Table of Contents

[Supplementary Methods 2](#_Toc34840148)

[Supplementary Tables 10](#_Toc34840149)

[Supplementary Figures 25](#_Toc34840150)

[References 26](#_Toc34840151)

[Supplementary references for main manuscript 29](#_Toc34840152)

# **Supplementary Methods**

First, we estimated the deaths, YLL and healthcare costs attributable to the current consumption of F&V in England compared with recommended consumption. This was considered as ‘the cost of doing nothing’. Second, we estimated ‘the cost of changing’ from governmental and societal perspectives by estimating the cost-effectiveness of three policies promoting consumption of F&V:

1. A nationwide SMC promoting the consumption of F&Vs;
2. A universal policy to subsidise F&Vs to reduce prices by 10%;
3. A targeted policy to subsidise F&Vs to reduce prices by 30% for low-income households.

Those dietary policies were compared with a baseline scenario of “no intervention”, which assumed that current consumption would remain stable. We also assumed that policies would be long-lasting and thus we performed a cross-sectional analysis based on the costs and benefits accrued over a one-year time horizon for all policies. The governmental perspective considered healthcare costs and the cost of F&V subsidies and SMC. The societal perspective considered healthcare costs, cost of the SMC, and costs of purchasing increased F&V. After estimating the costs of the three policies, we quantified the incremental cost-effectiveness ratio (ICER) for each. Those three policies were chosen based on previous cost-effectiveness studies conducted in France[1] and in the USA,[2, 3] because this would facilitate comparisons between countries, as well as on empirical evidence of such policies, like targeted subsidies in the USA and SMCs in several countries.[4] Although policy implementation is beyond the scope of this cost-effectiveness study, we considered that all policies could be realistically implemented in England. For the SMC, similar nationwide campaigns have been successfully implemented.[5, 6] For the subsidies, although there is no previous evidence in England, we considered that (1) the universal subsidy would effectively translate into a 10% reduction in price for all consumers at the point of purchase, and (2) the targeted subsidy could be delivered similarly to the Supplemental Nutrition Assistance Program in the USA.[7] All modelling and analysis were undertaken in Excel.

**Consumption of fruit and vegetables in England**

Consumption of F&V was obtained from the Health Survey for England 2017 (HSE), which provided detailed data on the proportion of adults (defined as individuals over 16 years old) eating from less than 1 to more than 5 portions of F&V a day, as well as average daily intake stratified by 10-year age group and sex (**Tables 1 and 2**).[8] We considered that the recommended daily intake of F&V for all adults was five portions per day (equivalent to 400 g), based on the “Five-A-Day guidelines” issued by the NHS[9] following the WHO recommendations.[10] Although this recommendation has been recently criticised by studies arguing that seven or even ten portions of F&V daily afforded greater reduction in mortality,[11, 12] the largest and most recent meta-analysis refuted that consumption of F&V above a threshold of about five servings a day could further lower mortality risk.[13] Considering the inconclusive evidence on the added benefit of extra portions of F&V together with the questionable rationale for setting unrealistic goals when most of the population fails to achieve the currently recommended intake, WHO and NHS recommendations have remained unchanged.

**Risk of inadequate intake of fruit and vegetables for chronic disease**

A systematic literature search was conducted to identify epidemiological studies that assessed the risk for chronic diseases associated with low intake of F&V. We selected the most recent dose-response meta-analyses of prospective observational studies that reported the association between consumption of F&V and each of the specific diseases considered in this study.[11, 14-21] This was complemented with the risk estimates provided by the report “Food, Nutrition, Physical Activity and the Prevention of Cancer: A Global Perspective”[22] and by the Global Burden of Disease Study[23], which relied on the same meta-analyses that we identified in our literature search. Based on those sources we considered the risks associated with cardiovascular disease (defined as ischaemic heart disease and ischaemic/haemorrhagic stroke), diabetes and cancers (lung, colorectum, oesophagus, stomach, bladder, mouth and pharynx, larynx and breast) (**Table S2**).

For cancers, we assumed a similar relative risk (RR) across all age groups. Considering the well-established age trend of the relative risks of metabolic risk factors for cardiovascular disease and diabetes,[24] we used the age-specific estimates provided by the Global Burden of Disease study.[23] This study identified the most important metabolic mediators for each dietary factor in the literature and then used the age trend of the RR of that mediator(s) and the disease endpoint to estimate the age-specific RR for each dietary factor (**Table S3**).

Whenever risk estimates were available separately for F&V, we estimated the combined RR for F&V as follows: .

**Population-attributable fractions (PAF)**

The PAF represented the proportional reduction in chronic disease that would occur if all the population consumed the recommended five portions a day of F&V. The PAF applied the RR of inadequate consumption of F&V for chronic disease to the distribution of consumption of F&V in the English population using the formula:

In this formula, Pi is the proportion of individuals in interval i; i (interval) refers to the consumption of <1, 1, 2, 3, 4, 5 or >5 portions per day; RR is the relative risk for each portion decrease in vegetables and fruit consumption; is the relative risk for interval i relative to the recommended number of servings, L is the recommended number of portions; Xi is the mid-value of interval i; and n is the number of portions below the recommended number of servings.[25]

The PAF was calculated using the distribution of consumption of F&V in English adults and the RR for each of the disease categories identified by the literature review.

**Direct healthcare costs**

The economic burden associated with low intake of F&V for the NHS represents the sum of avoidable direct healthcare costs for all diseases of interest. We adopted a macrolevel or top-down approach to allocate an overall healthcare budget to specific diseases, following the approach described by Briggs et al.[26] A detailed explanation of the methods used to estimate the costs for each disease category is provided in **Table S1**. Disease-specific costs were then multiplied by the PAFs to estimate the avoidable healthcare costs.

|  |
| --- |
| Table S1: Steps to estimate NHS costs for each disease category |
| Step 1: Allocate disease-specific programme budgeting expenditure to modelled disease |
| Disease-specific costs were derived from data provided by the 2017/18 NHS England programme budgeting, which reported expenditure by clinical commissioning groups, who are responsible for commissioning local NHS health care services in England, and by the NHS England budget.[27] As the diseases of interest corresponded to defined programme budgeting categories, the total expenditure for those categories was used. For type 2 diabetes, a proportion of 0.9 was applied to the total programme expenditure as type 1 diabetes accounts for about 10% of the cases in England.[28] For cancer types, the proportion of all cancers accounted for each cancer site was applied to the total programme expenditure for the category “Cancers and Tumours”.[29] |
| Step 2: Apply scaling factor for specialised service expenditure |
| Specialised services expenditure data are not available by individual diseases beyond 2012/13. Therefore 2012/13 programme budgeting data are used to estimate disease specific specialised services expenditure, when Primary Care Trusts (PCTs) were responsible for their commissioning, with costs reported under the 2012/13 care setting ‘Other Secondary Care’. Before 2013/14, local primary, secondary, and community health services in England were commissioned by PCTs. They were abolished in 2013 following the enactment of the 2012 Health and Social Care Act with Clinical Commissioning Groups (CCGs) subsequently taking responsibility for commissioning services. This changed how the English NHS budget was organised with specialised services and primary care expenditure (except for primary care prescribing) subsequently being allocated nationally rather than locally. Therefore, specialised services expenditure was reported in programme budgeting data when PCTs were responsible for commissioning services (prior to 2013/14) and not after they were abolished. Therefore, the ratio of 2012/13 programme budgeting expenditure on ‘Other Secondary Care’ to total 2012/13 programme budgeting expenditure for each relevant programme budgeting disease category was first calculated (not including expenditure on Prevention and Health Promotion, Other Secondary Care, and Primary Care as these care settings are not included in 2017/18 data). This ratio was then multiplied by the 2017/18 expenditure calculated in step 1 to estimate the specialised services expenditure by modelled disease. |
| Step 3: Allocate primary care costs |
| Primary care expenditure (except for money spent on prescribing) is not included in programme budgeting data. Assuming that primary care expenditure on a given disease is proportional to the amount spent on primary care prescribing, the proportion of total primary care prescribing spent on each disease was calculated and this was then multiplied by total primary care expenditure in 2017/18 to estimate primary care spend on each disease. |
| Step 4: Estimate total NHS England expenditure for each disease |
| Sum all the costs for each disease. |

**Cause-specific deaths and life expectancy in England**

Data for cause-specific deaths and life expectancy stratified by age and sex were obtained from the death statistics for England in 2017 released by the Office for National Statistics (**Table S6**).[30, 31]

Data for all deaths stratified by income were not available. Therefore, cause-specific deaths stratified by quintiles of the Index of Multiple Deprivation (IMD) were used. The IMD is the official and most widely used measure of relative deprivation for small areas in England. It combines information from seven domains to produce an overall relative measure of deprivation for each small area. The domains are combined using the following weights, which were derived from consideration of the academic literature on poverty and deprivation, as well as the levels of robustness of the indicators: income deprivation (22.5%); employment deprivation (22.5%); education, skills and training deprivation (13.5%); health deprivation and disability (13.5%); crime (9.3%); barriers to housing and services (9.3%); and living environment deprivation (9.3%). Although income deprivation only accounts for about one fourth of the IMD, the latest IMD report showed an almost exact match between the income quintile and overall IMD quintile.[32] Therefore, in the absence of data stratified by income, the IMD was considered as the best proxy for income and thus the deaths in the lowest income quintile were estimated from the two lowest quintiles of the IMD (**Table S8**).

