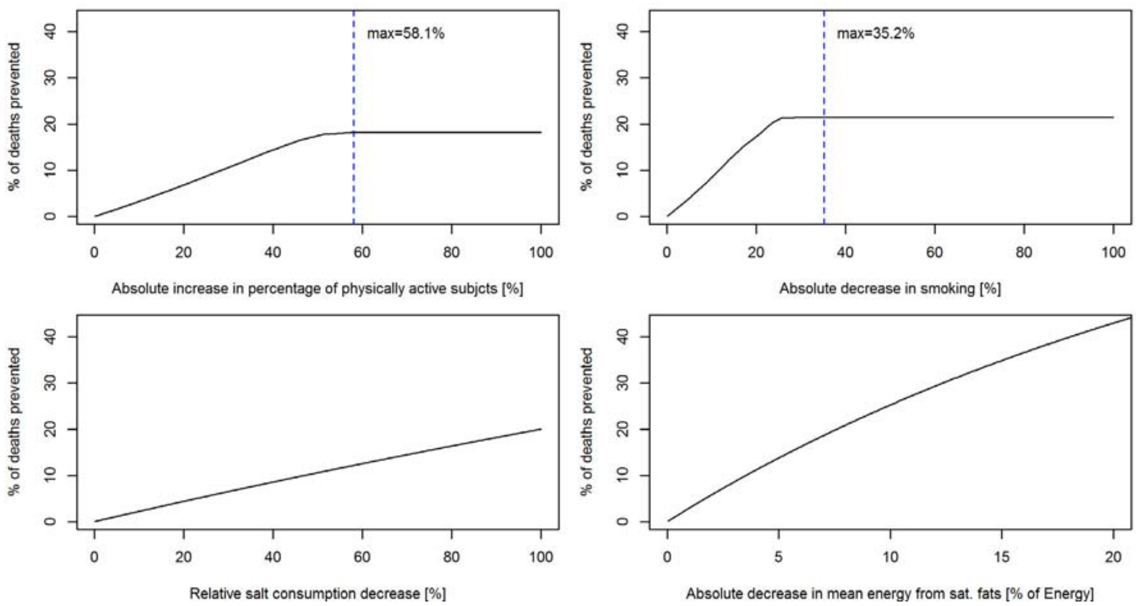


Figure 6.3: Northern Ireland: Forecasted effects of changes in four behavioural risk factors, and maximum effect for smoking and physical activity interventions



7. Poland

The age range of the analysis was 25-74 years. The size of the population of Poland in this age range was 25.1 million in 2011. According to population forecast, in year 2020 the number of subjects aged 25-74 years will be 25.6 million.

During the base year of the analysis (2011) the number of CHD deaths was 17 871. Assuming no future changes in mortality, the number of CHD deaths in final year (2020) will be 22 240, which is a 24.4% increase. Decrease in predicted number of deaths in 2020 under assumption of no mortality change in future is shown in Fig. 7.1 and Table 7.1.

If mortality will change according to the forecast based on current trends, we will observe 13 614 CHD deaths in 2020, which is 23.8% decrease (Fig. 7.2 and Table 7.2).

The relative effect of changes in different risk factors is presented on Fig. 7.3. This figure shows also maximum effect for changes in smoking (assuming no smoking in population) and physical activity (assuming no inactive subjects in population).

