**Addressing low consumption of fruit and vegetables in England: a cost-effectiveness analysis of public policies**

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Word count: 3000 words

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**Abstract**

**Background:** Most adults do not meet the recommended intake of five portions per day of fruit and vegetables (F&V) in England, but economic analyses of structural policies to change diet are sparse.

**Methods:** Using published data from official statistics and meta-epidemiological studies, we estimated the deaths, years-of-life lost (YLL), and the healthcare costs attributable to consumption of F&V below the recommended five portions per day by English adults. Then, we estimated the cost-effectiveness from governmental and societal perspectives of three policies: a universal 10% subsidy on F&V, a targeted 30% subsidy for low-income households, and a social marketing campaign (SMC).

**Findings:** Consumption of F&V below the recommended five portions a day accounted for 16,321 [10,091–23,516] deaths and 238,767 [170,350–311,651] YLL in England in 2017, alongside £705,951 [398,761–1,061,559] million in healthcare costs. All policies would increase consumption and reduce the disease burden attributable to low intake of F&V. From a societal perspective, the incremental cost-effectiveness ratios were £22,891 [22,300–25,079], £16,860 [15,589–19,763], and £25,683 [25,237–28,671] per life-year saved for the universal subsidy, targeted subsidy and SMC, respectively. At a threshold of £20,000 per life-year saved, the likelihood that the universal subsidy, the targeted subsidy and the SMC were cost-effective was 84%, 19% and 5%, respectively. The targeted subsidy would additionally reduce inequalities.

**Conclusions:** Low intake of F&V represents a heavy health and care burden in England. All dietary policies can improve consumption of F&V, but only a targeted subsidy to low-income households would most likely be cost-effective.

**What is already known on this subject?**

Epidemiological studies suggest that low consumption of fruit and vegetables is associated with an increased risk of cardiovascular diseases, type 2 diabetes and cancer.

Less than one-third of the adults in England meet the recommended intake of five portions of fruit and vegetables per day, and that proportion drops to less than one-fourth in the lowest income quintile.

Fiscal policies and information campaigns have been shown to increase consumption of fruit and vegetables and reduce the attributable health burden in some high-income countries, but evidence in England is lacking.

**What this study adds?**

Failure to meet the recommended five portions a day of fruit and vegetables a day represents a heavy health and care burden in England.

Dietary policies, such as universal and targeted subsidies or social marketing campaigns, can increase consumption of fruit and vegetables and hence reduce the attributable disease burden. However, the cost-effectiveness and impact on inequalities varies markedly between different policies. Therefore, a targeted subsidy to low-income households may be the most cost-effective and equitable strategy from a societal perspective.

**Introduction**

The association of low consumption of fruit and vegetables (F&V) with an increased risk of cardiovascular diseases (CVD), type 2 diabetes and cancer[1, 2] underpins the World Health Organisation’s (WHO) recommendation to eat five portions of F&V per day (equivalent to 400g).[3] However, English adults eat on average 3.8 portions per day, with only 29% reaching the recommended daily intake.[4] This proportion drops to 23% for adults in the lowest income quintile, which contributes to widening inequalities.[5] However, the burden of disease and associated healthcare costs attributable to failure to meet the recommended intake of F&V in England remain unknown. A previous study estimated that treating chronic diseases associated with a poor diet cost the National Health Service (NHS) £5.8 billion in 2006/07,[6] but the specific contribution of low F&V intake was not investigated. There is thus a need for robust estimates of the health and economic burden of low consumption of F&V in England.

The WHO has been urging governments to implement evidence-based policies to improve diet and particularly to increase intakes of of F&V.[7] Although different strategies are available, such as provision of information by social marketing campaigns (SMC) and direct economic incentives, the ideal approach remains unclear.[8] Fiscal measures may improve consumption, particularly among socio-economically deprived groups, who are more price sensitive and also have higher incidence of CVD and cancers, and poorer health outcomes.[9] Although there is some evidence on the quantitative impact of dietary policies in the UK[10] and from cost-effectiveness studies elsewhere,[11, 12] to our knowledge no evidence is currently available on the cost-effectiveness of interventions promoting consumption of F&V in England. Therefore, this study aimed (1) to estimate the deaths, years of life lost (YLL), and healthcare costs attributable to low intake of F&V in England, and (2) to compare the cost-effectiveness of three different policies promoting consumption of F&V – a nationwide SMC, a universal subsidy and a targeted subsidy to low-income households.

