HEALTH LUMEN

Cost benefit analysis of obesity interventions

HealthLumen on behalf of Nesta

October 2024

About HealthLumen

HealthLumen are specialists in precision epidemiological modelling, providing exceptional insights into the current prevalence and the future health and economic burden of non-communicable diseases (NCDs) and rare genetic diseases. Our purpose is to improve global health outcomes by creating data-driven insights for decision-making.

Our microsimulation-based modelling platform and powerful genetic database analysis, enable us to simulate the health and economic impact of proposed interventions before real-world implementation.

The model has been used over the past 15 years to provide actionable insights and generate evidence to support organisations in both the public and private sectors with making key decisions in the lifecycle of a product or service, and advocating for policy changes such as behavioural interventions.

The model has been extensively published and validated, implemented in over 80 countries, and covers over 20 NCDs, including obesity, type 2 diabetes (T2D), coronary heart disease (CHD), chronic obstructive pulmonary disease (COPD), stroke, hypertension, cancer, liver disease, chronic kidney disease, asthma, and dementia.

Of specific relevance to this project is our deep expertise in modelling obesity and the impact of interventions on the health and economic burden of the disease and its related comorbidities.

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Abbreviations and Glossary

Terms	Definition
Baseline scenario	Where current standard of care continues, assuming no change in obesity care.
BMI	Body mass index
Cost-effective	This refers to interventions that provide good value for the money spent, balancing costs with health benefits. NICE typically assesses cost-effectiveness using incremental cost-effectiveness ratios (ICERs), which compare the cost of a new intervention to its health benefits, often measured in quality-adjusted life years (QALYs). Generally, NICE considers interventions with an ICER of less than £20,000 per QALY as cost-effective. This means that for each QALY gained, the cost of the intervention should not exceed these thresholds.
Cost-saving	An intervention is considered cost-saving if it reduces overall healthcare costs while maintaining or improving health outcomes. This means the intervention not only improves health or prevents deterioration but also leads to a net reduction in healthcare spending compared to alternative options. Cost-saving interventions may prevent costly treatments, reduce hospitalisations, or lead to lower long-term care costs.
CHD	Coronary heart disease.
COPD	Chronic obstructive pulmonary disease.
Cumulative incidence	Successive additions of annual cases of a disease. For example, the cumulative incidence between 2023 and 2025 would be the sum of the all-new disease cases in each of those years.
Cumulative incidence avoided	This is the number of cases in the intervention scenario subtracted from the baseline value. The value represents the number of disease cases reduced over that time period as a result of the intervention, relative to baseline. For example, there may be 1000 new disease cases of type 2 diabetes in baseline between year 1 and year 5, and 700 new cases of type 2 diabetes cases in the intervention scenario. Therefore, 1000 minus 700 = 300 fewer disease cases as a result of the policy intervention compared to baseline.
Direct cost	The expenditure that is directly attributable to the utilisation of healthcare resources (e.g. outpatient visits, medication).
Green Book	Central government guidance on appraisal and evaluation.

ICER	Incremental cost-effectiveness ratios
Incidence	The occurrence of new cases of a disease over a given time period.
Indirect cost	Expenditure that is indirectly attributable to the disease or condition (e.g. absenteeism, presenteeism).
Microsimulation	A computer simulation model that replicates reality using national population and disease statistics. It is used to quantify the future burden of a disease and the long-term impact of a range of different scenarios on future outcomes. This method is referred to as ‘the microsimulation’.
NICE	National Institute for Health and Care Excellence.
NMB	Net monetary benefit. The difference between the monetary value of total expected quality-adjusted life years and total expected costs.
NPM	Nutrient Profiling Model score, a system developed to assess the healthiness of food and drink products. The Nutrient Profiling Model (NPM) was originally developed by the UK Food Standards Agency (FSA) to help regulate the promotion of foods high in fat, sugar, and salt (HFSS), particularly in advertising aimed at children.
QALY	Quality-adjusted life year. One QALY represents one year of life in perfect health, and the quality of life is measured on a scale from 0 (death) to 1 (perfect health).
Prevalence	The total number of cases (both pre-existing and newly occurring) of a disease in a particular population over a given time period.
Regression	A statistical technique for estimating the relationships between variables.
Static	This refers to the ‘steady state’ of the risk factor assuming no change from current risk factor exposure levels. However, changes in the population (e.g. aging) still occur.
T2D	Type two diabetes mellitus.
Utility weight	A measure of value for a health state.

Executive Summary

Background

The prevalence of obesity has been growing steadily in the UK. Obesity is associated with a high risk of non-communicable diseases, including cardiovascular and metabolic diseases, as well as several cancers.

Some policies, including the recently implemented sugar-sweetened-beverage tax, have been demonstrated to be cost-effective, but many other obesity-targeting policies have been researched to a lesser extent. These less-evaluated policies have the promise to reduce obesity levels whilst also being cost-effective to implement and maintain.

Aims and Objectives

This study aims to evaluate the health and economic benefits of 32 interventions targeting overweight and obesity in the UK, in addition to assessing their cost-effectiveness from 2019 to 2024.

