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A health economic evaluation of menu calorie labelling in the out-of-home sector in England: a modelling study

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Background: In 2022, England mandated calorie labelling for large businesses. While short-term evaluations exist, the long-term cost-effectiveness of this policy remains unknown. This study estimates long-term cost-effectiveness of the out-of-home calorie labelling policy by extrapolating real-world evidence that has estimated the short-term policy effects in England.

Methods: The lifetime health and economic impacts of out-of-home calorie labelling were simulated using a microsimulation model. The analysis adopted a public sector perspective to compare the policy with a counterfactual 'no intervention' scenario. The simulation generates a synthetic population for England aged 13–79 years combining data from the National Diet and Nutrition Survey (2009–19) and Health Survey for England (2018, 2019). The policy may impact calories consumed through two mechanisms: consumer behaviour changes and menu changes (reformulation and menu composition). Effect sizes were estimated from real-world evaluations of the policy implemented in England. Changes to daily calorie intake as a consequence of the policy were translated to modified weight trajectories. Simulated outcomes included changes in obesity, diabetes cases and related complications, cardiovascular events, osteoarthritis, cancers, dementia, quality-adjusted life years (QALYs) and National Health Service (NHS) costs. The results of this analysis were estimated from a Probabilistic Sensitivity Analysis (PSA) reported with 95% Uncertainty Intervals (UI) to explicitly account for and describe parameter uncertainty.

Results: The policy is likely to be cost-effective, yielding a lifetime per person cost-saving of -£9.15 (95% UI -£31.63, £2.90) (cost saving), and incremental QALYs 0.0021 (95% UI -0.0008, 0.0048) per person. The incremental net benefit was £50.23 (95% UI -£16.41, £74.68), with 94% of simulated iterations below the £20,000 per QALY willingness to pay threshold. Slightly greater cost-savings (–£10.62 95% UI -£40.49, £6.40) and QALY gains (0.0022 95% UI -0.0006, 0.0049) were observed in the most deprived group.

Conclusion: England's menu calorie labelling policy represents a cost-effective public health intervention from a public sector perspective, but the result is uncertain and conditional on modelling assumptions. The model identified greater incremental benefits in more deprived groups.

KEYWORDS

calorie labelling, economic evaluation, modelling, out of home, public health

Background

Obesity has increased globally in recent years and in 2022, 64.0% of adults aged 18 years and over in England were estimated to be overweight or living with obesity (1, 2). Obesity is associated with reduced life expectancy and is a risk factor for a range of chronic diseases, including cardiovascular disease and type 2 diabetes mellitus (3). Obesity has a strong association with socioeconomic position (2) and high economic impact (4). Obesity is a complex chronic disease shaped by obesogenic environments rather than individual behaviour alone. In England, the increased prevalence of eating out of the home has been attributed to increased calorie consumption in the out-of-home sector (5). Out-of-home foods are consistently linked to higher consumption of energy and nutrients of concern, such as saturated fat, salt, and sugar (6). Area level deprivation correlates strongly with takeaway outlet density, which influences diet quality and body weight in disadvantaged communities (7). To address these systemic drivers, the World Health Organization (WHO) emphasises a multi-sectoral strategy advocating policy action such as mandatory nutrition labelling, fiscal measures and marketing restrictions (8).

In April 2022, the government introduced a mandatory calorie labelling policy in England, which required large businesses (with 250 or more employees) selling food and drinks (e.g., restaurants, cafes, fast-food chains) to show calorie information [in kilocalories (kcal)] of food and non-alcoholic drink items prepared for immediate consumption at the point of choice (9). Prior to implementation, studies suggested that only 17–24% of businesses provided in-store menu calorie labelling (10, 11). The objective of the menu calorie labelling regulations was to support consumers to make informed choices by providing calorie information, and encourage businesses to reformulate their menus to reduce the calorie content of the food on offer (9).

Evidence for the effect of menu calorie labelling on calories purchased and consumed in the out-of-home sector reports mixed findings. A meta-analysis of studies found that menu labelling alone was not significantly effective in modifying menu selection (−37 kcal, 95% CI -95.85 to 34.18), but was effective if accompanied by information to add context and interpretation (−67 kcal 95% Confidence Interval (CI) -116.99 to −17.79) (12). Alternative meta-analysis of calorie labelling in out-of-home settings estimate statistically significant reductions of -47 kcal (13), with a later update finding a more modest −11 kcal (14) in energy purchased per 600 kcal meal. Furthermore, in a recent meta-analysis, researchers estimated that retailers reduced the energy content of menu items by 15 kcal on average (95% CI 8 to 23) following calorie labelling (15).