**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:

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

These three policies were based on previous studies[12, 13] and compared with a baseline scenario of “no intervention”, which assumed that current consumption would remain stable. We evaluated interventions over a one-year time horizon, assuming that costs and impacts of policies would be stable over time. 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) and generated a cost-effectiveness acceptability curve (CEAC) for each. Key steps are summarised below and detailed methods and assumptions in **Supplementary Data.**

Attributable deaths and healthcare costs

Consumption of F&V by adults in England was obtained from the Health Survey for England 2017.[4] Relative risks (RRs) for diseases associated with consumption of F&V were taken from recent meta-analyses[14-21] and reports (**Table S2**).[22, 23] For cancers, we assumed a similar RR across all age groups, but for CVD and diabetes, we used the age-specific estimates provided by the Global Burden of Disease study (**Table S3**).[23] We assumed a log-linear dose-response relationship to calculate the population-attributable fractions (PAF) using the distribution of consumption of F&V in English adults and the RR for each disease.[24] To estimate the direct healthcare costs, we used the approach described by Briggs et al[25] using data from the 2017/18 NHS England programme budgeting.[26] Disease-specific costs (**Table S5**) were then multiplied by the PAFs to estimate the avoidable healthcare costs in each disease category. Data for cause-specific deaths and life expectancy stratified by age and sex were obtained from the death statistics for England in 2017 (**Tables S7 and S8**).[27, 28] Deaths for low-income individuals were estimated using cause-specific deaths stratified by quintiles of the Index of Multiple Deprivation (IMD) (**Tables S9 and S10**). 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.

Impact of policies

Based on the outcomes of 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,[29] we estimated that the SMC would increase F&V consumption by 2% over one year. This is consistent with a meta-analysis of prospective studies which estimated that information campaigns increased F&V intake by 0.25 portion (or 7%) per day.[30] 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 assumed the same impact of SMC across income quintiles. The cost of the SMC was based on the initial budget of the “Change For Life” campaign in the UK uplifted for 2018 (£33 million per year).[31] The impacts of the fiscal policies on consumption were estimated based on uncompensated, unconditional, own price elasticities for F&V in England.[32] Overall elasticities were used for the universal subsidy and elasticities for the low-income quintile were used for the targeted subsidy. The costs of the subsidies were estimated as the relevant percentages of total expenditure on F&V after the subsidy was put in place. Total expenditures post-subsidies were estimated from baseline expenditure obtained from the Family Food statistics,[33] and the predicted increase in expenditure. PAFs associated with the predicted change in consumption of F&V for each policy were applied to cause-specific deaths and YLL to estimate the number of deaths prevented or postponed (DPP) and life-years saved (LYS).

Cost-effectiveness and impact on inequalities

The cost-effectiveness of each policy was estimated by calculating the ICER, defined as the ratio of extra cost per extra unit of health effect in comparison with the alternative of no intervention. The ICERs were calculated from both governmental and societal perspectives. Under the governmental perspective, we included the cost of subsidising consumption and the cost of the SMC. For the societal perspective, we further included the costs of additional F&V purchases, whilst the cost of subsidising existing consumption was excluded as it was a transfer cost (i.e., transfer of wealth from one segment of society to another).[34] The healthcare cost savings from reduced incidence of cardiovascular disease, diabetes and cancer were subtracted from costs under both perspectives. We estimated the probability of each intervention being cost-effective at a threshold of £20,000 per LYS, slightly lower than the NICE threshold of £30,000 per QALY,[35] since we considered that willingness to pay for a LYS would be slightly lower than for a QALY which represents a year of life at full health.