Key considerations

Results are conservative compared with some other assessments due to the following criteria:

- A willingness-to-pay threshold of **£20,000 per QALY** is applied in line with NICE guidance
- Often government impact assessments use less stringent thresholds of £60,000-70,000 per QALY to calculate net monetary benefit, therefore the impact presented here is conservative in comparison to those assessments
- We used a **discount rate of 3.5%** for both costs and health outcomes due to the short time horizon of the modelling study
- Other analysis may discount at the lesser 1.5% for health impacts across a longer time horizon - such as the impact assessment for Restricting in-store HFSS positioning which modelled a 25 year time horizon. We modelled a **5-year time horizon**.
- **Only 10 diseases were considered**, whereas several other conditions are related to obesity that were not included here e.g. postmenopausal breast cancer, back pain, and gout.
- Wider societal costs related to **unemployment benefits are not included**.
- Therefore this analysis is not comparable to many government assessments and 'cost effective' should be viewed only with regards to the assumptions used here.

Results

Over a period of 6 years, 9 of the 32 policies were cost-saving (where costs are reduced due to the intervention relative to baseline) and 3 were cost-effective (a cost per QALY of <£20,000). As a result these policies were projected to significantly reduce obesity-related complications, lower costs, and improve quality of life. The largest health impacts were found for policies such as a ban on all promotions on high in fat, salt, and sugar (HFSS) products in food retail businesses; restricting checkout, end-of-aisle, and store entrance sales of HFSS food and drinks and; regulating large retailers to change their organisation-wide converted nutrient profile model (NPM) score to 69 or greater across their entire food product portfolio. Fiscal policy measures produced the most cost-saving outcomes, explained by the fact that they can generate a significant amount of revenue for the UK government.

Conclusions

This study quantifies the potential benefit of implementing interventions to lower obesity levels. It suggests that implementing effective policies can reduce the health and economic burden associated with growing overweight and obesity rates in the UK.

Background

The prevalence of people living with obesity and overweight in the UK is on the rise. In England in 2019, 68% of men and 60% of women aged 16 years and over are living with overweight or obesity (defined as having a BMI >25 kg/m^2), with 27% of men and 29% of women considered as having obesity (defined as having a BMI >30 kg/m^2) (1). Among children there is a similar trend, with 18% of boys and 13% of girls between the ages of 2 and 15 living with obesity (1).

Such a large percentage of the population suffering from excess weight has several consequences, particularly considering that both overweight and obesity have been associated with an increased risk of many diseases including type 2 diabetes (T2D) (2, 3), hypertension (2), heart disease (2, 3), stroke (2, 3) and several cancers (3, 4), as well as neurodegenerative and autoimmune diseases (5).

There is a monetary cost to overweight and obesity due to the onset of ill-health and disability as a result of the many diseases stemming from this risk factor (3). Recent studies estimate the annual total cost of obesity and overweight to the UK to stand at £98 billion, driven mainly by three main sources: (a) years of healthy life lost; (b) informal caretaking by, for example, family members; and (c) healthcare costs and lost productivity (6).

Several policies have been reported to likely be effective in reducing obesity. In the past, effective UK government policies aimed to reduce overweight and obesity have included the Soft Drinks Industry Levy, which led to a decrease in the average sugar content of drinks by 46% over 5 years, and a sugar reduction programme which resulted in a nearly 15% reduction in the sugar content of breakfast cereals and a 13.5% reduction in the sugar content of yogurts and fromage frais (7). The anticipated monetary benefits from additional policies such as improved calorie labelling and food product placement restrictions are estimated to reach over £57 billion in health benefits and nearly £4 billion in NHS savings.

Despite a lot of evidence being available on a number of interventions (across the food, health and education system), their relative impact, feasibility, and cost-effectiveness are not well known. Nesta's 'A Healthy Life' mission aims to create a blueprint for halving the prevalence of obesity in the UK via a digital tool aimed at policy makers and planners. This study provides the impact of a range of policies in terms of their individual impact on obesity, their feasibility and cost-effectiveness.

Nesta have chosen policies for inclusion that could feasibly achieve their goal of halving the prevalence of obesity in the UK by 2030. The prevalence of overweight and obesity appears fairly uniform across regions of England (3), indicating that ameliorative efforts may be most beneficial if applied broadly. Examples of these policies include those related to advertising restrictions, education programs, weight management programs and medications, food product reformulations, and front of package re-labelling, among others. There are a total of 32 policies.

Nesta have commissioned HealthLumen to determine the cost-effectiveness of the chosen policies. The model used to produce this work simulated the population of the UK and predicted the future impact of the chosen obesity policies. The base year is 2019 and the end year is 2024.

Study aims and objectives

This study aims to quantify the health and economic impact of obesity on 10 obesity-related complications in the UK population, and to assess the cost-effectiveness and health and economic benefits of 32 policies.

The objectives are to:

- Project the prevalence of obesity and overweight and the relative change that would occur if a policy was to be implemented.
- Estimate the direct and indirect healthcare costs associated with 10 obesity-related diseases, and the cost savings associated with policy implementation as a result of reducing these 10 conditions.
- Quantify the quality-of-life impact of policy implementation.
- Assess the cost-effectiveness of the 32 policies analysed.