Years of life lost were calculated by multiplying the number of deaths by the life expectancy for each 5-year age and sex strata (**Tables S7 and S9**). The attributable deaths and YLL were calculated by multiplying the PAFs for each disease by the total number of deaths and YLL for each age and sex strata.

**Social marketing campaign**

The outcomes of the nationwide SMC were based on the “Five-A-Day” campaign in England, which was estimated to have increased consumption of F&V by 0.31 of a portion (equivalent to about 7%) over the first three years.[6] This is in keeping with a large meta-analysis of prospective studies that reported an overall 0.25 portions or 7% increase in consumption for different types of information campaigns.[33] Therefore, we estimated a 2% annual increase in consumption of F&V for the SMC. Data from the “Five-A-Day” campaign showed that the relative increase in consumption in the lowest income quartile was identical to the average of the other three quartiles and hence we considered that the impact of a SMC would be similar irrespective of household income. Although the increase in demand could increase price and thus limit consumption, this was not considered in this study.

The costs of the SMC were based on the initial budget of the “Change4Life” campaign in the UK (£75 million for three years in 2009).[34] Although this was a multipronged campaign promoting a healthy lifestyle in general and not only consumption of F&V, we considered that it provided the best estimate of what the current costs of a nationwide mass media campaign would be. Therefore, we assumed that the annual cost of the SMC would be £25 million in 2009, which corresponded to £33 million in 2018 (applying inflation rates provided by the Bank of England).[35] Due to the uncertainty in the assumptions, we additionally performed two-way sensitivity analysis considering the cost to vary between £20 and £40 million and the effect on consumption between 0.5% and 3%.

**Universal and targeted subsidies**

Uncompensated, unconditional, own price elasticities for F&V in the England obtained from the report by the Department for the Environment Food & Rural Affairs (DEFRA)[36] were used to estimate the impact of the fiscal policies on consumption (**Table S4**). Those elasticities are the most adequate for the purpose of policy simulations because they assume that a price decrease of one food category increases the food expenditure available to all related food categories (unconditional) and they capture both income and substitution effect (uncompensated). Long-run price elasticities (over a month) were used as these are more likely to have a significant impact on health outcomes than short-run elasticities (less than a month). As we were interested in the combined consumption of F&V, we estimated the price elasticity of both F&V as the mean of the individual price elasticities for each category. To estimate the impact of food subsidies on inequalities, uncompensated unconditional price elasticities for low-income households were used.[36]

To estimate the costs of implementing the subsidies, we used the family food statistics to obtain the total expenditure in F&V by households in England in 2017 stratified by income, which was considered as baseline expenditure (Q\*). The cost of each subsidy was estimated as S (i.e., the percentage of expenditure that was subsidised – 10% for universal subsidy and 30% for targeted subsidy) times the equilibrium quantity in the market when the subsidy was put in place, as given by the equation . Qs\* was calculated by multiplying the baseline expenditure by the expected increase in expenditure considering price elasticities. Using the price elasticities for the total population, the change in demand that would occur if the price decreased by 10% was calculated to estimate the impact on consumption of the universal subsidy. Using the price elasticities for low-income households, the change in demand that would occur if the price decreased by 30% was calculated to estimate the impact on consumption of the targeted subsidy. For the purpose of this analysis, demand was considered equivalent to consumption.

Low-income households were considered as those in the lowest quintile of equivalised household income as this was the definition used in the HSE 2017 and also in the DEFRA report, from which data regarding consumption of F&V and price elasticities were retrieved, respectively.

**Deaths prevented or postponed and life years saved by each intervention**

To estimate the number of deaths prevented or postponed (DPP) due to cardiovascular disease, diabetes and cancers attributable to changes in F&V intake, we assumed a log linear dose-effect relationship, using the following formula: , where RR is the reduction in relative risk for an additional serving per day and ΔF&V is the change in F&V intake (in servings per day). DPPs were then calculated for each sex and 10-year age strata. The number of life-years saved (LYS) was estimated by multiplying the number of DPP by the life expectancy for each age-sex bracket and disease category. We assumed that the time lag from a policy being implemented to the subsequent change in F&V consumption was less than a year and hence no time lag was modelled.

**Cost-effectiveness and impact on inequalities**

The cost-effectiveness of each intervention was estimated by calculating the incremental cost-effectiveness ratio.[37] The ICER for each intervention was calculated by dividing the difference in total costs (incremental cost) by the difference in the chosen measure of health outcome or effect (incremental effect) to provide a ratio of ‘extra cost per extra unit of health effect’. In this study, each intervention was compared with the alternative scenario of doing nothing. The ICERs were calculated both from governmental and societal perspectives. Under the governmental perspective, we included the cost of subsidising consumption and the cost of the SMC. Therefore, this was strictly equivalent to a ‘budgetary’ perspective. From a societal perspective, we assumed that (1) the costs of the subsidies, albeit funded by tax-payers’ money, would not fall on the healthcare system (i.e., it would be covered by other sectors of the public budget), and (2) part of the cost of the subsidies would represent a transfer of money from government to citizens because it would be subsidising consumption that would have occurred anyway. Therefore, under the societal perspective, we included the full costs of additional F&V consumption, whilst the cost of subsidising existing consumption was excluded. The healthcare cost savings were subtracted from all costs under both perspectives. The total costs for each subsidy were divided by the DPP and LYS to calculate the ICERs. For the SMC, we assumed that from a societal perspective in addition to the costs of running the campaign, the increase in F&V expenditure (paid by consumers) would also represent a cost for the society. Therefore, the total cost of the SMC was £33 million plus the predicted increase in F&V expenditure by households. For the combined policies, the sums of the total costs and the effectiveness of each policy were used to compute ICERs under governmental and societal perspectives.

To investigate the potential impact of the different interventions on inequalities, we calculated the health inequality index (HII) associated with each intervention. This index was defined as the variation in the proportion of deaths and YLL attributable to low consumption of F&V in the lowest income quintile versus the entire population for each intervention.[1] The following formula was used:

.

**Probabilistic sensitivity analysis**

The model was fully probabilistic. Each parameter was specified as a random variable with mean equal to the point estimate for the parameter. Variances for model parameters were determined from 95% confidence intervals for the source data where available. These data were not available for health care costs and the cost of the SMC; for these parameters we assumed a standard error of 20% of the mean value. We estimated the standard error as 25% of the mean value for the effectiveness of the SMC. Lognormal distributions were selected for RR parameters and elasticities; Dirichlet distributions for F&V consumption by category; Gamma distributions for health care and SMC costs, and the effectiveness of the SMC campaign.

Prior to evaluation of the model, a value was selected from the specified distribution for each parameter. Model results were reported as the mean value over 9,999 simulations. Non-parametric 95% credible intervals were determined as the 250th and 9750th values after ranking the 9,999 values for respective model output across.

Uncertainty in cost-effectiveness was conveyed using cost-effectiveness acceptability curves for each of the three policies compared with the alternative of no intervention. We determined the incremental net monetary benefit as the incremental health gain (LYS or DPP) multiplied by the value placed on a LYS or DPP minus the incremental cost for each of the 9,999 model simulations, and then calculated the proportion of the 9,999 simulations in which the incremental net monetary benefit was positive (intervention is cost-effective at that value for a LYS or DPP). We repeated these calculations over a range of values (zero to £50,000 for a LYS and zero to £1m for a DPP). We then plotted the proportion of simulations in which the intervention was cost-effective (positive incremental net monetary benefit) across the range of values for the LYS or DPP.