To investigate the potential impact of the different policies on inequalities, we calculated a health inequality index (HII) for each policy, 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 whole population.[12]

Sensitivity analysis

Probabilistic sensitivity analysis was undertaken to quantify the joint impact of uncertainty in F&V consumption, RRs associated with F&V consumption, healthcare costs, effectiveness of the SMC and price elasticities on all model outputs. Model parameters were specified as random variables to reflect the underlying uncertainty in the point estimates and a value was sampled for each parameter prior to evaluating the model (details on model inputs and outputs provided in **Table S11**). Mean outputs were calculated from 9,999 model simulations and non-parametric 95% credible intervals were estimated as the 250th and 9750th value after ranking values. In addition, we undertook a deterministic two-way sensitivity analysis on the cost of the SMC and its impact on F&V consumption, and extensive one-way sensitivity analysis (**Table S12**).

**Results**

Consumption of F&V by adults in England

Overall, adults consumed 3.8±0.1 portions of F&V in England in 2017 (**Table 1**). Adults in the lowest income quintile consumed 1.1 portions less than those in the highest income quintile (2.8±2.7 versus 3.9±3.0 portions, respectively). Considering a mean daily deficit of 1.2 portions per person, more than 55 million additional portions of F&V would have to be consumed daily in England if all adults were to meet the recommended intake (**Table 2)**.

Attributable deaths, years of life lost and costs

Cancers accounted for most of the deaths and YLL both in men and women, followed by ischaemic heart disease (IHD) and cerebrovascular disease (**Tables S7 and S8**). Similar patterns were observed for individuals in the lowest income quintile, although deaths were somewhat higher at younger ages in this quintile which therefore accounted for 21% of the total deaths and 23% of the total YLL (**Tables S9 and S10**). Overall, low consumption of F&V accounted for 16,321 [10,091 – 23,516] deaths in England in 2017, which represented about 10% of the total deaths caused by CVD, diabetes and the specific cancers considered in this study (**Table 3**). This corresponded to 238,767 [170,350 – 311,651] YLL (11% of the total YLL). YLL were substantially higher in men (143,774) than women (95,224) mainly due to the contribution of deaths at earlier ages from IHD in men (**Table 3**). The healthcare costs attributable to low consumption of F&V in England in 2017 amounted to £706 [399 – 1,062] million.

Cost-effectiveness of policies

The universal 10% subsidy would be the most effective at increasing F&V consumption across the whole population (increasing consumption by 0.25 [95% CI 0.17 to 0.38] portions), generating 2,595

[1,371 – 4,390] DPP and 37,476 [21,904 – 59,614] LYS (**Table 4**). The targeted 30% subsidy would increase consumption only in low-income households by 0.53 [0.35 to 0.77] portions, which would result in 1,356 [765 – 2,177] DPP and 17,867 [10,812 – 27,432] LYS. Overall, the SMC would increase consumption by 0.08 [0.04 to 0.11] portions, which would lead to 770 [365 – 1,357] DPP and 11,090 [5,749 – 18,602] LYS. From a governmental perspective, the ICERs were £37,752 [37,280 to 48,093], £34,178 [32,911 to 37,099] and £244 [dominant to 1,409] per LYS for the universal subsidy, targeted subsidy and SMC. From a societal perspective, the ICERs for the subsidies decreased to £22,891 [22,300 to 25,079] and £16,860 [15,589 to 19,763] for the universal and targeted subsidies, respectively, whilst the ICER for the SMC increased to £25,683 [25,237 to 28,671]. Sensitivity analyses for the SMC assuming that cost could vary between £20 and £40 million and effect between 0.5% and 3% showed that the ICER would vary from £25,000 to £31,000 from a societal perspective **(Table S6)**. One-way sensitivity analysis indicated that ICERs were most sensitive to uncertainty in RRs of disease (**Figure S1**). The targeted subsidy would reduce the HII by -0.7% [-1.0 to -0.4], whilst the other policies would result in a marginal increase. The CEACs showed that, at threshold of £20,000 per LYS, the likelihood that the targeted subsidy, the universal subsidy and the SMC were cost-effective from a societal perspective was 84%, 19% and 5%, respectively (**Figure 1**).

**Discussion**

This study estimated the health and economic burden of low intake of F&V as well as the cost-effectiveness of three policies to increase F&V consumption. Overall, F&V intake below the recommended five portions a day was responsible for about 16,000 deaths and 239,000 YLL from CVD, type 2 diabetes and cancer in England in 2017, which amounted to about £706 million in healthcare spending. Universal and targeted subsidies and a SMC would increase consumption of F&V, but the magnitude of the impact and the associated costs varied substantially. At a threshold of £20,000 per LYS, the targeted 30% subsidy to low-income households was most likely cost-effective, whilst the universal 10% subsidy and the SMC were unlikely to be cost-effective. The targeted subsidy had the additional benefit of reducing inequalities.