Figure 7.1: Poland: Forecasted change in number of deaths due to changes in risk factors, assumed no changes in future mortality

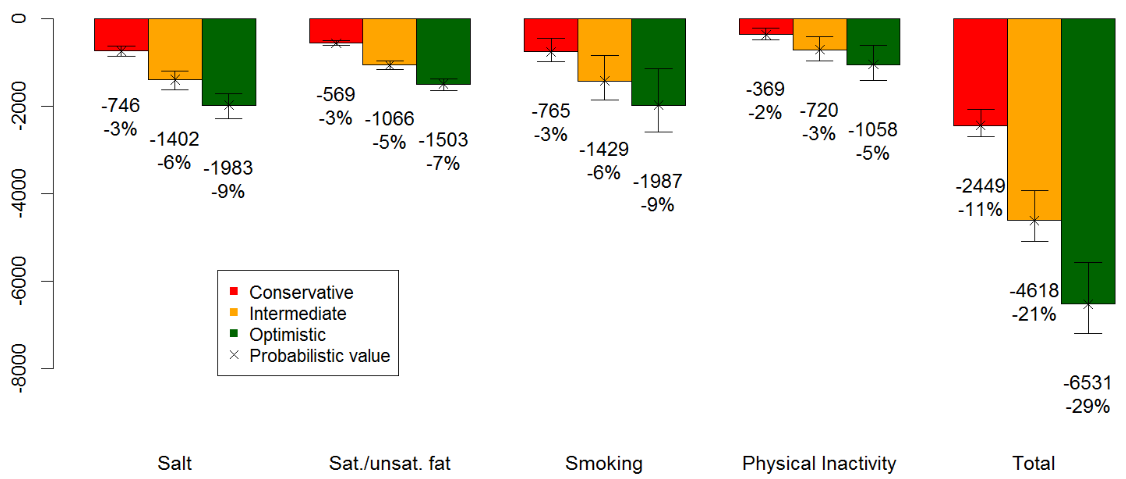


Table 7.1: Poland: Forecasted change in number of deaths due to changes in risk factors, assumed no changes in future mortality

	Scenario											
	Conservative				Intermediate				Optimistic			
Risk Factor	N	%	LCL	UCL	N	%	LCL	UCL	N	%	LCL	UCL
All	2449	11%	2083	2699	4618	21%	3932	5097	6531	29%	5583	7197
Phys. activity	369	2%	216	489	720	3%	419	965	1058	5%	613	1422
Salt intake	746	3%	640	866	1402	6%	1208	1626	1983	9%	1716	2298
Sat. fats	569	3%	518	622	1066	5%	975	1170	1503	7%	1376	1652
Smoking	765	3%	463	989	1429	6%	840	1870	1987	9%	1148	2603

Table 7.2: Poland: Forecasted change in number of deaths due to changes in risk factors, assumed changes in future mortality according to current trend

	Scenario											
	Conservative				Intermediate				Optimistic			
Risk Factor	N	%	LCL	UCL	N	%	LCL	UCL	N	%	LCL	UCL
All	1484	11%	1250	1650	2803	21%	2358	3116	3971	29%	3353	4397
Phys. activity	226	2%	128	303	441	3%	249	597	648	5%	364	882
Salt intake	455	3%	386	532	856	6%	730	998	1210	9%	1037	1410
Sat. fats	342	3%	308	379	642	5%	579	712	905	7%	820	1004
Smoking	462	3%	276	603	865	6%	499	1143	1208	9%	683	1588

Figure 7.2: Poland: Forecasted change in number of deaths due to changes in risk factors, assumed changes in future mortality according to current trend