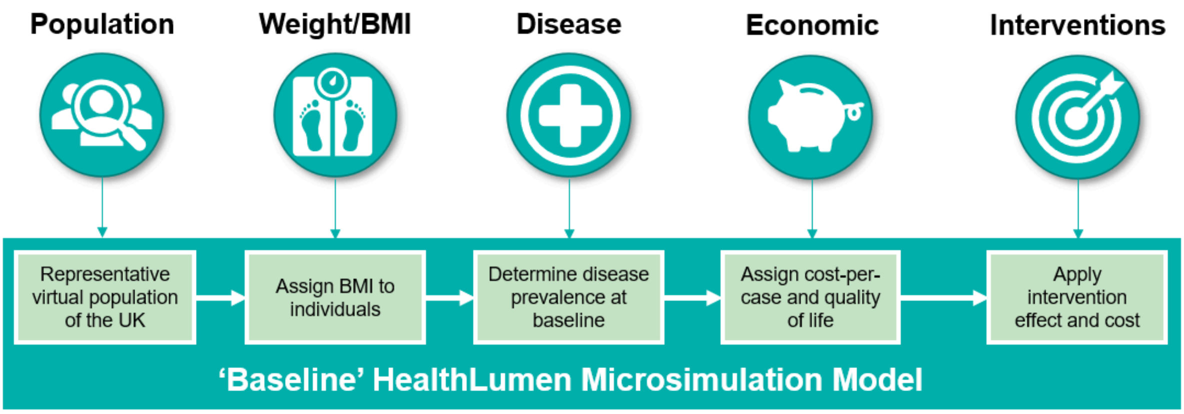
By quantifying the projected burden of overweight and obesity, alongside the value of the proposed interventions, this study aims to enable stakeholders (policymakers, payers, and practitioners) to make more informed decisions on obesity-related policy implementation.

Methods

Model structure and parameters

A well-validated microsimulation model (8) was used to create a virtual population and project the epidemiological and economic burden of obesity-related morbidity in the UK over 6 years (2019-2024)[1]. In the start year, each virtual individual was assigned an age, sex, BMI, baseline disease status, and relative risk of future disease development. The microsimulation utilized here comprised population, BMI, complications, economic, and intervention modules, as detailed in **Figure 1**. Further technical details can be found in the supplementary Appendix 1. A summary of the approach is outlined below. Data inputs and related references can be found in Appendix 2.

Figure 1. Schematic of the microsimulation model



BMI, body mass index

Population module

A virtual population of individuals in the UK was created using disaggregated data of the following parameters: population estimates by age and sex, population projections, total fertility rate (TFR), mothers' age at birth, and death risk by age and sex for the UK. The virtual population that was created in the microsimulation intentionally matched key characteristics of the UK population in 2019. A total population of 100 million individuals was created for inclusion in the microsimulation, which was then scaled to match the true size of the UK population in 2019, and the projected population size thereafter.

BMI module

BMI was simulated dynamically across the entire UK virtual population, accounting for changes as age increased. BMI projections from 2019 to 2024 were made by performing a multinomial logistic regression on the HSE BMI data. Each year, an individuals' BMI changed based on age increase. The dynamic year-to-year nature of BMI in the microsimulation model allowed adult individuals to change BMI each

[1] Years were chosen to align with Nesta's modelling

simulation year and fall into one of the following categories: normal weight (<25 kg/m^2), overweight (25–29.99 kg/m^2), obesity (30–39.99 kg/m^2) and morbid obesity (⩾40 kg/m^2). Children were categorised as overweight or obese according to the 85^{th} and 95^{th} centile based on UK90 reference curves (9).

Comorbidity and complication module

Peer-reviewed publications in English between 1999 and 2024 were identified by literature and Google searches. Data on complication relative risk, incidence, prevalence, and mortality were gathered. The microsimulation includes the following diseases associated with obesity: T2D, hypertension, coronary heart disease (CHD), colorectal cancer, gall bladder disease, ovarian cancer, liver cancer, stroke, depression, and knee osteoarthritis.

Virtual individuals were assigned a probability by age and sex of having a disease at simulation start (2019) based on prevalence data. Each subsequent year (2020–2024), individuals were assigned a certain risk of developing an incident BMI-associated comorbidity. This risk was determined using incidence statistics by age and sex, and relative risks based on an individual's BMI. The risk of incident complications increased for each individual with age and BMI. Individuals could have had an outcome of death from an included disease or any other cause based on known mortality statistics. As a result of treatment interventions, such as the 2 policies involving GLP-1s, the policy involving bariatric surgery, and the policy involving total diet replacement, individuals could be subject to remission of disease, namely for T2D or hypertension, as determined by remission statistics.

Health economics module

Annual per-patient costs for the included complications were assigned to virtual patients each year. Health state utility weights measure quality of life (0=death, 1=perfect health) and are typically measured with the EQ-5D questionnaire. Each individual in the model was assigned a health state utility weight based on their disease.

Social care costs

In order to determine social care costs, we first established the probability that somebody requires social care costs, based on their BMI, and then social care costs were tagged to each individual requiring social care. Social care costs were calculated by multiplying the yearly difference in hours of formal social care between individuals with and without obesity (estimated to be 164.45 hours annually), and the hourly cost of a social care worker (estimated at £28.67 in 2020) (10).

Intervention costs

Thirty-two intervention scenarios were analysed. The impact of each intervention on BMI was calculated by Nesta based on daily calorie reduction. Methods of their approach are described elsewhere (see: https://blueprint.nesta.org.uk/our-method/). Literature reviews were conducted on articles published between 1999 and 2024 in English to identify the costs associated with each policy (Appendix 3a and b).