Attributable burden of disease and costs

The proportion of deaths attributable to low consumption of F&V may seem modest, but the absolute numbers are substantial, because CVD and cancer remain leading causes of death in England.[28] Furthermore, low consumption of F&V accounted for a higher proportion of cause-specific YLL than deaths, because the RRs associated with low F&V consumption (and hence the PAFs) are higher,[23, 36] and intake of F&V is lower in younger age groups. Those figures are in keeping with a recent WHO report, which estimated that low intake of F&V accounted for 1.8% of the global burden of disease, with up to 7% of the deaths attributable to low intake of F&V in high-income countries.[37] More recently, the Global Burden of Disease study estimated that dietary factors overall accounted for 44%, 33% and 7% of the deaths caused by CVD, type 2 diabetes and cancer in the UK in 2017, respectively. As only about a fifth of the deaths were attributable to low intake of F&V in the European region where the UK was included, our estimates are close to what would be expected for England.[23]

Our estimate of £706 million for the healthcare costs attributable to low consumption of F&V is in between those reported for Australia and Canada. Cadilhac et al. estimated the economic burden attributable to low consumption of F&V to be $AUD269 million in 2008 (about £147 million or £7 per capita per year),[38] whilst Lieffers et al estimated those costs to be $CAD3.3 billion per year in 2015 (equivalent to £2.2 billion or £56 per capita per year).[39] However, the latter included both direct healthcare costs (30.5%) and indirect costs due to productivity losses (69.5%). Although lack of data prevented estimating indirect costs, if a similar proportion of direct and indirect costs was applied to England, the total cost of failing to meet the recommended intake of F&V would equate to £1.7 billion per year (£31 per capita). Differences in cost estimates may have arisen from differences in baseline consumption of F&V, healthcare practice and unit costs, and methodological differences.[40] For instance, we applied age-specific RRs for diabetes and CVD, whereas the aforementioned studies applied a constant RR across all age groups, which likely overestimated risk reductions in older age groups where the burden of disease was largest.[36]

Cost-effectiveness of policies

From a governmental perspective, the SMC but not the subsidies appear to be cost-effective. However, assuming a societal perspective, arguably the most indicated to evaluate public health interventions,[41] the ICERs for the subsidies decreased because transfer costs associated with subsidising existing consumption were excluded. In contrast, the ICERs for the SMC increased substantially after inclusion of the costs of increased F&V expenditure by households. From a societal perspective, the targeted subsidy is most likely cost-effective and its ICER compares favourably with other subsidies like fuel subsidies for cold homes with ICERs between £40,000 and £400,000 per QALY. Alongside cost-effectiveness, policy making should consider impact on inequalities, and the targeted subsidy was the only policy capable of reducing inequalities, consistent with studies in France and the USA.[12, 13]

Other key studies have shown similar findings. The cost-effectiveness of several interventions (e.g. dietary counselling, worksite interventions, telephone contacts) targeting individual F&V consumption was estimated using a multi-state life-table approach in Australia, with no strong evidence that any were cost-effective in reducing disability-adjusted-life-years from a healthcare perspective[42]. Unlike financial incentives, such interventions rely on individual agency and may be difficult to scale up to a population perspective. In the USA, recent estimates suggested that a universal 10% subsidy could prevent 150,500 CVD deaths by 2030 (a 2% reduction), and a targeted subsidy would reduce inequalities, broadly consistent with our analyses.[11] However, this study did not consider the cost-effectiveness of subsidies. More recently, a microsimulation study investigated the impact of a 30% subsidy to low-income and older people in the USA on CVD and diabetes, estimating that it would be highly cost-effective from both healthcare and societal perspectives.[43]