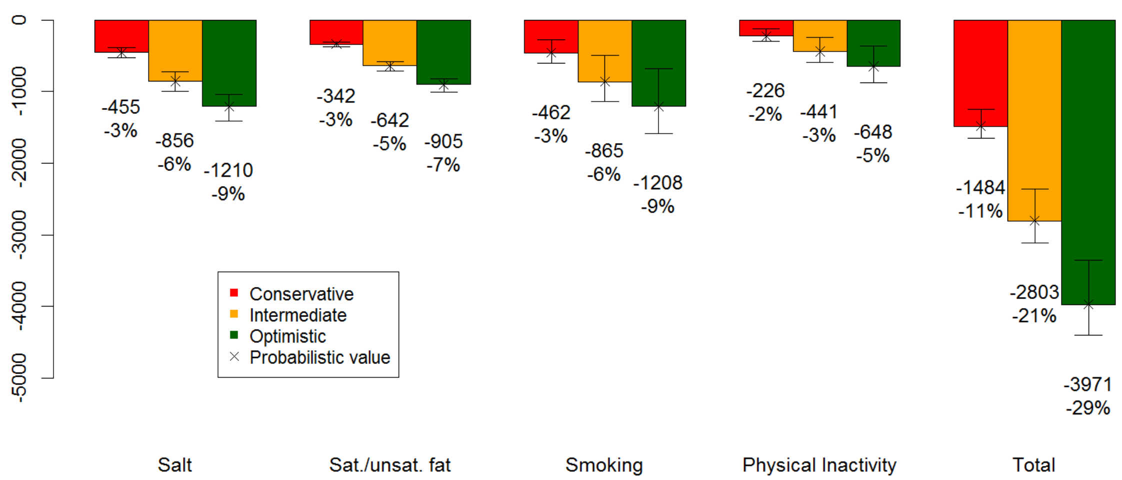
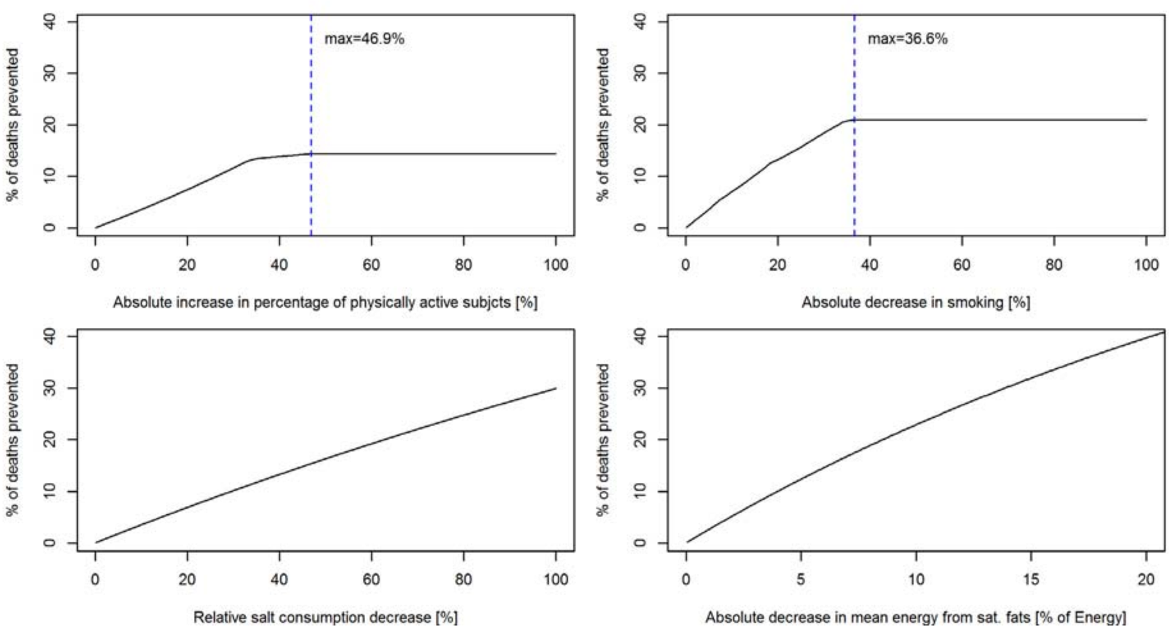


Figure 7.3: Poland: Forecasted effects of changes in four behavioural risk factors, and maximum effect for smoking and physical activity interventions



8. Scotland

The age range of the analysis was **25-74** years. The size of the population of Scotland in this age range was 3.3 million in 2010. According to population forecast, in year 2020 number of subjects aged 25-74 years will be 3.5 million.