Method for standardising costs

Costs found in the literature search spanned the years 1999–2024, and therefore were standardised to fit the study period of 2019 to 2024. In order to scale these costs we used the open access CCEMG–EPPI Centre Cost Converter initially developed by the Campbell and Cochrane Economics Methods Group (CCEMG) and the Evidence for Policy and Practice Information (EPPI) Centre at University College London; it is currently maintained by the EPPI Centre (11). The EPPI tool takes currency from a designated year and country, and then converts it to the currency value for the desired year and country. Full details on this web-based tool have been published previously (12). Briefly, this tool first adjusts the cost from the original year to the target year using a Gross Domestic Product deflator index dataset from the International Monetary Fund (2022) (11). Then, it converts the original currency to the target currency using Purchasing Power Parities for GDP rates from either the IMF or the Organisation for Economic Cooperation and Development (2022) (11).

Cost-effectiveness analysis

The principle cost-effectiveness outcomes were incremental cost-effectiveness ratios (ICER) and net monetary benefit (NMB).

The ICER was based on the net difference between healthcare and intervention costs incurred (incremental costs) divided by the difference in health outcomes – quality-adjusted life years (QALYs) gained. We considered interventions with an ICER of less than £20,000 per QALY gained to be cost-effective as per recommendations from the National Institute for Health and Care Excellence (NICE) (13, 14).

NICE guidelines also recommend that costs and health outcomes should be discounted at 3.5% per year. So, 1 QALY (or £100) experienced/spent in Year 2 would have a present value of 0.966 QALYs (£96.62). While the Government Green Book recommends differentially discounting health benefits (QALYs) at 1.5% but costs at 3.5%, this is usually for long-term perspectives and impact assessments, that assume a different preference for the value of health versus the value of money over time (15).

NESTA's model horizon of 6 years assumes that the costs and health impacts will be incurred and occurring in a short-time frame, and so an equal discounting approach to both health and costs as recommended by NICE (3.5% was preferred).

The NMB is calculated by multiplying to incremental QALYs gained by the willingness-to-pay threshold (£20,000/QALY) and subtracting the incremental cost of the intervention. A positive NMB indicates that the policy is cost-effective, and a negative NMB indicates that the policy is not cost-effective.

Results

Baseline model

The prevalence of obesity and the health and economic burden of obesity-related complications are projected to increase in the UK between 2019 and 2024, presenting a significant and increasing burden to health systems and patients.

Risk factor

In ages 16+, the prevalence of overweight was projected to decrease from 40.5% to 40.2% in males, and 30.5% to 28.9% in females between 2019 and 2024, while the number of people living with obesity increased from 26.9% to 28.2% in males, and 30.1% to 34.8% in females between 2019 and 2024.

In children aged 2–15 years, 13% of girls and 18% of boys are estimated to be obese in 2019 (1). Static trends were run to 2024 for children due to small sample sizes and uncertainty around the projections.

Burden of obesity-related diseases

As a result of projected changes in rates of obesity between 2019 and 2024, it is estimated that there will be 6,671,307 new cases of the modelled obesity-related diseases (Table 1).

Table 1. Cumulative incidence of obesity-related diseases projected by 2024

Disease[1]	Cumulative incidence by 2024
Type 2 diabetes	1,567,250
Hypertension	888,251
CHD	737,135
Colorectal cancer	260,018
Gall bladder disease	1,587,937
Ovarian cancer	45,687
Stroke	794,328
Liver cancer	38,271
Depression	54,523
Knee osteoarthritis	697,907

1. These obesity-related diseases were identified through literature to be used in this study as outlined in Methods.

Intervention model

Of the 32 interventions, 25 had robust evidence of an effect on overweight or obesity and, therefore, these 25 policies were modelled to quantify their projected health impacts.

Cumulative incidence cases avoided

As a result of these Nesta policies, the greatest benefits were seen for outcomes including gallstone disease, T2D, and hypertension. The same 3 policies had the greatest impact on each of these: (a) a ban on all HFSS promotions in food retail businesses (volume and price), resulted in 33,562 cases of CHD avoided, 62,839 cases of hypertension avoided, and 119,288 cases of T2D avoided; (b) restricting checkout, end-of-aisle, and store entrance sales of HFSS food and drink ('Restrict in-store HFSS positioning') resulted in 17,640 cases of CHD avoided, 37,126 cases of hypertension avoided, and 63,595 cases of T2D avoided; and (c) regulating large retailers to change their organisation-wide converted NPM score to 69 or greater across their entire food product portfolio ('Introduce healthiness targets for large retailers'), resulted in 29,637 cases of CHD avoided, 57,094 cases of hypertension, and 107,009 cases of T2D avoided over the study period. Gallstone disease was also greatly impacted by these policies, with 143,888, 82,417, and 129,771 cases avoided due to (a), (b), (c) above respectively. These 3 policies resulted in the greatest total avoidance of disease burden.

Table 2 presents the cumulative incidence cases avoided by disease in 2024 for each policy.