Implications for health policy and the NHS

Public health strategies can aim to improve the environment (“structural policies”), facilitate individual behaviour change (“agentic policies”) or both.[44] Although dietary policy has traditionally favoured agentic approaches dependent on individual behaviour, there has been a gradual shift to structural policies in recent years years[45, 46], as the latter are more equitable and less susceptible to market forces.[47, 48] Indeed, F&V purchases have been declining since the financial crisis in 2007, at least partly because the rise in F&V price has been higher than the average increase in food prices.[49] Economic austerity has compounded this effect by decreasing purchasing power, particularly for low-income households, which has shifted diets towards cheaper calories and a reduction in F&V intakes.[50, 51] The departure of the UK from the European Union (EU) may further increase F&V prices because 84% of fruits and 43% of vegetables in England are imported, and mostly from EU countries.[52] As price remains a key determinant of consumer behaviour, particularly among deprived groups,[53] the burden of ill health and inequalities attributable to low consumption of F&V may increase.[54] Our study provides valuable data to understand how agentic and structural policy can compensate for price rises and minimise detrimental impacts on population health and the NHS.[55-57]

Strengths and limitations

Our analyses were comprehensive in terms of disease impacts of low F&V. We used the best available data sources, mostly governmental and/or institutional databases, instead of extrapolating evidence from other countries or published literature of uncertain reliability. For instance, previous studies[11, 13] assumed a 10% reduction in price would increase consumption by 14% based on a meta-analysis of interventional and prospective longitudinal studies.[58] We used more conservative estimates of price elasticities specific for England provided by the Department for Environment, Food and Rural Affairs.[32] Where possible we used age-specific RRs whilst previous studies failed to account for age-attenuation of RRs.[12, 39] To enhance the applicability of our study by policy-makers in England, we followed NICE guidelines for estimating cost-effectiveness of public health interventions.[35, 59]

Our study has some limitations. Firstly, we assumed no latency period between policy implementation and effect. Whilst the long-term impact is of interest, this would add further complexity and is unlikely to substantially change our findings.[60] Second, the total costs attributable to each disease category were estimated by making assumptions about the costs of primary care and specialised services. However, we used the most robust approach available, developed and validated specifically for NHS data. Third, as mortality data were not stratified by income, we used the IMD as a proxy for income. However, the most recent IMD report showed an almost exact overlap between IMD and income quintiles. Fourth, this study focused on direct healthcare costs, because data for indirect costs were not available. Fifth, we did not consider the potential increase in prices of F&V arising from an increase in demand. Sixth, although we used the best evidence currently available, our estimates were affected by methodological limitations of the data sources, particularly confounding in observational studies investigating associations between F&V intake and disease risk. Seventh, lack of data precluded estimating some costs (e.g. administration costs for subsidies) that could be incurred by the government and/or society. These costs may be modest for a universal subsidy but higher for a targeted subsidy. Data availability also prevented estimating QALYs, which would have been valuable for comparison of different public health interventions.[35] Finally, we restricted our analysis to changes in mortality and did not estimate utility gains or cost-utility. Further benefits from increased F&V consumption would be expected from reductions in morbidity, and there may be additional health benefits, such as higher fibre intake, lower energy content, and replacement of unhealthy foods.[61-65] However, in England, demand for fruits and vegetables seems less responsive to changes in food expenditure than demand for fats, starches and meat products, which means that additional food expenditure tends to be spent on foods other than F&V.[32] However, imperfect implementation and the influence of extraneous factors, particularly among the most deprived households, may potentially reduce the health benefits.[66] Indeed, price is only one amongst myriad factors that influence dietary choices, including sociocultural, physical and psychological determinants.[67, 68] Although the magnitude of those opposing effects is uncertain, our model likely provides a conservative estimate of the impact of the dietary policies on mortality in England.

**Conclusion**

Both a SMC and subsidies promoting F&V consumption can substantially increase consumption and reduce the burden of disease and healthcare costs attributable to low intake of F&V in England. A targeted subsidy to low-income households is most likely cost-effective and can additionally reduce inequalities. By estimating “the cost of doing nothing” as well as “the cost of changing” using dietary policy, this study provides the much-needed evidence to inform resource allocation and priority setting in public health.

**Contributors**

ACPG and MP conceived the study design, did the statistical analysis and wrote the manuscript. All authors provided critical revisions of the draft and approved the submitted draft. The corresponding author attests that all listed authors meet authorship criteria and that no others meeting the criteria have been omitted. MP is the guarantor.