During the base year of the analysis (2010) the number of CHD deaths was **2 925.** Assuming no future changes in mortality, the number of CHD deaths in final year (2020) will be **3 366**, which is 15.1% increase. Decrease in predicted number of deaths in 2020 under assumption of no mortality change in future is shown in Fig. 8.1 and Table 8.1.

If mortality will change according to the forecast based on current trends, we will observe **1 787** CHD deaths in 2020, which is 38.9% decrease (Fig. 8.2 and Table 8.2).

The relative effect of changes in different risk factors is presented on Fig. 8.3. This figure shows also maximum effect for changes in smoking (assuming no smoking in population) and physical activity (assuming no inactive subjects in population).

Figure 8.1: Scotland: Forecasted change in number of deaths due to changes in risk factors, assumed no changes in future mortality

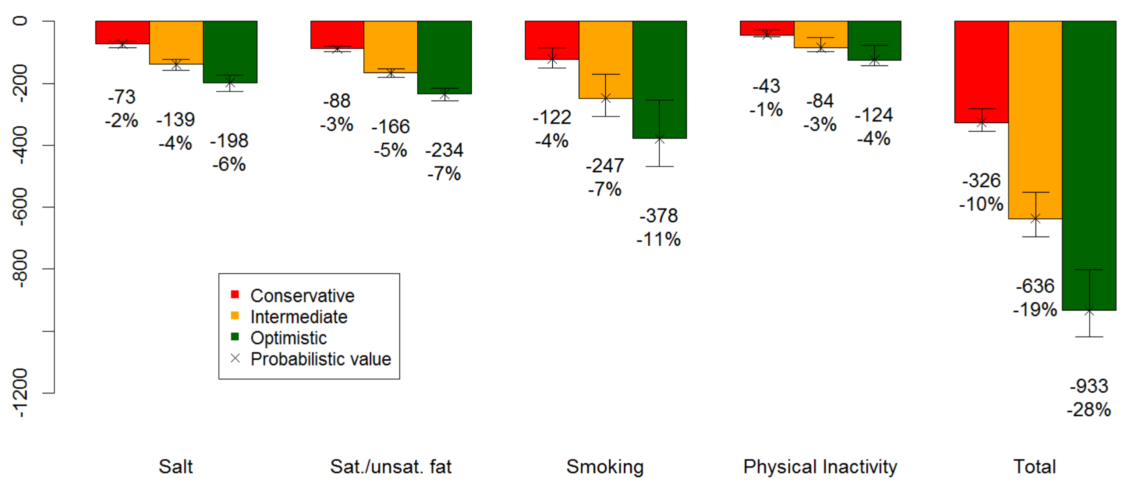


Table 8.1: Scotland: Forecasted change in number of deaths due to changes in risk factors, assumed no changes in future mortality

	Scenario											
	Conservative				Intermediate				Optimistic			
Risk Factor	N	%	LCL	UCL	N	%	LCL	UCL	N	%	LCL	UCL
All	326	10%	282	354	636	19%	550	694	933	28%	802	1017
Phys. activity	43	1%	27	49	84	3%	53	97	124	4%	77	143
Salt intake	73	2%	64	83	139	4%	121	158	198	6%	173	225
Sat. fats	88	3%	81	96	166	5%	152	181	234	7%	215	256
Smoking	122	4%	85	149	247	7%	171	307	378	11%	255	468

Table 8.2: Scotland: Forecasted change in number of deaths due to changes in risk factors, assumed changes in future mortality according to current trend

	Scenario											
	Conservative				**Intermediate**				**Optimistic**			
Risk Factor	N	%	LCL	UCL	N	%	LCL	UCL	N	%	LCL	UCL
All	176	10%	145	200	343	19%	282	391	503	28%	410	573
Phys. activity	23	1%	15	27	45	3%	28	54	66	4%	41	79
Salt intake	39	2%	32	46	74	4%	61	88	105	6%	87	125
Sat. fats	49	3%	43	56	92	5%	80	106	130	7%	113	150
Smoking	65	4%	44	81	132	7%	90	166	202	11%	134	253