Mathematical models can be used in public health to bring together information from multiple sources to forecast policy effects (16). By extrapolating short-term changes in intermediate outcomes, such as calorie changes, models enable policymakers to evaluate long-term health and cost-effectiveness (17). Furthermore, simulation modelling allows for the exploration of heterogeneous effects across socioeconomic groups, identifying populations most likely to benefit from interventions.

Broadly modelling studies in the United Kingdom and European countries (18, 19), and cost-effectiveness analyses for the United States (20–22) and Kenya (23) have found that out-of-home calorie labelling policy would improve long term health outcomes due to changes in consumer behaviour, and menu change (18–20, 22). However, predictive models operate under simplified assumptions that cannot fully capture the friction of complex, dynamic food systems. Implementing public health policies in the real world introduces significant uncertainties surrounding real-world compliance, enforcement, consumer awareness, and industry adaptation (24). To bridge this gap between theoretical projection and population impact, robust real-world evidence derived from natural experiment methodologies is critical (25, 26). Natural experiments evaluate policies as they naturally unfold in real time, capturing empirical dynamics that models overlook and providing the grounded data needed to update and recalibrate future economic evaluations (24).

Recent real-world evaluations of England's mandatory calorie labelling policy have failed to detect a statistically significant impact on individual calorie consumption (27, 28), challenging the primary driver of health benefits assumed in earlier modelling studies. Emerging real-world evidence supports prior evidence identifying a reduction in the caloric content of food offerings driven by voluntary menu changes by out-of-home businesses (29, 30). Furthermore, while UK evaluations have measured the dietary and health impact of the policy, no study to date has translated this real-world evidence into formal cost-effectiveness analyses or economic evaluations tailored to the UK healthcare context.

The aim of this study is to estimate the lifetime cost-effectiveness of the out-of-home calorie labelling policy in England on health outcomes and healthcare costs, and to observe the distribution of these impacts across socioeconomic groups. The analysis is novel as it draws on emerging evidence from real-world evaluations of the policy in England to understand the effects of the intervention instead of relying on global meta-estimates.

Method

Health economic analysis

We evaluated the lifetime discounted costs and Quality-Adjusted Life Years (QALYs) to estimate the incremental net benefit of calorie labelling compared with no intervention assuming a willingness-to-pay threshold of £20,000 per QALY (31). A lifetime perspective was chosen to capture long-term impacts of body mass index (BMI) on non-communicable disease outcomes and mortality.

The analysis adopted a public sector perspective to include direct medical costs, social care costs and costs incurred by actors whose primary intent is to improve human health (32). In this example the analysis includes the cost to national and local governments to implement and enforce the calorie labelling policy, but excludes costs incurred by businesses. Costs were inflated to 2022 prices, and costs and QALYs were discounted at a rate of 3.5% (31). We conducted probabilistic sensitivity analysis (PSA) with 1,000 samples taken from an appropriate statistical distribution. A completed AdViSHE checklist detailing the model validation process can be found in Section 11 of the Supplementary material (33). A Consolidated Health Economic Evaluation Reporting Standards 2022 (CHEERS) checklist for the analysis is provided in the Supplementary material section 13 (34).

Baseline population

The baseline population was based on individuals aged 13–79 extracted from the Health Survey for England (HSE) 2018 and 2019 (35). These years of the HSE were chosen to reflect the survey data available at the time of analysis and inclusion of key health information needed for the model, such as the EQ-5D, that is not collected in every survey year. From this dataset, information on individuals' age, sex, ethnicity, socioeconomic profile [Index of Multiple Deprivation and National Statistics Socio-economic classification (NS-SEC)], metabolic risk factors (weight, height, systolic blood pressure, total cholesterol, High Density Lipoprotein (HDL) cholesterol, HbA1c), medical history and health-related quality of life (EQ-5D) was collected. Missing data were imputed to preserve demographic representation in the dataset, using predictive mean matching. Age in years was imputed using additional data from HSE 2014. The National Diet and Nutrition Survey (NDNS) collects detailed information on food consumption in the United Kingdom (UK) (36). The survey asks respondents to report on the frequency that respondents purchase meals out-of-home and from take-aways (36). All years of the NDNS were included to increase the sample size and improve the precision of estimates for out-of-home (OOH) preferences across sociodemographic groups. Data synthesis was conducted to combine individual data from the HSE and NDNS accounting for common sociodemographic factors including age, sex, NS-SEC and ethnicity. The method uses iterative proportional fitting (37) to align with age-sex distributions from the census 2021 data (38) and matches individuals from HSE to out-of-home eating preferences within similar sociodemographic groups reported in the NDNS population. Table 1 summarises the characteristics of the synthetic population in comparison with the source datasets. Further details on data synthesis provided in section 2 of the Supplementary material.