**Declaration of competing interests**

None to be declared.

**Acknowledgements**

Although this study was not funded, JAC acknowledges support of Qatar National Research Fund (NPRP10-1208-160017).

**Data sharing statement**

All data used in this study are publicly available in the Office for National Statistics and NHS Digital websites.

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**Figure legends**

**Figure 1: Cost-effectiveness curves for each intervention from governmental and societal perspectives**

The cost-effectiveness curves were estimated considering the mean cost (in £ thousands) for each death prevented or postponed (DPP) (A and B) and life-year saved (LYS) (C and D) by each intervention adopting a governmental (A and C) and a societal perspective (B and D). SMC, social marketing campaign

**Table 1: Consumption of F&V by adults in England in 2017[4]**

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Sex | Age | % Consuming given number of portions of F&V per day | | | | | | | Portions per day  (mean±SD) | Deficit  (mean) | Missing portions to 5  (millions) |
|  |  | None | More than 0  but less than 1 | 1 portion or more  but less than 2 | 2 portions or more  but less than 3 | 3 portions or more  but less than 4 | 4 portions or more  but less than 5 | 5 portions or more |  |  |  |
| Male | **16-24 years** | 12.1 | 4.1 | 18.2 | 13.8 | 20.5 | 8.9 | 22.5 | 3.3±0.2 | 1.7 | 4.30 |
|  | **25-34 years** | 11.2 | 4.9 | 18.2 | 16.6 | 14.6 | 12.7 | 21.8 | 3.3±0.2 | 1.7 | 6.39 |
|  | **35-44 years** | 7.6 | 3.1 | 15.6 | 13.5 | 17.8 | 13.6 | 28.8 | 3.8±0.1 | 1.2 | 4.21 |
|  | **45-54 years** | 9.7 | 2.9 | 15.9 | 16.9 | 16.2 | 13.6 | 24.9 | 3.6±0.1 | 1.4 | 5.48 |
|  | **55-64 years** | 6.9 | 2.2 | 16.9 | 18.8 | 12.3 | 15.9 | 27.0 | 3.7±0.1 | 1.3 | 4.16 |
|  | **65-74 years** | 6.5 | 2.7 | 13.1 | 16.8 | 15.1 | 14.2 | 31.6 | 4.0±0.1 | 1.0 | 2.64 |
|  | **75+ years** | 3.6 | 2.7 | 13.8 | 19.1 | 17.1 | 13.7 | 29.9 | 3.8±0.1 | 1.4 | 2.72 |
|  | **All men** | 8.6 | 3.3 | 16.2 | 16.3 | 16.2 | 13.2 | 26.2 | 3.6±0.1 | 1.4 | 30.90 |
| Female | **16-24 years** | 9.3 | 3.8 | 21.8 | 20.3 | 12.6 | 9.2 | 22.9 | 3.3±0.2 | 1.7 | 4.90 |
|  | **25-34 years** | 7.1 | 3.2 | 15.1 | 13.8 | 15.1 | 12.7 | 33.0 | 4.0±0.1 | 1.0 | 3.90 |
|  | **35-44 years** | 5.8 | 2.4 | 13.5 | 16.8 | 13.6 | 11.9 | 36.1 | 4.2±0.1 | 0.8 | 2.87 |
|  | **45-54 years** | 6.5 | 2.1 | 14.1 | 16.5 | 18.0 | 13.2 | 29.7 | 3.9±0.1 | 1.1 | 4.34 |
|  | **55-64 years** | 5.8 | 3.5 | 12.8 | 15.7 | 13.0 | 13.1 | 36.1 | 4.1±0.1 | 0.9 | 3.06 |
|  | **65-74 years** | 6.0 | 2.3 | 12.2 | 15.6 | 17.4 | 12.8 | 33.6 | 4.2±0.1 | 0.8 | 2.41 |
|  | **75+ years** | 3.9 | 3.0 | 14.8 | 20.5 | 17.4 | 13.5 | 26.9 | 3.8±0.1 | 1.2 | 3.26 |
|  | **All women** | 6.4 | 2.9 | 14.8 | 16.8 | 15.3 | 12.4 | 31.5 | 3.9±0.1 | 1.1 | 24.73 |
| All adults | | 7.5 | 3.1 | 15.5 | 16.5 | 15.7 | 12.8 | 28.9 | 3.8±0.1 | 1.2 | 55.20 |