# **Supplementary Tables**

**Table S2: Relative risks extracted from the literature and population attributable fractions for all adults[11, 14-21]**

|  |  |  |  |
| --- | --- | --- | --- |
| Disease | RR | 95% CI | PAF |
| **Ischaemic heart disease** | 0.96 | 0.94 – 0.99 | 0.08 |
| **Cerebrovascular Disease** | 0.87 | 0.79 – 0.95 | 0.23 |
| **Diabetes mellitus type 2** | 0.94 | 0.90 – 0.98 | 0.11 |
| **Cancers** |  |  |  |
| **Mouth and pharynx** | 0.96 | 0.91 – 1.01 | 0.08 |
| **Larynx** | 0.96 | 0.91 – 1.01 | 0.08 |
| **Oesophagus** | 0.85 | 0.71 – 0.97 | 0.28 |
| **Stomach** | 0.98 | 0.94 – 1.02 | 0.04 |
| **Colorectal** | 0.98 | 0.94 – 1.02 | 0.02 |
| **Breast** | 0.98 | 0.97 – 1.00 | 0.04 |
| **Bladder** | 0.97 | 0.95 – 0.99 | 0.05 |
| **Trachea and lung** | 0.92 | 0.88 – 0.97 | 0.14 |

**Table S3: Age-specific relative risks extracted from the Global Burden of Disease study[23]**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | 25-29 years | 30-34 years | 35-39 years | 40-44 years | 45-49 years | 50-54 years | 55-59 years | 60-64 years | 65-69 years | 70-74 years | 75-79 years | 80-84 years | 85-89 years | 90-94 years | 95+ years |
| Fruits |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Ischaemic heart disease | 1.254 (1.083 to 1.442) | 1.209 (1.07 to 1.361) | 1.159 (1.054 to 1.271) | 1.131 (1.045 to 1.221) | 1.125 (1.043 to 1.211) | 1.114 (1.039 to 1.193) | 1.099 (1.034 to 1.167) | 1.087 (1.03 to 1.146) | 1.078 (1.027 to 1.13) | 1.07 (1.025 to 1.117) | 1.064 (1.022 to 1.106) | 1.057 (1.02 to 1.095) | 1.057 (1.02 to 1.095) | 1.057 (1.02 to 1.095) | 1.057 (1.02 to 1.095) |
| Ischaemic stroke | 2.024 (1.465 to 2.818) | 1.834 (1.39 to 2.444) | 1.621 (1.301 to 2.043) | 1.48 (1.239 to 1.787) | 1.403 (1.204 to 1.653) | 1.333 (1.171 to 1.533) | 1.272 (1.142 to 1.432) | 1.222 (1.116 to 1.348) | 1.181 (1.096 to 1.283) | 1.145 (1.078 to 1.225) | 1.114 (1.061 to 1.175) | 1.054 (1.029 to 1.082) | 1.054 (1.029 to 1.082) | 1.054 (1.029 to 1.082) | 1.054 (1.029 to 1.082) |
| Intracerebral haemorrhage | 1.688 (1.319 to 2.182) | 1.576 (1.273 to 1.972) | 1.444 (1.215 to 1.732) | 1.365 (1.18 to 1.595) | 1.336 (1.167 to 1.544) | 1.3 (1.15 to 1.483) | 1.26 (1.131 to 1.415) | 1.226 (1.115 to 1.358) | 1.193 (1.099 to 1.305) | 1.164 (1.084 to 1.256) | 1.133 (1.069 to 1.207) | 1.065 (1.034 to 1.1) | 1.065 (1.034 to 1.1) | 1.065 (1.034 to 1.1) | 1.065 (1.034 to 1.1) |
| Subarachnoid haemorrhage | 1.688 (1.319 to 2.182) | 1.576 (1.273 to 1.972) | 1.444 (1.215 to 1.732) | 1.365 (1.18 to 1.595) | 1.336 (1.167 to 1.544) | 1.3 (1.15 to 1.483) | 1.26 (1.131 to 1.415) | 1.226 (1.115 to 1.358) | 1.193 (1.099 to 1.305) | 1.164 (1.084 to 1.256) | 1.133 (1.069 to 1.207) | 1.065 (1.034 to 1.1) | 1.065 (1.034 to 1.1) | 1.065 (1.034 to 1.1) | 1.065 (1.034 to 1.1) |
| Diabetes mellitus type 2 | 1.125 (1.027 to 1.238) | 1.122 (1.0236 to 1.232) | 1.119 (1.026 to 1.226) | 1.113 (1.024 to 1.214) | 1.102 (1.022 to 1.194) | 1.093 (1.02 to 1.176) | 1.085 (1.019 to 1.16) | 1.076 (1.017 to 1.143) | 1.068 (1.015 to 1.128) | 1.061 (1.014 to 1.114) | 1.052 (1.012 to 1.098) | 1.036 (1.008 to 1.066) | 1.036 (1.008 to 1.066) | 1.036 (1.008 to 1.066) | 1.036 (1.008 to 1.066) |
| Vegetables |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Ischaemic heart disease | 1.249 (1.089 to 1.446) | 1.205 (1.074 to 1.362) | 1.154 (1.057 to 1.269) | 1.126 (1.047 to 1.219) | 1.121 (1.045 to 1.21) | 1.111 (1.042 to 1.193) | 1.098 (1.037 to 1.168) | 1.086 (1.032 to 1.148) | 1.077 (1.029 to 1.133) | 1.07 (1.027 to 1.12) | 1.064 (1.024 to 1.109) | 1.057 (1.022 to 1.097) | 1.057 (1.022 to 1.097) | 1.057 (1.022 to 1.097) | 1.057 (1.022 to 1.097) |
| Ischaemic stroke 100 g/day | 1.249 (1.049 to 1.463) | 1.211 (1.042 to 1.388) | 1.165 (1.033 to 1.3) | 1.132 (1.027 to 1.238) | 1.113 (1.023 to 1.203) | 1.095 (1.02 to 1.17) | 1.079 (1.017 to 1.141) | 1.065 (1.014 to 1.116) | 1.054 (1.012 to 1.096) | 1.044 (1.009 to 1.077) | 1.035 (1.007 to 1.061) | 1.017 (1.004 to 1.029) | 1.017 (1.004 to 1.029) | 1.017 (1.004 to 1.029) | 1.017 (1.004 to 1.029) |
| Intracerebral hemorrhage 100 g/day | 1.177 (1.046 to 1.326) | 1.153 (1.04 to 1.278) | 1.122 (1.032 to 1.22) | 1.102 (1.027 to 1.184) | 1.095 (1.025 to 1.17) | 1.086 (1.023 to 1.153) | 1.075 (1.02 to 1.134) | 1.066 (1.018 to 1.117) | 1.057 (1.015 to 1.101) | 1.049 (1.013 to 1.086) | 1.04 (1.011 to 1.071) | 1.02 (1.005 to 1.035) | 1.02 (1.005 to 1.035) | 1.02 (1.005 to 1.035) | 1.02 (1.005 to 1.035) |
| Subarachnoid hemorrhage | 1.177 (1.046 to 1.326) | 1.153 (1.04 to 1.278) | 1.122 (1.032 to 1.22) | 1.102 (1.027 to 1.184) | 1.095 (1.025 to 1.17) | 1.086 (1.023 to 1.153) | 1.075 (1.02 to 1.134) | 1.066 (1.018 to 1.117) | 1.057 (1.015 to 1.101) | 1.049 (1.013 to 1.086) | 1.04 (1.011 to 1.071) | 1.02 (1.005 to 1.035) | 1.02 (1.005 to 1.035) | 1.02 (1.005 to 1.035) | 1.02 (1.005 to 1.035) |

**Table S4: Unconditional uncompensated price elasticities for fruit and vegetables in England[36]**

|  |  |  |  |
| --- | --- | --- | --- |
|  | Fruits | Vegetables | Fruits and vegetables |
| Overall | -0.698 | -0.633 | -0.6655 |
| Low-income quintile | -0.583 | -0.646 | -0.6145 |

**Table S5: Healthcare costs for disease groups associated with consumption of fruit and vegetables[26, 38]**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Disease group | Clinical commission group costs | Specialised services costs | Primary care costs | Total costs |
| Ischaemic heart disease | 784,963 | 34,425 | 299,629 | 1,119,016 |
| Cerebrovascular disease | 929,745 | 74,768 | 18,623 | 1,023,135 |
| Type 2 diabetes | 1,337,116 | 31,884 | 856,103 | 2,225,104 |
| Cancer | 1,291,448 | 441,678 | 127,293 | 1,860,419 |

Types of cancer included in this study: bladder, stomach, breast, colorectum, oesophagus, trachea and lung, pharynx, larynx, and oral cavity