Figure 8.2: Scotland: Forecasted change in number of deaths due to changes in risk factors, assumed changes in future mortality according to current trend

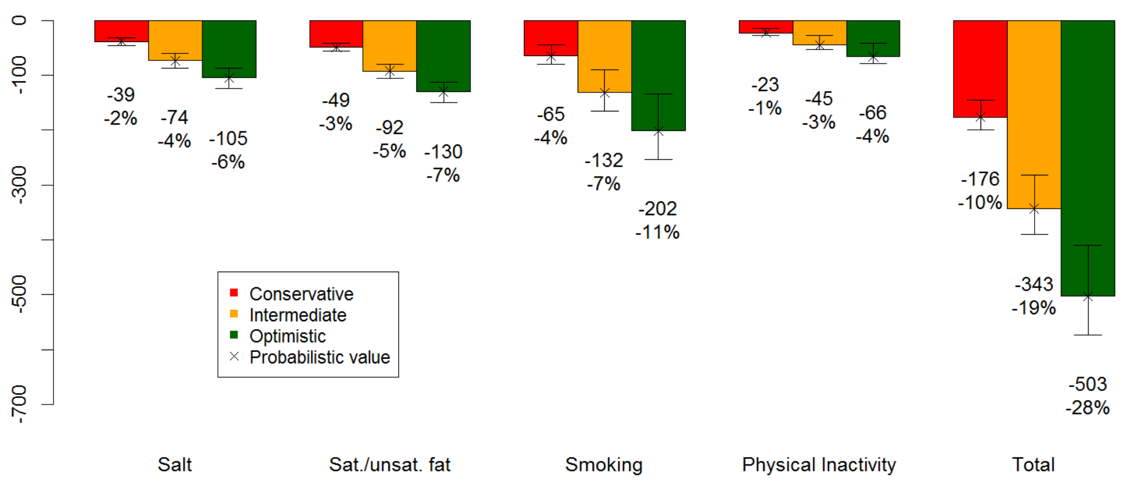
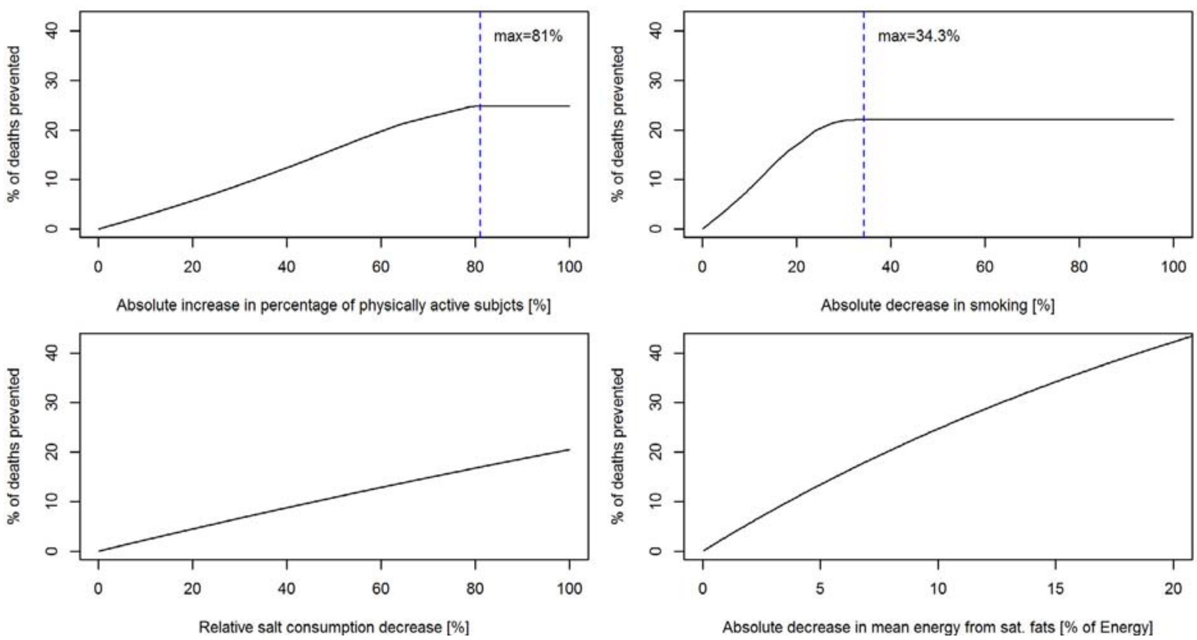