Table 2. Cumulative incidence avoided by 2024 by policy

	Disease				
Policy	**CHD**	**Colon cancer**	**Depression**	**Gallstone disease**	**Hypertension**
Restrict advertising of HFSS products	17,213 (±1,948)	4,918 (±1,166)	1,043 (±531)	85,311 (±2,837)	38,735 (±2,107)
Ban HFSS volume promotions in food retail businesses	1,292 (±1,959)	763 (±1,166)	226 (±533)	3,096 (±2,875)	3,347 (±2,128)
Ban on all HFSS promotions in food retails businesses (volume and price)	33,562 (±1,938)	9,434 (±1,158)	1,246 (±530)	143,888 (±2,812)	62,839 (±2,092)
Ban HFSS volume promotions in out-of-home businesses	458 (±1,960)	639 (±1,166)	228 (±533)	-1,323 (±2,877)	1,433 (±2,129)
Ban discretionary HFSS promotions in out of home businesses	2,478 (±1,959)	948 (±1,165)	201 (±533)	8,460 (±2,873)	5,686 (±2,127)
Increase referrals to total diet replacement weight management	2,181 (±1,956)	1,574 (±1,164)	133 (±533)	22,799 (±2,866)	9,324 (±2,124)
Enforce front-of-pack labelling	8,610 (±1,954)	2,830 (±1,163)	352 (±532)	38,442 (±2,859)	19,001 (±2,119)
Restrict in-store HFSS positioning	17,640 (±1,948)	5,253 (±1,161)	655 (±532)	82,417 (±2,839)	37,126 (±2,108)
Restrict delivery platform HFSS 'location' promotion restrictions on delivery platforms	459 (±1,960)	630 (±1,166)	233 (±533)	-1,244 (±2,877)	1,453 (±2,129)
Mandate OOH sector to implement calorie reduction targets	469 (±1,960)	807 (±1,167)	602 (±532)	8,972 (±2,872)	5,196 (±2,127)
Mandate retailer and manufacturer calorie reduction targets	5,798 (±1,957)	2,023 (±1,165)	760 (±531)	34,947 (±2,861)	17,196 (±2,120)
Incentivise reformulation of HFSS	1,924 (±1,959)	763 (±1,166)	200 (±533)	5,639 (±2,874)	4,496 (±2,127)
Universal free school meals	-87 (±1,958)	-242 (±1,168)	-286 (±534)	610 (±2,876)	1,165 (±2,130)
Invest in active transport	-1,406 (±1962)	1,100 (±1,168)	458 (±532)	-1,963 (±2,877)	211 (±2,130)
Mandate health-based standards in public sector catering contracts	503 (±1,960)	688 (±1,166)	237 (±533)	-822 (±2,877)	1,638 (±2,129)
Increasing school-based physical activity	47 (±1,958)	-331 (±1,170)	211 (±533)	-2,661 (±2,877)	146 (±2,130)
Mass media campaigns	3,544 (±1,956)	1,664 (±1,165)	97 (±533)	10,761 (±2,871)	6,657 (±2,126)
Extend access to pharmacological interventions	461 (±1,956)	500 (±1,165)	143 (±533)	6,992 (±2,873)	1,780 (±2,129)
Extend access to Semaglutide	14,995 (±1,948)	6,582 (±1,158)	971 (±531)	150,398 (±2,807)	59,705 (±2,094)
Expand access to bariatric surgery	53 (±1,959)	27 (±1,166)	26 (±533)	792 (±2,876)	13 (±2,130)
Increase referrals to family-based obesity prevention programmes	-62 (±1,960)	126 (±1,167)	300 (±533)	-2,772 (±2,878)	-1,584 (±2,131)
Expand the soft drinks industry levy	1,172 (±1,959)	778 (±1,166)	248 (±533)	2,464 (±2,875)	3,064 (±2,128)
Implement the 'Recipe for Change' policy	13,211 (±1,951)	4,112 (±1,162)	549 (±532)	62,868 (±2,848)	29,032 (±2,113)
Fund citizen incentives to improve healthier behaviours	364 (±1,959)	595 (±1,165)	86 (±533)	5,535 (±2,874)	1,552 (±2,129)
Introduce healthiness targets for large retailers	29,637 (±1,939)	8,603 (±1,160)	1,083 (±531)	129,771 (±2,818)	57,094 (±2,096)