**Table S6: Sensitivity analysis for the cost and impact of the social marketing campaign**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | ICER from a societal perspective (£000) | | | | | |
|  | **Cost** | | | | |
|  | **20** | **25** | **30** | **35** | **40** |
| Impact | **0.5** | 30.70 | 32.52 | 34.33 | 36.15 | 37.97 |
| **1** | 27.09 | 28.00 | 28.91 | 29.82 | 30.73 |
| **1.5** | 25.90 | 26.51 | 27.11 | 27.72 | 28.33 |
| **2** | 25.32 | 25.77 | 26.23 | 26.69 | 27.14 |
| **2.5** | 24.98 | 25.34 | 25.71 | 26.07 | 26.44 |
| **3** | 24.76 | 25.07 | 25.37 | 25.67 | 25.98 |
|  | **ICER from a governmental perspective (£000)** | | | | | |
|  | **Cost** | | | | |
|  | **20** | **25** | **30** | **35** | **40** |
| Impact | **0.5** | 4.50 | 6.32 | 8.14 | 9.96 | 11.78 |
| **1** | 0.87 | 1.78 | 2.69 | 3.60 | 4.51 |
| **1.5** | -0.34 | 0.27 | 0.87 | 1.48 | 2.09 |
| **2** | -0.95 | -0.49 | -0.04 | 0.42 | 0.88 |
| **2.5** | -1.31 | -0.95 | -0.58 | -0.22 | 0.15 |
| **3** | -1.55 | -1.25 | -0.95 | -0.64 | -0.34 |

**Table S7: Cause-specific deaths stratified by age and sex in England in 2017 for diseases associated with consumption of fruit and vegetables for all population[30]**

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Cerebrovascular disease | Diabetes mellitus | Ischaemic heart disease | Malignant neoplasm of bladder | Malignant neoplasm of breast | Malignant neoplasm of colon | Malignant neoplasm of larynx | Malignant neoplasm of lip, oral cavity and pharynx | Malignant neoplasm of oesophagus | Malignant neoplasm of rectosigmoid junction, rectum and anus | Malignant neoplasm of stomach | Malignant neoplasm of trachea, bronchus and lung |
| Female |  |  |  |  |  |  |  |  |  |  |  |  |
| 15-19 | 2 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| 20-24 | 3 | 4 | 3 | 0 | 1 | 2 | 0 | 0 | 1 | 1 | 1 | 1 |
| 25-29 | 7 | 9 | 1 | 0 | 13 | 5 | 0 | 0 | 0 | 3 | 3 | 5 |
| 30-34 | 23 | 17 | 5 | 3 | 48 | 15 | 0 | 4 | 1 | 11 | 6 | 8 |
| 35-39 | 26 | 14 | 34 | 4 | 120 | 28 | 0 | 5 | 2 | 41 | 11 | 24 |
| 40-44 | 73 | 17 | 54 | 11 | 252 | 26 | 0 | 13 | 5 | 28 | 14 | 49 |
| 45-49 | 117 | 36 | 139 | 17 | 437 | 51 | 1 | 19 | 16 | 57 | 22 | 151 |
| 50-54 | 203 | 46 | 285 | 25 | 651 | 103 | 4 | 41 | 63 | 102 | 55 | 335 |
| 55-59 | 231 | 85 | 424 | 40 | 681 | 142 | 12 | 54 | 88 | 130 | 57 | 644 |
| 60-64 | 347 | 98 | 678 | 52 | 750 | 192 | 14 | 86 | 146 | 155 | 70 | 1079 |
| 65-69 | 590 | 131 | 1102 | 112 | 910 | 308 | 11 | 94 | 210 | 235 | 86 | 1745 |
| 70-74 | 976 | 201 | 1650 | 157 | 1122 | 424 | 19 | 101 | 276 | 306 | 129 | 2374 |
| 75-79 | 1752 | 285 | 2445 | 195 | 1066 | 531 | 16 | 97 | 272 | 341 | 193 | 2183 |
| 80-84 | 2871 | 497 | 3567 | 289 | 1171 | 655 | 13 | 90 | 344 | 457 | 239 | 1936 |
| 85-89 | 4108 | 581 | 4563 | 287 | 1109 | 700 | 10 | 95 | 296 | 378 | 207 | 1528 |
| 90+ | 5717 | 835 | 5574 | 297 | 1171 | 553 | 9 | 61 | 226 | 310 | 140 | 897 |
| Total | 17046 | 2859 | 20524 | 1489 | 9502 | 3735 | 109 | 760 | 1946 | 2556 | 1233 | 12959 |
| Male |  |  |  |  |  |  |  |  |  |  |  |  |
| 15-19 | 8 | 9 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| 20-24 | 11 | 7 | 2 | 0 | 0 | 3 | 0 | 0 | 2 | 3 | 0 | 1 |
| 25-29 | 14 | 14 | 23 | 0 | 0 | 5 | 0 | 0 | 2 | 6 | 2 | 4 |
| 30-34 | 25 | 20 | 65 | 1 | 0 | 17 | 0 | 5 | 8 | 15 | 4 | 3 |
| 35-39 | 41 | 31 | 125 | 3 | 0 | 27 | 0 | 9 | 14 | 25 | 11 | 24 |
| 40-44 | 83 | 35 | 278 | 16 | 2 | 24 | 5 | 34 | 22 | 32 | 26 | 59 |
| 45-49 | 162 | 62 | 628 | 20 | 2 | 71 | 14 | 65 | 96 | 69 | 34 | 177 |
| 50-54 | 247 | 83 | 1153 | 39 | 3 | 108 | 30 | 140 | 194 | 125 | 83 | 421 |
| 55-59 | 332 | 104 | 1733 | 80 | 4 | 188 | 38 | 159 | 315 | 228 | 127 | 759 |
| 60-64 | 466 | 140 | 2337 | 142 | 5 | 294 | 57 | 254 | 455 | 322 | 167 | 1411 |
| 65-69 | 756 | 179 | 3165 | 247 | 10 | 385 | 90 | 247 | 665 | 462 | 231 | 2147 |
| 70-74 | 1194 | 259 | 4239 | 442 | 9 | 564 | 91 | 264 | 787 | 545 | 317 | 2801 |
| 75-79 | 1708 | 372 | 4649 | 499 | 9 | 580 | 85 | 183 | 724 | 555 | 366 | 2792 |
| 80-84 | 2498 | 548 | 5524 | 699 | 3 | 760 | 65 | 154 | 583 | 578 | 427 | 2364 |
| 85-89 | 2644 | 539 | 5386 | 609 | 13 | 613 | 49 | 84 | 415 | 417 | 287 | 1512 |
| 90+ | 2444 | 411 | 4019 | 450 | 7 | 377 | 27 | 69 | 230 | 236 | 161 | 754 |
| Total | 12633 | 2813 | 33327 | 3247 | 67 | 4016 | 551 | 1667 | 4512 | 3619 | 2243 | 15229 |

**Table S8: Cause-specific years of life lost stratified by age and sex in England in 2017 for diseases associated with consumption of fruit and vegetables for all population[39]**