Figure 8.3: Scotland: Forecasted effects of changes in four behavioural risk factors, and maximum effect for smoking and physical activity interventions



9. Sweden

The age range of the analysis was 25-74 years. The size of the population of Sweden in this age range was 5.8 million in 2010. According to population forecast, in year 2020 number of subjects aged 25-74 years will be 6.3 million.

During the base year of the analysis (2010) the number of CHD deaths was 3 412. Assuming no future changes in mortality, the number of CHD deaths in final year (2020) will be 3 793, which is a 11.2% increase. Decrease in predicted number of deaths in 2020 under assumption of no mortality change in future is shown in Fig. 9.1 and Table 9.1.

If mortality will change according to the forecast based on current trends, we will observe 2 388 CHD deaths in 2020, which is 30% decrease (Fig. 9.2 and Table 9.2).

The relative effect of changes in different risk factors is presented on Fig. 9.2. This figure shows also maximum effect for changes in smoking (assuming no smoking in population) and physical activity (assuming no inactive subjects in population).

Figure 9.1: Sweden: Forecasted change in number of deaths due to changes in risk factors, assumed no changes in future mortality

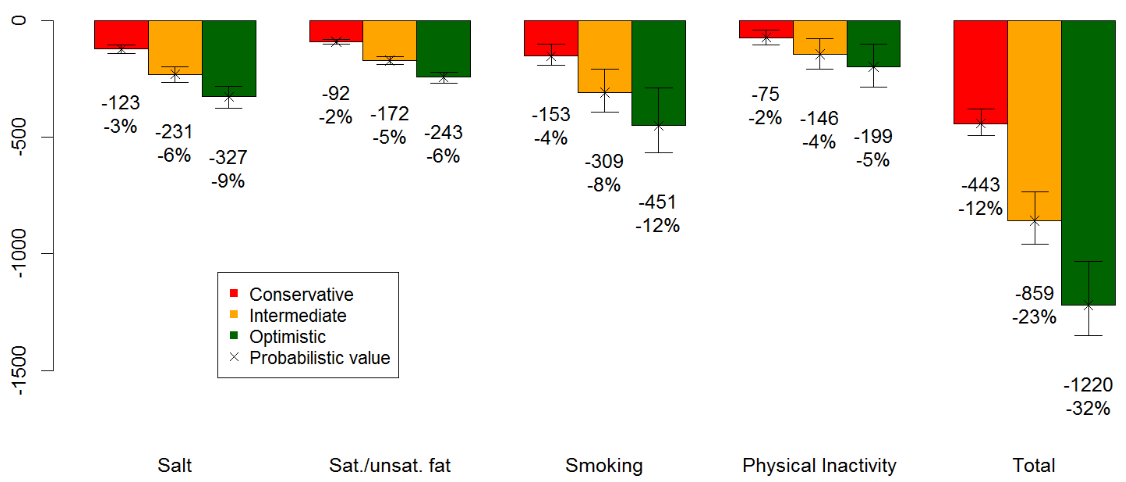


Table 9.1: Sweden: Forecasted change in number of deaths due to changes in risk factors, assumed no changes in future mortality