	Disease				
Policy	**Knee Osteoarthritis**	**Liver cancer**	**Ovarian cancer**	**Stroke**	**Type 2 Diabetes**
Restrict advertising of HFSS products	24,702 (±1,887)	612 (±445)	270 (±491)	9,182 (±2,037)	64,221 (±2,815)
Ban HFSS volume promotions in food retail businesses	1,882 (±1,903)	49 (±446)	-270 (±493)	1,066 (±2,039)	2,925 (±2,843)
Ban on all HFSS promotions in food retail businesses (volume and price)	49,307 (±1,870)	1,283 (±443)	146 (±492)	17,843 (±2,028)	119,288 (±2,790)
Ban HFSS volume promotions in out-of-home businesses	452 (±1,904)	54 (±446)	-232 (±493)	597 (±2,039)	26 (±2,845)
Ban discretionary HFSS promotions in out of home businesses	3,265 (±1,902)	113 (±446)	-297 (±493)	1,475 (±2,039)	6,532 (±2,842)
Increase referrals to total diet replacement weight management	2,530 (±1,902)	224 (±446)	105 (±492)	1,761 (±2,040)	-1,235 (±2,845)
Enforce front of pack labelling	11,965 (±1,896)	384 (±445)	-164 (±492)	4,449 (±2,037)	29,243 (±2,831)
Restrict in-store HFSS positioning	25,741 (±1,887)	726 (±444)	-71 (±492)	9,501 (±2,035)	63,595 (±2,816)
Restrict delivery platform HFSS ‘location’ promotion restrictions on delivery platforms	470 (±1,904)	53 (±446)	-235 (±493)	615 (±2,039)	79 (±2,845)
Mandate OOH sector to implement calorie reduction targets	1,716 (±1,903)	-164 (±447)	93 (±492)	191 (±2,042)	4,894 (±2,842)
Mandate retailer and manufacturer calorie reduction targets	9,862 (±1,897)	-24 (±447)	63 (±492)	2,587 (±2,041)	22,934 (±2,834)
Incentivise reformulation of HFSS	2,491 (±1,903)	61 (±446)	-277 (±493)	1,275 (±2,039)	4,528 (±2,843)
Universal free school meals	-860 (±1,905)	261 (±446)	-122 (±492)	971 (±2,048)	-186 (±2,845)
Invest in active transport	-1,050 (±1,905)	173 (±446)	-405 (±493)	-442 (±2,045)	287 (±2,845)
Mandate health-based standards in public sector catering contracts	573 (±1,904)	52 (±446)	-235 (±493)	709 (±2,039)	315 (±2,845)
Increasing school-based physical activity	-11 (±1,904)	270 (±446)	-105 (±492)	1480 (±2,041)	-1,471 (±2,845)
Mass media campaigns	3,538 (±1,902)	95 (±446)	-111 (±492)	-51 (±2,045)	13,577 (±2,839)
Extend access to pharmacological interventions	-524 (±1,905)	130 (±446)	-125 (±492)	682 (±2,040)	-938 (±2,845)
Extend access to Semaglutide	25,707 (±1,887)	1,041 (±444)	367 (±491)	6,945 (±2,036)	21,740 (±2,844)
Expand access to bariatric surgery	238 (±1,904)	5 (±447)	-53 (±492)	-92 (±2,040)	-172 (±2,845)
Increase referrals to family-based obesity prevention programmes	-1,345 (±1,905)	182 (±446)	-164 (±492)	107 (±2,095)	426 (±2,845)
Expand the soft drinks industry levy	1,737 (±1,903)	59 (±446)	-266 (±493)	1,036 (±2,039)	2,521 (±2,844)
Implement the ‘Recipe for Change’ policy	19,395 (±1,891)	586 (±445)	-84 (±492)	7,212 (±2,036)	48,356 (±2,822)
Fund citizen incentives to improve healthier behaviours	838 (±1,904)	136 (±446)	-74 (±492)	4733 (±2,039)	2,604 (±2,844)
Introduce healthiness targets for large retailers	44,039 (±1,874)	1,103 (±444)	98 (±492)	15,773 (±2,029)	107,009 (±2,795)

Cost-effectiveness analysis

We modelled a 6 year time horizon, in contrast to longer-term government impact assessments. Of the 25 modelled interventions, 9 were cost-saving and 3 were cost-effective at a threshold of £20,000/QALY, with the remainder either not cost-effective or not significant. With a longer time horizon, it may be that more of the policies, especially those directed towards children, would become cost-effective, since preventing obesity early in life would help prevent later onset obesity-related NCDs (Table 3). Taking a less stringent threshold of £60,000/QALY would make another 1 policy cost-effective.

Table 3. Intervention cost and cost-effectiveness value by policy

Policy	Effect size	Intervention cost	Government cost	Industry cost	ICER	NMB	QALY gained
Restrict advertising of HFSS products	-59.6 kcal (Adults); -57.7 kcal (Children)	£273.18M	£107.19M	£165.99M	-£14,870.32	£4.16bn	119,290
Ban HFSS volume promotions in food retail businesses	-2.6 kcal (Adults); -2.48 kcal (Children)	£50.86M	£0.51M	£50.35M	ns	£43.80M	2,323
Ban on all HFSS promotions in food retails businesses (volume and price)	-87.6 kcal (Adults)	£107.86M	£0.51M	£107.35M	-£15,906.84	£7.78bn	216,565
Ban HFSS volume promotions in out-of-home businesses	-0.52 kcal (Adults)	£15.67M	£0.52M	£15.15M	ns	-£139.93M	-3,699
Ban discretionary HFSS promotions in out of home businesses	-5.15 kcal (Adults)	£27.19M	£0.52M	£26.67M	-£13,697.80	£286.55M	8,504
Increase referrals to TDR weight management services	-10.7kg, with a regain of 2.2kg for 2 years	£1.86bn	£1.86bn	£0	-£12,893.75	£6,913,297,342	210,171
Enforce front of pack labelling	-27kcal (Adults)	£32.8M	£20.5M	£12.3M	-£17,049.89	£1.89bn	51,116
Restrict in-store HFSS positioning	-60 kcal (Adults); -66 kcal (Children)	£2.53bn	£0.23M	£2.53bn	£5,072.35	£1.70bn	113,972
Restrict delivery platform HFSS 'location' promotion restrictions on delivery platforms	-0.71 (Adults)	£5.57M	£0.05M	£5.52M	ns	-£126.10M	-3,637
Mandate OOH sector to implement calorie reduction targets	-0.92kcal (Adults)	£2.15bn	£11.69M	£2.14bn	£276,441.30	-£1.80bn	7,007
Mandate retailer and manufacturer calorie reduction targets	-22 kcal (Adults); -21.3kcal (Children)	£7.03M	£0.18M	£6.85M	-£17,159.64	£1,721,963,173	46,340
Data collection on the healthiness of product portfolios	0	£4.11M	£1.65M	£2.46M	NA	NA	NA