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Malignant neoplasm of lip, oral cavity and pharynx | Malignant neoplasm of oesophagus | Malignant neoplasm of stomach | Malignant neoplasm of colon | Malignant neoplasm of rectosigmoid junction, rectum and anus | Malignant neoplasm of larynx | Malignant neoplasm of trachea, bronchus and lung | Malignant neoplasm of breast | Malignant neoplasm of bladder | Diabetes mellitus | Ischaemic heart disease | Cerebrovascular disease |
| Female |  |  |  |  |  |  |  |  |  |  |  |  |
| 15-19 | 0 | 0 | 0 | 0 | 70 | 0 | 0 | 0 | 0 | 202 | 0 | 133 |
| 20-24 | 0 | 62 | 63 | 127 | 61 | 0 | 61 | 62 | 0 | 247 | 190 | 186 |
| 25-29 | 0 | 0 | 170 | 295 | 182 | 0 | 288 | 751 | 0 | 518 | 60 | 408 |
| 30-34 | 219 | 50 | 319 | 804 | 580 | 0 | 431 | 2,516 | 156 | 886 | 262 | 1,194 |
| 35-39 | 246 | 95 | 520 | 1,371 | 1,985 | 0 | 1,151 | 5,830 | 193 | 659 | 1,601 | 1,238 |
| 40-44 | 561 | 213 | 611 | 1,148 | 1,243 | 0 | 2,113 | 11,009 | 471 | 718 | 2,297 | 3,159 |
| 45-49 | 717 | 612 | 843 | 1,992 | 2,198 | 37 | 5,798 | 17,044 | 653 | 1,372 | 5,245 | 4,497 |
| 50-54 | 1,383 | 2,169 | 1,850 | 3,542 | 3,487 | 126 | 11,238 | 22,525 | 855 | 1,528 | 9,539 | 6,854 |
| 55-59 | 1,566 | 2,596 | 1,663 | 4,216 | 3,854 | 343 | 18,740 | 20,316 | 1,169 | 2,443 | 12,224 | 6,699 |
| 60-64 | 2,127 | 3,650 | 1,743 | 4,867 | 3,920 | 349 | 26,711 | 19,057 | 1,272 | 2,382 | 16,649 | 8,614 |
| 65-69 | 1,961 | 4,375 | 1,780 | 6,478 | 4,929 | 218 | 35,950 | 19,209 | 2,317 | 2,664 | 22,567 | 12,230 |
| 70-74 | 1,693 | 4,642 | 2,177 | 7,226 | 5,188 | 304 | 39,475 | 19,097 | 2,630 | 3,315 | 27,260 | 16,428 |
| 75-79 | 1,252 | 3,537 | 2,518 | 6,971 | 4,473 | 198 | 28,128 | 13,943 | 2,538 | 3,653 | 31,460 | 22,770 |
| 80-84 | 862 | 3,341 | 2,302 | 6,394 | 4,452 | 121 | 18,497 | 11,381 | 2,799 | 4,748 | 34,319 | 27,813 |
| 85-89 | 656 | 2,030 | 1,410 | 4,808 | 2,586 | 69 | 10,336 | 7,621 | 1,952 | 3,959 | 31,154 | 28,155 |
| 90+ | 289 | 1,063 | 657 | 2,622 | 1,461 | 42 | 4,196 | 5,510 | 1,395 | 3,923 | 26,178 | 26,912 |
| Total | 13,530 | 28,435 | 18,625 | 52,860 | 40,667 | 1,805 | 203,111 | 175,872 | 18,400 | 33,217 | 221,007 | 167,290 |
| Male |  |  |  |  |  |  |  |  |  |  |  |  |
| 15-19 | 0 | 0 | 0 | 0 | 64 | 0 | 0 | 0 | 0 | 578 | 66 | 520 |
| 20-24 | 0 | 124 | 0 | 180 | 171 | 0 | 57 | 0 | 0 | 418 | 120 | 645 |
| 25-29 | 0 | 112 | 118 | 272 | 315 | 0 | 211 | 0 | 0 | 727 | 1,230 | 756 |
| 30-34 | 240 | 399 | 193 | 873 | 743 | 0 | 153 | 0 | 45 | 976 | 3,137 | 1,227 |
| 35-39 | 390 | 627 | 497 | 1,203 | 1,121 | 0 | 1,058 | 0 | 132 | 1,346 | 5,517 | 1,809 |
| 40-44 | 1,348 | 873 | 1,038 | 975 | 1,289 | 187 | 2,295 | 88 | 649 | 1,357 | 11,005 | 3,296 |
| 45-49 | 2,273 | 3,398 | 1,206 | 2,531 | 2,468 | 480 | 6,170 | 69 | 715 | 2,142 | 21,826 | 5,707 |
| 50-54 | 4,230 | 6,034 | 2,562 | 3,401 | 3,893 | 913 | 12,791 | 97 | 1,189 | 2,517 | 35,075 | 7,516 |
| 55-59 | 4,145 | 8,385 | 3,347 | 5,040 | 6,128 | 1,002 | 19,892 | 113 | 2,098 | 2,679 | 45,301 | 8,662 |
| 60-64 | 5,605 | 10,138 | 3,695 | 6,614 | 7,236 | 1,234 | 31,026 | 112 | 3,193 | 3,032 | 51,314 | 10,273 |
| 65-69 | 4,460 | 12,361 | 4,230 | 7,123 | 8,528 | 1,648 | 38,948 | 190 | 4,532 | 3,238 | 57,653 | 13,697 |
| 70-74 | 3,867 | 11,696 | 4,685 | 8,445 | 8,117 | 1,311 | 40,846 | 138 | 6,561 | 3,745 | 62,101 | 17,569 |
| 75-79 | 2,069 | 8,217 | 4,123 | 6,604 | 6,346 | 949 | 31,340 | 105 | 5,711 | 4,163 | 52,480 | 19,368 |
| 80-84 | 1,283 | 4,928 | 3,576 | 6,428 | 4,853 | 529 | 19,716 | 26 | 5,934 | 4,555 | 46,312 | 21,046 |
| 85-89 | 500 | 2,486 | 1,713 | 3,683 | 2,502 | 292 | 8,987 | 77 | 3,650 | 3,207 | 32,292 | 15,907 |
| 90+ | 290 | 974 | 676 | 1,590 | 992 | 114 | 3,167 | 29 | 1,897 | 1,726 | 16,960 | 10,300 |
| Total | 30,700 | 70,750 | 31,659 | 54,963 | 54,766 | 8,660 | 216,657 | 1,044 | 36,307 | 36,406 | 442,388 | 138,297 |

**Table S9: Cause-specific deaths stratified by age and sex in England in 2017 for diseases associated with consumption of fruit and vegetables for the low-income quintile of the population[30]**

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Cerebrovascular diseases | Diabetes mellitus | Ischaemic heart diseases | Malignant neoplasm of bladder | Malignant neoplasm of breast | Malignant neoplasm of colon | Malignant neoplasm of larynx | Malignant neoplasm of lip, oral cavity and pharynx | Malignant neoplasm of oesophagus | Malignant neoplasm of rectosigmoid junction, rectum and anus | Malignant neoplasm of stomach | Malignant neoplasm of trachea, bronchus and lung |
| Female |  |  |  |  |  |  |  |  |  |  |  |  |
| 15-19 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 20-24 | 1 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| 25-29 | 1 | 3 | 0 | 0 | 4 | 1 | 0 | 0 | 0 | 0 | 1 | 2 |
| 30-34 | 13 | 8 | 1 | 0 | 16 | 3 | 0 | 0 | 1 | 3 | 1 | 1 |
| 35-39 | 10 | 6 | 18 | 0 | 25 | 3 | 0 | 1 | 1 | 7 | 3 | 9 |
| 40-44 | 22 | 7 | 23 | 3 | 57 | 4 | 0 | 5 | 1 | 4 | 3 | 15 |
| 45-49 | 36 | 12 | 60 | 5 | 86 | 7 | 1 | 8 | 5 | 18 | 8 | 41 |
| 50-54 | 53 | 18 | 102 | 4 | 104 | 18 | 4 | 12 | 12 | 21 | 16 | 116 |
| 55-59 | 83 | 33 | 149 | 10 | 122 | 29 | 6 | 19 | 26 | 32 | 20 | 210 |
| 60-64 | 98 | 41 | 229 | 16 | 123 | 28 | 2 | 26 | 31 | 31 | 21 | 321 |
| 65-69 | 146 | 42 | 319 | 30 | 142 | 57 | 5 | 20 | 48 | 48 | 22 | 504 |
| 70-74 | 197 | 66 | 477 | 35 | 164 | 65 | 8 | 20 | 57 | 55 | 24 | 624 |
| 75-79 | 384 | 78 | 639 | 38 | 194 | 94 | 7 | 24 | 56 | 59 | 33 | 567 |
| 80-84 | 514 | 120 | 743 | 56 | 207 | 104 | 6 | 28 | 63 | 68 | 49 | 494 |
| 85-89 | 674 | 105 | 815 | 52 | 178 | 100 | 4 | 14 | 51 | 61 | 41 | 369 |
| 90+ | 795 | 122 | 860 | 43 | 182 | 66 | 1 | 10 | 32 | 49 | 30 | 174 |
| Total | 3028 | 664 | 4436 | 292 | 1604 | 579 | 44 | 187 | 384 | 457 | 272 | 3448 |
| Male |  |  |  |  |  |  |  |  |  |  |  |  |
| 15-19 | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 20-24 | 4 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 1 |
| 25-29 | 3 | 8 | 11 | 0 | 0 | 1 | 0 | 0 | 0 | 4 | 0 | 1 |
| 30-34 | 6 | 6 | 29 | 1 | 0 | 2 | 0 | 2 | 3 | 5 | 0 | 0 |
| 35-39 | 16 | 18 | 43 | 2 | 0 | 8 | 0 | 5 | 3 | 5 | 3 | 9 |
| 40-44 | 26 | 16 | 92 | 2 | 0 | 5 | 3 | 13 | 9 | 8 | 7 | 31 |
| 45-49 | 41 | 25 | 233 | 5 | 1 | 17 | 7 | 21 | 27 | 17 | 7 | 61 |
| 50-54 | 85 | 28 | 398 | 13 | 0 | 17 | 12 | 52 | 42 | 31 | 21 | 149 |
| 55-59 | 105 | 39 | 553 | 25 | 0 | 41 | 8 | 52 | 77 | 50 | 37 | 237 |
| 60-64 | 133 | 50 | 764 | 32 | 1 | 74 | 24 | 74 | 120 | 75 | 49 | 440 |
| 65-69 | 228 | 49 | 862 | 54 | 2 | 84 | 20 | 72 | 122 | 89 | 62 | 635 |
| 70-74 | 260 | 70 | 1002 | 71 | 1 | 89 | 28 | 62 | 144 | 93 | 64 | 683 |
| 75-79 | 335 | 93 | 1028 | 90 | 0 | 109 | 22 | 40 | 151 | 92 | 89 | 669 |
| 80-84 | 411 | 117 | 1039 | 103 | 0 | 126 | 21 | 31 | 89 | 108 | 86 | 504 |
| 85-89 | 368 | 94 | 824 | 97 | 3 | 84 | 7 | 17 | 58 | 61 | 52 | 284 |
| 90+ | 317 | 50 | 571 | 63 | 1 | 55 | 6 | 11 | 29 | 32 | 17 | 121 |
| Total | 2340 | 667 | 7449 | 558 | 9 | 712 | 158 | 452 | 874 | 672 | 494 | 3825 |