	Scenario											
	Conservative				Intermediate				Optimistic			
Risk Factor	N	%	LCL	UCL	N	%	LCL	UCL	N	%	LCL	UCL
All	443	12%	379	494	859	23%	734	960	1220	32%	1033	1349
Phys. activity	75	2%	42	107	146	4%	79	209	199	5%	102	285
Salt intake	123	3%	106	142	231	6%	200	267	327	9%	284	377
Sat. fats	92	2%	83	101	172	5%	157	189	243	6%	222	269
Smoking	153	4%	103	192	309	8%	208	394	451	12%	288	568

Table 9.2: Sweden: Forecasted change in number of deaths due to changes in risk factors, assumed changes in future mortality according to current trend

	Scenario											
	Conservative				Intermediate				Optimistic			
Risk Factor	N	%	LCL	UCL	N	%	LCL	UCL	N	%	LCL	UCL
All	275	12%	212	338	534	22%	410	656	757	32%	573	920
Phys. activity	47	2%	24	72	92	4%	46	141	125	5%	60	191
Salt intake	77	3%	59	99	145	6%	111	185	206	9%	158	263
Sat. fats	56	2%	45	69	106	4%	85	129	149	6%	121	183
Smoking	94	4%	60	127	192	8%	120	260	277	12%	167	369

Figure 9.2: Sweden: Forecasted change in number of deaths due to changes in risk factors, assumed changes in future mortality according to current trend

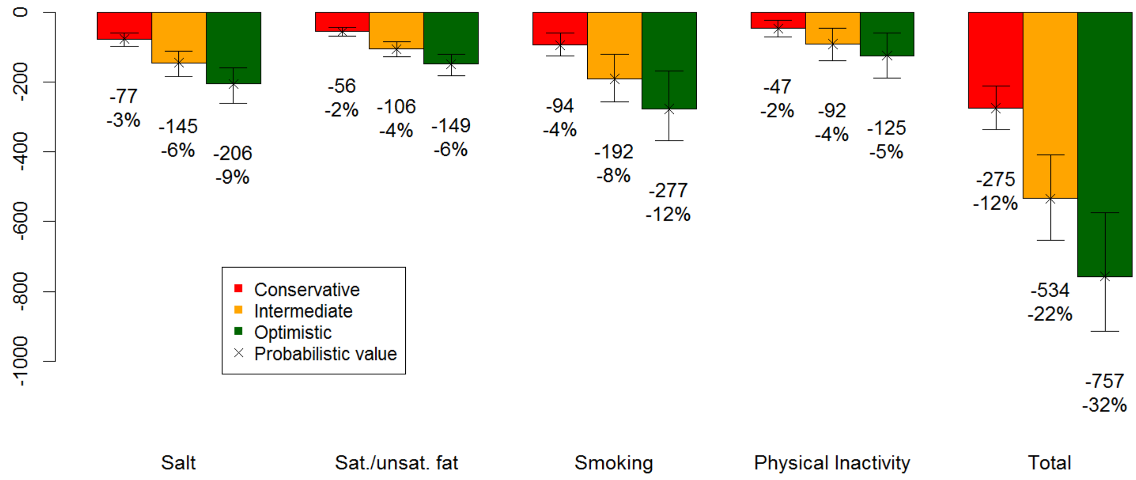
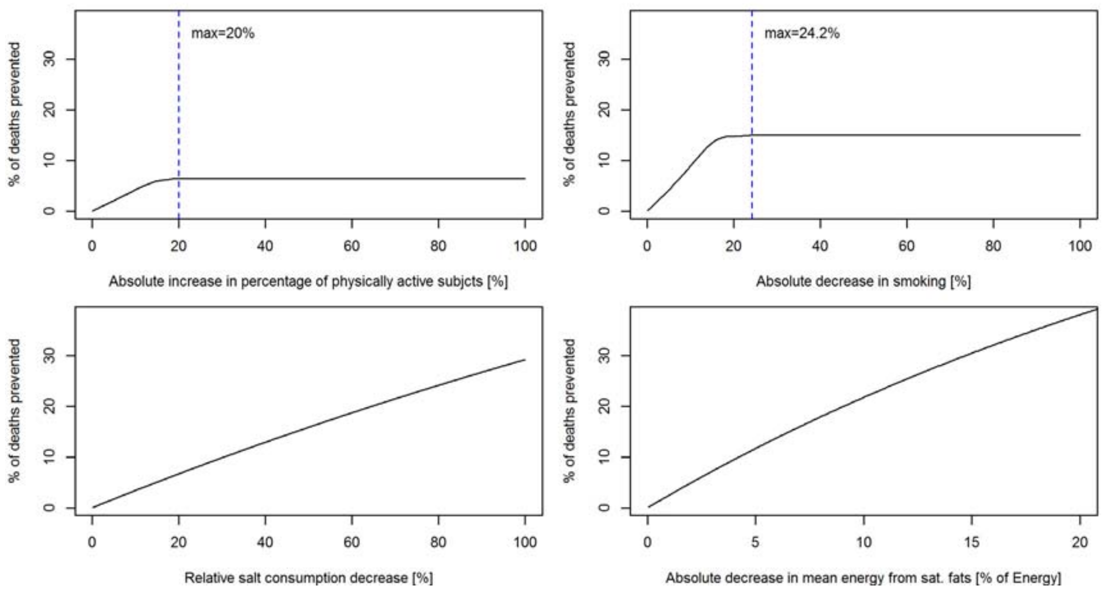