F%V, fruit and vegetables; SD, standard deviation

**Table 2: Consumption of fruit and vegetables in England stratified by household income quintile, age and sex in 2017[4]**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Lowest Quintile | Second lowest Quintile | Middle Quintile | Second highest Quintile | Highest Quintile |
| Men |  |  |  |  |  |
| 16-24 | 2.4 (2.6) | 3.5 (3.0) | 3.2 (2.4) | 3.2 (2.7) | 3.7 (2.6) |
| 25-34 | 1.9 (2.6) | 3.7 (4.1) | 3.0 (2.8) | 3.3 (2.8) | 3.7 (2.8) |
| 35-44 | 3.8 (2.7) | 3.2 (2.5) | 3.8 (2.9) | 4.5 (3.3) | 3.8 (2.2) |
| 45-54 | 2.7 (2.6) | 2.7 (2.3) | 3.5 (2.5) | 3.3 (2.3) | 4.3 (3.0) |
| 55-64 | 3.1 (2.7) | 3.1 (2.6) | 3.4 (3.0) | 3.9 (3.2) | 4.3 (2.2) |
| 65-74 | 3.4 (2.7) | 3.2 (2.8) | 3.9 (2.6) | 4.1 (2.2) | 4.3 (2.6) |
| 75+ | 3.1 (1.9) | 3.7 (2.3) | 4.2 (2.4) | 4.5 (2.5) | 4.5 (2.9) |
| All | 2.6 (2.7) | 2.9 (2.9) | 3.2 (2.8) | 3.4 (2.9) | 3.6 (2.8) |
| Female |  |  |  |  |  |
| 16-24 | 2.2 (1.9) | 3.5 (3.2) | 2.7 (2.1) | 2.9 (2.3) | 4.6 (3.3) |
| 25-34 | 3.5 (2.7) | 3.7 (2.8) | 3.8 (3.0) | 3.8 (2.7) | 4.3 (2.8) |
| 35-44 | 3.7 (3.3) | 3.7 (2.5) | 4.3 (2.9) | 4.3 (3.0) | 4.6 (2.7) |
| 45-54 | 3.3 (2.8) | 3.7 (3.2) | 3.7 (3.0) | 3.8 (2.6) | 4.6 (3.1) |
| 55-64 | 3.3 (2.7) | 3.7 (2.8) | 4.3 (2.7) | 4.4 (2.8) | 5.2 (2.8) |
| 65-74 | 3.8 (2.6) | 3.1 (2.3) | 4.2 (2.7) | 4.3 (2.2) | 4.8 (4.7) |
| 75+ | 3.3 (2.7) | 3.3 (2.0) | 4.3 (2.7) | 4.1 (2.3) | 4.2 (2.6) |
| Female | 3.0 (2.8) | 3.1 (2.8) | 3.6 (2.9) | 3.6 (2.8) | 4.1 (3.2) |
| Total | 2.8 (2.7) | 3.0 (2.8) | 3.4 (2.9) | 3.5 (2.8) | 3.9 (3.0) |

Values presented as mean (SD)