**Table S10: Cause-specific years of life lost stratified by age and sex in England in 2017 for diseases associated with consumption of fruit and vegetables for the low-income quintile of the population[39]**

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Malignant neoplasm of lip, oral cavity and pharynx | Malignant neoplasm of oesophagus | Malignant neoplasm of stomach | Malignant neoplasm of colon | Malignant neoplasm of rectosigmoid junction, rectum and anus | Malignant neoplasm of larynx | Malignant neoplasm of trachea, bronchus and lung | Malignant neoplasm of breast | Malignant neoplasm of bladder | Diabetes mellitus | Ischaemic heart diseases | Cerebrovascular diseases |
| Female |  |  |  |  |  |  |  |  |  |  |  |  |
| 15-19 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 64 | 0 | 66 |
| 20-24 | 0 | 0 | 0 | 0 | 61 | 0 | 61 | 0 | 0 | 120 | 61 | 59 |
| 25-29 | 0 | 0 | 54 | 56 | 0 | 0 | 109 | 219 | 0 | 166 | 0 | 56 |
| 30-34 | 0 | 50 | 51 | 151 | 151 | 0 | 50 | 804 | 0 | 399 | 50 | 654 |
| 35-39 | 46 | 45 | 134 | 134 | 320 | 0 | 408 | 1,141 | 0 | 274 | 813 | 451 |
| 40-44 | 201 | 40 | 123 | 163 | 161 | 0 | 606 | 2,310 | 121 | 282 | 932 | 897 |
| 45-49 | 284 | 179 | 289 | 255 | 643 | 37 | 1,476 | 3,103 | 177 | 431 | 2,149 | 1,296 |
| 50-54 | 378 | 379 | 499 | 563 | 665 | 126 | 3,629 | 3,260 | 126 | 566 | 3,197 | 1,659 |
| 55-59 | 511 | 702 | 537 | 783 | 863 | 160 | 5,662 | 3,289 | 268 | 891 | 4,011 | 2,243 |
| 60-64 | 590 | 702 | 481 | 632 | 702 | 46 | 7,282 | 2,792 | 360 | 926 | 5,189 | 2,226 |
| 65-69 | 374 | 899 | 415 | 1,069 | 903 | 93 | 9,433 | 2,663 | 561 | 788 | 5,960 | 2,735 |
| 70-74 | 300 | 856 | 359 | 974 | 829 | 119 | 9,366 | 2,469 | 529 | 996 | 7,156 | 2,958 |
| 75-79 | 280 | 656 | 386 | 1,100 | 688 | 81 | 6,623 | 2,268 | 445 | 912 | 7,457 | 4,489 |
| 80-84 | 245 | 551 | 428 | 909 | 594 | 52 | 4,320 | 1,812 | 490 | 1,050 | 6,497 | 4,495 |
| 85-89 | 88 | 321 | 259 | 630 | 384 | 25 | 2,325 | 1,121 | 327 | 661 | 5,136 | 4,246 |
| 90+ | 44 | 142 | 133 | 292 | 217 | 5 | 769 | 805 | 189 | 541 | 3,803 | 3,517 |
| Total | 3,341 | 5,521 | 4,149 | 7,711 | 7,183 | 744 | 52,116 | 28,055 | 3,592 | 9,068 | 52,411 | 32,046 |
| Male |  |  |  |  |  |  |  |  |  |  |  |  |
| 15-19 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 121 | 0 | 121 |
| 20-24 | 0 | 0 | 0 | 0 | 111 | 0 | 57 | 0 | 0 | 109 | 0 | 221 |
| 25-29 | 0 | 0 | 0 | 52 | 204 | 0 | 50 | 0 | 0 | 405 | 561 | 150 |
| 30-34 | 90 | 135 | 0 | 94 | 231 | 0 | 0 | 0 | 45 | 275 | 1,328 | 276 |
| 35-39 | 204 | 125 | 125 | 329 | 208 | 0 | 371 | 0 | 83 | 742 | 1,771 | 658 |
| 40-44 | 480 | 329 | 258 | 183 | 290 | 107 | 1,137 | 0 | 73 | 584 | 3,369 | 952 |
| 45-49 | 681 | 866 | 223 | 555 | 552 | 225 | 1,967 | 31 | 162 | 795 | 7,472 | 1,319 |
| 50-54 | 1,438 | 1,166 | 588 | 472 | 861 | 335 | 4,147 | 0 | 360 | 780 | 11,064 | 2,369 |
| 55-59 | 1,235 | 1,835 | 873 | 966 | 1,188 | 186 | 5,622 | 0 | 590 | 919 | 13,078 | 2,466 |
| 60-64 | 1,455 | 2,379 | 966 | 1,469 | 1,484 | 466 | 8,704 | 19 | 635 | 988 | 15,073 | 2,627 |
| 65-69 | 1,158 | 1,975 | 1,004 | 1,360 | 1,440 | 320 | 10,244 | 32 | 874 | 791 | 13,929 | 3,684 |
| 70-74 | 797 | 1,853 | 831 | 1,145 | 1,199 | 362 | 8,790 | 13 | 912 | 906 | 12,905 | 3,350 |
| 75-79 | 399 | 1,507 | 890 | 1,089 | 918 | 220 | 6,669 | 0 | 899 | 931 | 10,256 | 3,348 |
| 80-84 | 232 | 667 | 646 | 946 | 810 | 157 | 3,776 | 0 | 776 | 877 | 7,797 | 3,085 |
| 85-89 | 93 | 318 | 285 | 461 | 335 | 38 | 1,558 | 16 | 532 | 516 | 4,520 | 2,018 |
| 90+ | 44 | 115 | 68 | 219 | 127 | 24 | 483 | 4 | 251 | 199 | 2,273 | 1,263 |
| Total | 8,303 | 13,271 | 6,756 | 9,340 | 9,958 | 2,441 | 53,574 | 117 | 6,192 | 9,937 | 105,394 | 27,907 |

**Table S11: Model inputs and outputs**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Inputs | Value | Sources | Equations | Outputs |
| Risk of chronic diseases (stratified by age for cardiovascular diseases and diabetes) | Tables S2 and S3 | WCRF 2018, GBD 2019 |  | Attributable deaths  Attributable years of life lost (YLL)  Attributable costs |
| Number of deaths and years of life lost stratified by age, sex and index of multiple deprivation quintiles | Tables S7 to S10 | ONS 2018 |
| Healthcare costs associated with diseases of interest | Table S5 | NHS Digital\* |
| Fruit and vegetable intake stratified by age and sex | Table 2 | NHS Digital 2018 |  | Deaths prevented or postponed (DPP)  Life-years saved (LYS) |
| Price elasticities for F&V in England, overall | Table S4 | Tiffin, Balcombe et al. 2011 | Percentage increase in consumption = percentage fall in price x |elasticity| |
| Price elasticities for F&V in England, lowest income quintile | Table S4 | Tiffin, Balcombe et al. 2011 |
| SMC impact (% change in consumption) | Table 4 and Table S6 | Capacci and Mazzocchi 2011 |
| SMC cost (£) | Table 4 | Mitchell 2011 | ICER = Incremental benefit (DPP or LYS)/incremental cost (vs no action)  . | ICERs,  Health inequality index |
| Subsidy cost (£) | Table 4 | DEFRA 2018 |