Policy	Effect size	Intervention cost	Government cost	Industry cost	ICER	NMB	QALY gained
Incentivise reformulation of HFSS	-3.81kcal (Adults)	£467.31M	£467.31M	£0	£74,122.31	-£275.09M	5,083
Obesity monitoring for children	0	£86M	£86M	£0	NA	NA	NA
Reduce number of takeaways in proximity to schools	0	£554,602	£554,602	£0	NA	NA	NA
Grocery stores in deprived areas with low supermarket density	0	£7.13M	£7.13M	£0M	NA	NA	NA
Universal free school meals	BMI reduction of 8.7%, 6.5% and 2.8% for children aged 5-7, 8-10, and 11-12 respectively	£14.60bn	£14.60bn	£0	ns	-	-
Extend Healthy Start	0	£397.21M	£397.21M	£0	NA	NA	NA
Invest in active transport	Increase of 2.14 minutes per week of active travel for every 1 kilometre closer they lived to the infrastructure.	£467.31M	£467.31M	£0	ns	-	-
Mandate health-based standards in public sector catering contracts	-1.00kcal (Adults)	£13.69M	£13.69M	£0	ns	-	-
Nutritional education in schools	0	£467.31M	£467.31M	£0	NA	NA	NA
Increasing school-based physical activity	-0.07kg/m^2 (Children 5-18)	£467.31M	£467.31M	£0	ns	-	-
Mass media campaigns	-8.09kcal (Adults)	£5.77M	£5.77M	£0	-£17,161.38	£640.00M	17,222
Extend access to pharmacological interventions	-11.1% weight loss yr 1, 67% regain	£2.34bn	£2.34bn	£0	£29,451.72	£405,703,386	42,929
Extend access to Semaglutide	-15.83% change in weight, with a 67% regain (Adults)	£38.04bn	£38.04bn	£0	£11,714.26	£9,424,976,175	1,137,493

Policy	Effect size	Intervention cost	Government cost	Industry cost	ICER	NMB	QALY gained
Expand access to bariatric surgery	-23% weight loss, 0.81kg annual weight regain (Adults)	£280.80M	£280.80M	£0	£6,146.88	£212.89M	15,367
Increase referrals to family-based obesity prevention programmes	-0.01kg/m2 in QIMD 4 or 5 (Children 5-18yrs)	£397.21M	£397.21M	£0	ns	-	-
Expand the soft drinks industry levy*	-2.3kcal (Adults)	-£107M	-£107.12M	£0.11M	ns	ns	1,891
Implement the 'Recipe for Change' policy*	-44.9kcal (Adults)	-£18.28bn	-£18,278M	£1.87M	-£231,646.80	£21.48bn	85,348
Fund citizen incentives to improve healthier behaviours	-1.2kg in the first year, then a regain of 0.01kg per month (Adults)	£467.31M	£467.31M	£0	£110,177.46	-£326,223,776	3,618
Achieve Baby Friendly accreditation from UNICEF	0	£300.49M	£300.49M	£0	NA	NA	NA
Introduce healthiness targets for large retailers	-78kcal (Adults)	£56.27M	£0.25M	£56.02M	-£16,227.92	£7.05bn	194,716

*NA, not applicable because the effect size is 0 so assumed no difference from baseline; ns, results show that the ICER is not significantly different from baseline; '-' not reported since the ICER is not significant. ICER colour reflects cost-effectiveness: green=cost-saving; orange=cost-effective at a threshold of £20,000/QALY; red=not cost-effective. *These policies generate revenue for government, therefore total intervention costs are negative.*

Discussion

This study quantified the 6-year economic impact of a range of policy interventions to reduce overweight and obesity either in children, adults or both children and adults in the UK. Of the 32 policies, 9 were cost-saving, 3 were cost-effective, and 20 were not significant or not cost-effective at a willingness-to-pay threshold of £20,000 per QALY. Fiscal policies (i.e. adding taxes to sugar and salt) were the most cost-saving. Using a less a stringent WTP threshold of £60,000/QALY would result in the GLP-1 policy ('Extend access to pharmacological interventions') becoming cost-effective.

Fiscal policies can potentially alter consumption patterns by discouraging consumption of unhealthy foods and encouraging consumption of healthier foods through subsidies and other support. The food environment that surrounds most people in their daily lives is filled with highly processed and easily accessible foods rich in unhealthy fats, sugars, and salt. These foods are often aggressively marketed and relatively cheap. Consequently, people frequently struggle to make nutritious food choices. Unhealthy eating habits have become a major global public health concern, leading to non-communicable diseases (NCDs) such as obesity, diabetes, heart disease, stroke, and various cancers (16). This study shows that strong fiscal policies are effective in reducing these NCDs, highly cost-effective for health systems and revenue generating for governments.