**Table 3: Deaths and healthcare costs attributable to the inadequate consumption of F&V in England**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | Deaths (N [95% CI], (%)) | | | Years of life lost (N [95% CI], (%)) | | | Healthcare costs (£000 [95% CI]) |
| Disease | **Women** | **Men** | **Total** | **Women** | **Men** | **Total** | **Total** |
| Ischaemic heart  disease | 2,196  [346 – 4,698]  (10.2) | 3,865  [1,294 – 6,993]  (11.5) | 6,060  [1,670 – 11,581]  (10.8) | 25,666  [8,711 – 46,287]  (11.2) | 60,211  [29,318 – 93,497]  (13.4) | 85,877  [38,872 – 138,595]  (12.7) | 84,609  [0 – 197,563] |
| Cerebrovascular  disease | 1,826  [371 – 3,997]  (10.2) | 1,514  [524 – 2,894]  (11.2) | 3,340  [900 – 6,892]  (10.8) | 23,472  [10,888 – 40,161]  (13.7) | 23,771  [14,146 – 34,927]  (16.9) | 47,243  [25,097 – 74,701]  (15.2) | 239,288  [72,460 – 441,975] |
| Diabetes mellitus  type 2 | 257  [49 – 590]  (8.4) | 269  [79 – 545]  (9.0) | 527  [129 – 1,136]  (8.7) | 3,651  [1,546 – 6,387]  (10.6) | 4,471  [2,240 – 7,026]  (11.9) | 8,123  [3,780 – 13,396]  (11.3) | 242,396  [15,392 – 520,330] |
| Cancer | 2,741  [1,577 – 3,885]  (8.0) | 3,652  [2,010 – 5,235]  (10.5) | 6,394  [3,638 – 9,102]  (9.3) | 42,587  [24,544 – 60,402]  (7.8) | 54,937  [30,135 – 78,758]  (10.9) | 97,524  [55,521 – 138,490]  (9.3) | 139,659  [82,945 – 205,096] |
| Total | 7,020  [3,985 – 10,583]  (9.1) | 9,300  [5,945 – 13,129]  (10.8) | 16,321  [10,091 – 23,516]  (10.1) | 95,376  [65,546 – 127,258]  (9.6) | 143,391  [102,191 – 186,928]  (12.7) | 238,767  [170,350 – 311,651]  (11.3) | 705,951  [398,761 – 1,061,559] |

CI, credible interval; N, number; % of cause-specific deaths and years of life lost

**Table 4: Comparison of three different policies promoting consumption of F&V**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | | Universal 10% subsidy | Targeted 30% subsidy | Social marketing campaign |
| Consumption variation (portions) | **All** | 0.25  [0.17 – 0.38] | 0.11  [0.07 – 0.15] | 0.08  [0.04 – 0.11] |
| **Lowest quintile** | 0.18  [0.12 – 0.26] | 0.53  [0.35 – 0.77] | 0.06  [0.03 – 0.09] |
| Deaths prevented or postponed | **All** | 2,595  [1,371 – 4,390] | 1,356  [765 – 2,177] | 770  [365 – 1,357] |
| **Lowest quintile** | 462  [154 – 918] | 1,356  [765 – 2,177] | 148  [46 – 308] |
| Life years saved | **All** | 37,476  [21,904 – 59,614] | 17,867  [10,812 – 27,432] | 11,089  [5,749 – 18,602] |
| **Lowest quintile** | 6,954  [2,694 – 12,891] | 17,867  [10,812 – 27,432] | 2,235  [810 – 4,343] |
| Health care costs averted  (£000) | | 102,094  [53,506 – 170,479] | 45,196  [23,402 – 73,624] | 30,352  [14,340 – 53,488] |
| Government subsidy for F&V (£000) | | 1,406,456  [1,336,102 – 1,474,613] | 608,129  [544,251 – 676,259] | 33,006  [16,722 - 55,121] |
| Cost of additional F&V consumption (£000) | | 956,437  [631,129 – 1,398,213] | 345,741  [226,655 – 502,893] | 281,227  [160,281 – 434,519] |
| Government  perspective | **ICER DPP (£)** | 544,447  [507,244 – 690,219] | 451,534  [440,099 – 507,798] | 3,522  [dominant – 20,156] |
| **ICER LYS (£)** | 37,752  [37,280 – 48,093] | 34,178  [32,911 – 37,099] | 244  [dominant – 1,409] |
| Societal  perspective | **ICER DPP (£)** | 331,676  [303,415 – 359,929] | 222,749  [202,817 – 264,285] | 370,689  [342,405 – 410,258] |
| **ICER LYS (£)** | 22,891  [22,300 – 25,079] | 16,860  [15,589 – 19,763] | 25,683  [25,237 – 28,671] |
| Health Inequality Index (%) | | 0.1  [-0.2 – 0.4] | -0.7  [-1.0 – -0.4] | 0.0  [0.0 – 0.1] |

DPP, deaths prevented or postponed; ICER, incremental cost-effectiveness ratio; LYS, life-years saved