**\*** NHS Planning and Financial Allocations for 2017/18 provided by NHS Digital (not published)

**Table S12: Summary of parameters varied in tornado plot**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Parameter | Mean | lower | upper |  | Source |
| Relative risks |  |  |  |  |  |
| Lip and oral cavity cancer, Nasopharynx cancer, Larynx cancer | 0.96 | 0.91 | 1.00 |  | Published 95% CI |
| Oesophageal cancer | 0.85 | 0.71 | 0.97 |  | Published 95% CI |
| Tracheal, bronchus and lung cancer | 0.92 | 0.88 | 0.97 |  | Published 95% CI |
| Bladder | 0.97 | 0.95 | 0.99 |  | Published 95% CI |
| Stomach and Breast | 0.98 | 0.97 | 1.00 |  | Published 95% CI |
| Colorectal cancer | 0.99 | 0.98 | 1.00 |  | Published 95% CI |
| Diabetes type 2\* | 0.94 | 0.89 | 1.00 |  | Published 95% CI |
| Ischaemic heart disease\* | 0.96 | 0.92 | 0.98 |  | Published 95% CI |
| Cerebrovascular disease\* | 0.87 | 0.79 | 0.95 |  | Published 95% CI |
| Consumption of F&V |  |  |  |  |  |
| Men |  |  |  |  |  |
| 25-34 years | 3.33 | 3.03 | 3.63 |  | CI derived from published se |
| 35-44 years | 3.81 | 3.53 | 4.08 |  | CI derived from published se |
| 45-54 years | 3.56 | 3.28 | 3.84 |  | CI derived from published se |
| 55-64 years | 3.72 | 3.47 | 3.97 |  | CI derived from published se |
| 65-74 years | 4.01 | 3.68 | 4.35 |  | CI derived from published se |
| 75+ years | 3.82 | 3.59 | 4.06 |  | CI derived from published se |
| Women | 0.00 | 0.00 | 0.00 |  |  |
| 25-34 years | 3.97 | 3.72 | 4.22 |  | CI derived from published se |
| 35-44 years | 4.20 | 3.96 | 4.44 |  | CI derived from published se |
| 45-54 years | 3.89 | 3.67 | 4.11 |  | CI derived from published se |
| 55-64 years | 4.09 | 3.87 | 4.31 |  | CI derived from published se |
| 65-74 years | 4.16 | 3.91 | 4.41 |  | CI derived from published se |
| 75+ years | 3.77 | 3.52 | 4.03 |  | CI derived from published se |
| Price elasticities |  |  |  |  |  |
| Overall | -0.67 | -1.06 | -0.27 |  | assumed se of 20% of mean |
| Disease costs by category |  |  |  |  |  |
| Ischaemic Heart Disease | £1,119,016 | £724,168 | £1,598,407 |  | assumed se of 20% of mean |
| Cerebrovascular Disease | £1,023,135 | £662,119 | £1,461,450 |  | assumed se of 20% of mean |
| Type 2 Diabetes | £2,225,104 | £1,439,970 | £3,178,347 |  | assumed se of 20% of mean |
| Cancers |  |  |  |  |  |
| Bladder | £109,436 | £70,821 | £156,319 |  | assumed se of 20% of mean |
| Stomach | £72,958 | £47,214 | £104,213 |  | assumed se of 20% of mean |
| Breast | £547,182 | £354,107 | £781,597 |  | assumed se of 20% of mean |
| Colorectal | £437,746 | £283,286 | £625,278 |  | assumed se of 20% of mean |
| Oesophageal | £109,436 | £70,821 | £156,319 |  | assumed se of 20% of mean |
| Trachea and lung | £474,224 | £306,893 | £677,384 |  | assumed se of 20% of mean |
| Pharynx, Larynx, Oral | £109,436 | £70,821 | £156,319 |  | assumed se of 20% of mean |
| Expenditure on F&V, |  |  |  |  |  |
| Overall | £4.90 | £4.73 | £5.07 |  | CI derived from published se |

F&V – fruit and vegetables; CI – confidence interval; se – standard error

\*The model was amended to apply a common, age invariant value for this relative risk prior to sensitivity analysis.

# **Supplementary Figures**



**Figure S1: Tornado Plot**

F&V, fruit and vegetables; ICER, incremental cost-effectiveness ratio; RR, relative risk

# **References**

1 Dallongeville J, Dauchet L, de Mouzon O*, et al.* Increasing fruit and vegetable consumption: a cost-effectiveness analysis of public policies. *Eur J Public Health* 2011;**21**:69-73.

2 Pearson-Stuttard J, Bandosz P, Rehm CD*, et al.* Comparing effectiveness of mass media campaigns with price reductions targeting fruit and vegetable intake on US cardiovascular disease mortality and race disparities. *Am J Clin Nutr* 2017;**106**:199-206.

3 Pearson-Stuttard J, Bandosz P, Rehm CD*, et al.* Reducing US cardiovascular disease burden and disparities through national and targeted dietary policies: A modelling study. *PLoS Med* 2017;**14**:e1002311.

4 Brambila-Macias J, Shankar B, Capacci S*, et al.* Policy Interventions to Promote Healthy Eating: A Review of What Works, What Does Not, and What is Promising. *Food and Nutrition Bulletin* 2011;**32**:365-75.

5 Capacci S, Mazzocchi M. Five-a-day, a price to pay: an evaluation of the UK program impact accounting for market forces. *J Health Econ* 2011;**30**:87-98.

6 Castiglione C, Mazzocchi M. Ten years of five-a-day policy in the UK: Nutritional outcomes and environmental effects. *Ecological Economics* 2019;**157**:185-94.

7 Center on Budget and Policy Priorities. Chart Book: SNAP Helps Struggling Families Put Food on the Table. USA 2019.

8 NHS Digital. Health Survey for England 2017. UK: NHS Digital 2018.

9 PHE. The Eatwell Guide. UK: Public Health England 2016.

10 WHO/FAO. Diet, nutrition and the prevention of chronic diseases: report of a joint WHO/FAO expert consultation. Geneva, Switzerland: World Health Organisation and Food and Agriculture Organization of the United Nations 2002.

11 Aune D, Giovannucci E, Boffetta P*, et al.* Fruit and vegetable intake and the risk of cardiovascular disease, total cancer and all-cause mortality—a systematic review and dose-response meta-analysis of prospective studies. *International Journal of Epidemiology* 2017;**46**:1029-56.

12 Oyebode O, Gordon-Dseagu V, Walker A*, et al.* Fruit and vegetable consumption and all-cause, cancer and CVD mortality: analysis of Health Survey for England data. *Journal of Epidemiology and Community Health* 2014;**68**:856-62.

13 Wang X, Ouyang Y, Liu J*, et al.* Fruit and vegetable consumption and mortality from all causes, cardiovascular disease, and cancer: systematic review and dose-response meta-analysis of prospective cohort studies. *BMJ : British Medical Journal* 2014;**349**:g4490.

14 Hu D, Huang J, Wang Y*, et al.* Fruits and vegetables consumption and risk of stroke: a meta-analysis of prospective cohort studies. *Stroke* 2014;**45**:1613-9.

15 Wang X, Ouyang Y, Liu J*, et al.* Fruit and vegetable consumption and mortality from all causes, cardiovascular disease, and cancer: systematic review and dose-response meta-analysis of prospective cohort studies. *Bmj* 2014;**349**:g4490.

16 Li M, Fan Y, Zhang X*, et al.* Fruit and vegetable intake and risk of type 2 diabetes mellitus: meta-analysis of prospective cohort studies. *BMJ Open* 2014;**4**:e005497.

17 Vieira AR, Vingeliene S, Chan DS*, et al.* Fruits, vegetables, and bladder cancer risk: a systematic review and meta-analysis. *Cancer Med* 2015;**4**:136-46.

18 Aune D, Chan DS, Vieira AR*, et al.* Fruits, vegetables and breast cancer risk: a systematic review and meta-analysis of prospective studies. *Breast Cancer Res Treat* 2012;**134**:479-93.

19 Key TJ. Fruit and vegetables and cancer risk. *Br J Cancer* 2011;**104**:6-11.

20 Vieira AR, Abar L, Vingeliene S*, et al.* Fruits, vegetables and lung cancer risk: a systematic review and meta-analysis. *Ann Oncol* 2016;**27**:81-96.

21 Liu J, Wang J, Leng Y*, et al.* Intake of fruit and vegetables and risk of esophageal squamous cell carcinoma: a meta-analysis of observational studies. *Int J Cancer* 2013;**133**:473-85.

22 WCRF. Diet, Nutrition, Physical Activity and Cancer: a Global Perspective. The Third Expert Report. World Cancer Research Fund International 2018.

23 GBD. Health effects of dietary risks in 195 countries, 1990-2017: a systematic analysis for the Global Burden of Disease Study 2017. *Lancet (London, England)* 2019;**393**:1958-72.