When comparing the range of policies modelled, there are several points to consider. Firstly, with regards to policies impacting children alone, none of the policies were cost-effective. However, it is important to note that the diseases modelled were largely 'older age' diseases, therefore the effects of these policies will take many years to unfold, and longer than the 5-year time horizon studied here; the aim of this project was to examine reducing existing levels of overweight and obesity, rather than preventing healthy weight individuals from moving towards becoming overweight or obese. Therefore, it is important to note that policies that help to establish healthy eating behaviour early in life are imperative to prevent weight gain and related diseases in adulthood (17). Furthermore, these policies provide other benefits to children that are not captured in this study, such as improved diet/nutrition, dental health, and educational outcomes (18-21).

Second, there are population-level policies, such as marketing restrictions with smaller effect sizes, that capture a larger group of people in comparison to individual-level interventions, such as bariatric surgery, which have a large effect size but capture fewer people. These varying types of policy interventions have different mechanisms for producing a cost benefit. For example, some may focus on population behaviour change, and others on individual clinical treatment, with the former working to prevent the onset of obesity-related diseases, while the latter is effective in putting some of these diseases (such as diabetes and hypertension) into remission. We note that we found no significant impact of bariatric surgery or pharmacological interventions in reducing the number of new cases of obesity-related disease.

Third, it is important to consider the decisions that were made when quantifying policy costs. For example, for the policies previously proposed by the UK government (e.g. restricting advertising and banning price promotions for HFSS foods), we took the lower cost estimates provided in government impact assessments for the proposed policy, to remain conservative in our projections. Further, the direct pass-on of costs to consumers was not considered, as we assumed most costs would be to industry and government. However, it is unclear how industry would respond to a new policy and what costs, if any, would be passed on to consumers. For example, the soft drinks industry level (SDIL), which was not designed to be a direct tax on consumers, saw the industry fully pass on the levy to consumers in the form of step changes in prices; noticeable and immediate price increases in the higher category of eligible beverages (i.e. drinks with high sugar content) were observed after the levy was introduced (22).

Finally, there is the political and real-world feasibility and acceptability of these policies to consider when interrogating their costs. For example, a 'low hanging fruit' policy, such as extending free school meals to all primary school children, would be relatively simple to implement and would likely be very popular nationally. However, the policy is relatively costly, and the return on investment would require a longer time horizon than what is presented here.

Strengths and limitations

There are both strengths and limitations that should be considered when interpreting the findings of this study and drawing conclusions.

One of the key strengths of this study is that it uses well-validated microsimulation methods that enable virtual populations of many millions of individuals to be simulated, capturing the heterogeneity observed in real-world populations of interest. The model incorporates data from multiple sources, including epidemiological studies, published datasets, and observational data. Further, this study was able to extract the most recent data from the Office for National Statistics, Health Survey for England, and wider literature to replicate the characteristics of the population of the UK. While this study is specific to the population of the UK, the model can easily be adapted to other countries and regions where different epidemiological and risk factor trends may be observed.

Limitations of this study include the granularity of some epidemiological data used, particularly concerning the relative risks for BMI-related complications in children. Further, some relative risks were categorical, so small changes in BMI may not have impacted disease burden. Consequently, some effects, such as for T2D, are likely to be underestimated, since only categorical rather than dose-response relationships were available for children. Also, the costs of interventions were not always available, meaning that reliance on proxy data was necessary in some cases. However, the model is flexible in that it can easily be updated as soon as new estimates become available. Lastly, informal social care was not accounted for in this study, and therefore the savings stated in this study would likely have been much greater if these costs had been considered.

Future work

Future work might quantify the impact of combined 'baskets' of interventions. It would also be important to consider policy impacts by different socio-economic groups and the extent to which policies narrow health inequalities in obesity-related disease. However, the extent of this project is such that effect size data may not yet be granular enough to carry out such analysis. Given that NCDs have several interacting risk factors, including obesity, alcohol consumption, and smoking, future work might also quantify the health and economic impact of a package of consecutive fiscal policies to combat a range of NCD risk factors as part of a wider public health package of policies. Examples of such policies might include sugar taxes, minimum unit pricing of alcohol, and a tobacco duty escalator (23, 24).

This study modelled a 6-year time horizon only, with the effect of a policy implemented in 2019 quantified over the consecutive 5 years. However, as mentioned above, obesity-related NCDs tend to be older age conditions, therefore the full effects of these policies may not unfold for many years. Therefore, future work might model these policies (at least the child-focussed policies) 10 or 20 years into the future.

Conclusion

In conclusion, this report emphasises the significant potential of implementing targeted obesity interventions to mitigate the growing health and economic burden associated with obesity in the UK. Through rigorous microsimulation modelling, it was demonstrated that several of the selected policies could effectively reduce the prevalence of obesity, thereby lowering the incidence of related diseases and improving QALYs. Moreover, the cost-effectiveness analysis indicates that many of these interventions provide substantial health benefits relative to their costs, making them viable options for policymakers aiming to address this public health challenge. The findings support the prioritisation of these interventions as part of a broader strategy to combat obesity, ultimately contributing to improved public health outcomes and reduced healthcare expenditures in the UK.

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