Figure 9.3: Sweden: Forecasted effects of changes in four behavioural risk factors, and maximum effect for smoking and physical activity interventions



List of Figures

List of Tables

References

[1] Unal B, Critchley JA, Capewell S, Explaining the Decline in Coronary Heart Disease Mortality in England and Wales Between 1981 and 2000, Circulation. 2004; 109: 1101-1107

[2] He, F J, The Effect of longer-term modest salt reduction on blood pressure, The Cochrane database of systematic reviews, 2004(3):CD004937

[3] Tang JL, Armitage JM, Lancaster T, Silagy CA, Fowler GH, Neil HA, Systematic review of dietary intervention trials to lower blood total cholesterol in free-living subjects. BMJ. 1998 Apr 18;316(7139):1213-20.

[4] Lewington S, Clarke R, Qizilbash N, Peto R, Collins R, Age-specific relevance of usual blood pressure to vascular mortality: a meta-analysis of individual data for one million adults in 61 prospective studies. Lancet. 2002 Dec 14;360(9349):1903-13.

[5] Lewington S, Whitlock G, Clarke R, Sherliker P, Emberson J, Halsey J, Qizilbash N, Peto R, Collins R. Blood cholesterol and vascular mortality by age, sex, and blood pressure: a meta-analysis of individual data from 61 prospective studies with 55,000 vascular deaths. Lancet. 2008 Jul 26;372(9635):292.

[6] Ezzati M, Henley SJ, Thun MJ, Lopez AD. Role of smoking in global and regional cardiovascular mortality. Circulation. 2005 Jul 26;112(4):489-97.

[7] Bull F, Armstrong TP, Dixon T, Ham S, Neiman A, et al. (2004) Physical inactivity. In: Ezatti M, Lopez AD, Rodgers A, Murray CJL, editors. Comparative quantification of risk. Global and regional burden of disease attributable to selected major risk factors. Volume 1 ed. Geneva: World Health Organization. pp. 729-881.

[8] Joubert J, Norman R, Lambert EV, Groenewald P, Schneider M, et al. (2007) Estimating the burden of disease attributable to physical inactivity in South Africa in 2000. S Afr Med J 97:725-731.

[9] Barendregt, J. J. The effect size in uncertainty analysis. Value in Health, 2010, 13(4): 388-391