24 Singh GM, Danaei G, Farzadfar F*, et al.* The age-specific quantitative effects of metabolic risk factors on cardiovascular diseases and diabetes: a pooled analysis. *PLoS One* 2013;**8**:e65174.

25 Ekwaru JP, Ohinmaa A, Loehr S*, et al.* The economic burden of inadequate consumption of vegetables and fruit in Canada. *Public Health Nutr* 2017;**20**:515-23.

26 Briggs ADM, Scarborough P, Wolstenholme J. Estimating comparable English healthcare costs for multiple diseases and unrelated future costs for use in health and public health economic modelling. *PLoS One* 2018;**13**:e0197257.

27 NHS England. NHS Planning and Financial Allocations for 2018/19. UK: NHS England 2018.

28 PHE. Diabetes Prevalence Model. England, UK: Public Health England 2016.

29 Cancer Research UK. Statistics by cancer type. UK: Cancer Research UK 2019.

30 Patel V. Deaths registered in England and Wales (series DR) 2017. England, UK: Office for National Statistics 2018.

31 Campbell A. Age-standardised mortality rates and years of life lost for causes considered avoidable, amenable and preventable, England and Wales, and English regions. England, UK: Office for National Statistics 2018.

32 Ministry of Housing Communities & Local Government. All ranks, deciles and scores for the indices of deprivation, and population denominators UK: Ministry of Housing, Communities & Local Government 2015.

33 Afshin A, Abioye AI, Ajala ON*, et al.* Abstract P087: Effectiveness of Mass Media Campaigns for Improving Dietary Behaviors: A Systematic Review and Meta-analysis. *Circulation* 2013;**127**:AP087-AP.

34 Mitchell S. Change4Life: Three Year Social Marketing Strategy. UK: Department of Health 2011.

35 Bank of England. Inflation calculator.

36 Tiffin R, Balcombe K, Salois M*, et al.* Estimating Food and Drink Elasticities. UK: Department for Environment Food & Rural Affairs (DEFRA) 2011.

37 YHEC. Incremental Cost-Effectiveness Ratio (ICER). York: York Health Economics Consortium 2016.

38 NHS England. Programme budgeting.

39 ONS. Health state life expectancies by national deprivation deciles, England and Wales: 2015 to 2017. England: Office for National Statistics 2018.

# **Supplementary references for main manuscript**

31. Mitchell S. Change4Life: Three Year Social Marketing Strategy. UK: Department of Health, 2011.

32. Tiffin R, Balcombe K, Salois M, Kehlbacher A. Estimating Food and Drink Elasticities. UK: Department for Environment Food & Rural Affairs (DEFRA), 2011.

33. DEFRA. Family Food 2016/17: Expenditure. UK: Department for the Environment, Food & Rural Affairs, 2018.

34. Claxton K, Walker S, Palmer S, Sculpher M. Appropriate Perspectives for Health Care Decisions. Research Paper 54: Centre for Health Economics, University of York, UK, 2010.

35. NICE. Guide to the processes of technology appraisal. Process and methods [PMG29]. UK: National Institute for Health and Care Excellence; 2018.

36. Singh GM, Danaei G, Farzadfar F, et al. The age-specific quantitative effects of metabolic risk factors on cardiovascular diseases and diabetes: a pooled analysis. *PLoS One* 2013; **8**(7): e65174.

37. Lock K, Pomerleau J, Causer L, Altmann DR, McKee M. The global burden of disease attributable to low consumption of fruit and vegetables: implications for the global strategy on diet. *Bull World Health Organ* 2005; **83**(2): 100-8.

38. Cadilhac DA, Magnus A, Sheppard L, Cumming TB, Pearce DC, Carter R. The societal benefits of reducing six behavioural risk factors: an economic modelling study from Australia. *BMC Public Health* 2011; **11**: 483.

39. Lieffers JRL, Ekwaru JP, Ohinmaa A, Veugelers PJ. The economic burden of not meeting food recommendations in Canada: The cost of doing nothing. *PLoS One* 2018; **13**(4): e0196333.

40. Mozaffarian D, Angell SY, Lang T, Rivera JA. Role of government policy in nutrition—barriers to and opportunities for healthier eating. *BMJ* 2018; **361**: k2426.

41. Byford S, Raftery J. Perspectives in economic evaluation. *Bmj* 1998; **316**(7143): 1529-30.

42. Cobiac LJ, Tam K, Veerman L, Blakely T. Taxes and Subsidies for Improving Diet and Population Health in Australia: A Cost-Effectiveness Modelling Study. *PLoS medicine* 2017; **14**(2): e1002232-e.

43. Lee Y, Mozaffarian D, Sy S, et al. Cost-effectiveness of financial incentives for improving diet and health through Medicare and Medicaid: A microsimulation study. *PLoS medicine* 2019; **16**(3): e1002761-e.

44. McLaren L, McIntyre L, Kirkpatrick S. Rose's population strategy of prevention need not increase social inequalities in health. *Int J Epidemiol* 2010; **39**(2): 372-7.

45. Capewell S, Graham H. Will cardiovascular disease prevention widen health inequalities? *PLoS Med* 2010; **7**(8): e1000320.

46. Amies-Cull B, Briggs ADM, Scarborough P. Estimating the potential impact of the UK government's sugar reduction programme on child and adult health: modelling study. *Bmj* 2019; **365**: l1417.

47. Capacci S, Mazzocchi M. Five-a-day, a price to pay: an evaluation of the UK program impact accounting for market forces. *J Health Econ* 2011; **30**(1): 87-98.

48. Jones NR, Conklin AI, Suhrcke M, Monsivais P. The growing price gap between more and less healthy foods: analysis of a novel longitudinal UK dataset. *PLoS One* 2014; **9**(10): e109343.

49. DEFRA. Food Statistics in your pocket: Prices and expenditure. 2019. https://www.gov.uk/government/publications/food-statistics-pocketbook/food-statistics-in-your-pocket-prices-and-expenditure (accessed 7 July 2019).

50. Griffith R, O’Connell M, Smith K. Food expenditure and nutritional quality over the Great Recession. 2013. https://www.ifs.org.uk/conferences/Food\_expenditure2013.pdf (accessed 30 June 2019).

51. Griffith R, O'Connell M, Smith K. Shopping Around: How Households Adjusted Food Spending Over the Great Recession. *Economica* 2016; **83**(330): 247-80.

52. DEFRA. Food statistics pocketbook 2017. UK: Department for Environment, Food & Rural Affairs, 2017.

53. Farrow L, Georgieva I. Trade-offs in future food systems – consumer perspectives – A GFS Food Futures panel project. UK: OPM Group, 2016.

54. Seferidi P, Laverty AA, Pearson-Stuttard J, et al. Impacts of Brexit on fruit and vegetable intake and cardiovascular disease in England: a modelling study. *BMJ Open* 2019; **9**(1): e026966.

55. Shaikh AR, Yaroch AL, Nebeling L, Yeh MC, Resnicow K. Psychosocial predictors of fruit and vegetable consumption in adults a review of the literature. *Am J Prev Med* 2008; **34**(6): 535-43.

56. Estaquio C, Druesne-Pecollo N, Latino-Martel P, Dauchet L, Hercberg S, Bertrais S. Socioeconomic differences in fruit and vegetable consumption among middle-aged French adults: adherence to the 5 A Day recommendation. *J Am Diet Assoc* 2008; **108**(12): 2021-30.

57. Benach J, Malmusi D, Yasui Y, Martinez JM. A new typology of policies to tackle health inequalities and scenarios of impact based on Rose's population approach. *J Epidemiol Community Health* 2013; **67**(3): 286-91.

58. Afshin A, Penalvo JL, Del Gobbo L, et al. The prospective impact of food pricing on improving dietary consumption: A systematic review and meta-analysis. *PLoS One* 2017; **12**(3): e0172277.

59. NICE. Methods for the development of NICE public health guidance. Third ed. UK: National Institute for Health and Care Excellence; 2012.

60. Thow AM, Downs SM, Mayes C, Trevena H, Waqanivalud T, Cawleye J. Fiscal policy to improve diets and prevent noncommunicable diseases: from recommendations to action. *Bulletin of the World Health Organisation* 2018; **96**: 201-10.

61. Irz X, Leroy P, Réquillart V, Soler LG. Beyond Wishful Thinking: Integrating Consumer Preferences in the Assessment of Dietary Recommendations. *PLoS One* 2016; **11**(6): e0158453.

62. Griffith R, von Hinke S, Smith S. Getting a healthy start: The effectiveness of targeted benefits for improving dietary choices. *J Health Econ* 2018; **58**: 176-87.