Intervention effects

The intervention effects and cost of calorie labelling are reported in Table 2. The effect of the calorie labelling policy on calories is described through two mechanisms. First, calorie labelling may impact consumer behaviour, i.e., the choice of foods from menus affected by the policy. Second, restaurants may change their menus (recipe change, portion size or new products hereafter referred to as menu change) in response to the policy. In the base case, both mechanisms apply to individuals reporting food consumption from the out-of-home sector. We compare the intervention with a counterfactual 'no intervention' scenario. Wider impacts on dietary quality are not included due to an absence of evidence on wider nutritional intake.

Estimated change in consumer behaviour was taken from a post-implementation study using controlled interrupted time series analysis of market research data for the out-of-home sector. Kalbus et al. estimated a non-significant reduction in calories purchased from the out of home sector of −95.6 kcal (95% CI -471.2 to 280.0) per person per week, and an increase in calories in the time trend coefficient (28). Using static, unchanged calorie labels, their analysis excludes reformulation effects. The total change in calories purchased per day was estimated based on the difference in calories observed in the first 6 months after the policy was implemented. The analysis assumes equivalence in purchases and consumption of calories. The time trend estimate in this analysis indicated that any initial change in calorie consumption was not sustained over the long term, a pattern also seen in other studies (62). We assume consumer behaviour returns linearly to baseline levels after 6 months, with the total change in calories averaged over the first cycle of the model as a daily reduction in calories. Based on the estimated effect and trend from Kalbus et al. (28) and the assumptions described above, we estimated an average daily reduction in calories of 2 kcal per day (95% CI -36.4 to 32.6) averaged over the first 12 months. Changes to calorie intake impacted the simulated weight trajectories in the first year of the simulation after which weight returned to the natural history trajectory. Due to the small and non-significant effects on purchases from large chains, we also assume no impact on calories consumed across other meals.

Changes in restaurants' response to the policy are captured through the estimated change in average calories on the menu pre- vs. post-policy in England. Essman et al. (29) estimated that the average calories per menu item was reduced by 9 kcal (95% CI 16 to 1 kcal). Daily calorie change per person was then estimated by multiplying the change in average calories per menu item by the number of dishes purchased per week from chains (1.56 per week) [authors' analysis of Worldpanel by Numerator's OOH Purchase panel, 47 weeks ending 27 November 2022 (28)]. Change in daily calories consumed due to menu changes was assumed to be maintained over time, which would lead to a long-term reduction in weight trajectories due to a reduction in excess calorie consumption.

The costs of enforcing the policy are taken from a government policy impact assessment which estimated £25,000 for implementation, and £100,000 per year for enforcement (40). We reflected uncertainty in the implementation costs by assuming the standard error of the total costs was 10% of the point estimates. Industry costs for reformulation and menu changes are not included in line with a public sector perspective. Table 2 reports the treatment effects and costs, with full details on input parameters and uncertainty distributions used in probabilistic sensitivity analysis provided in the Supplementary material.

Simulation model

We used a discrete microsimulation model (School for Public Health Research (SPHR) Obesity and Diabetes Prevention Model) with one-year cycles that meets the requirements of behavioural interventions for obesity to estimate the effects of the mandatory calorie menu labelling policy in England (41, 42). The model code for the analysis is available on request to the corresponding author. The model sampled 200,000 individuals using population weights designed to match the age-sex distribution of the target population of England

TABLE 1 Simulated baseline population representative of the general population of England aged 13–79 compared with underlying data sources.

Variable		Census 2021 (38)	Health survey for England 2018/19 (39)	NDNS waves 1–11 (36)	Simulated Cohort
Male		49%	45%	43%	49%
Female		51%	55%	57%	51%
Age 13–24 years		18%	14%	32%	17%
Age 25–34 years		17%	14%	13%	17%
Age 35–44 years		16%	17%	16%	16%
Age 45–54 years		16%	18%	16%	16%
Age 55–64 years		16%	17%	13%	16%
Age 65–79 years		17%	22%	15%	18%
White ethnicity		82%	85%	91%	85%
Non-white ethnicity		18%	15%	9%	15%
IMD5 (least deprived)		NA	19%	NA	19%
IMD4		NA	20%	NA	20%
IMD3		NA	20%	NA	20%
IMD2		NA	21%	NA	21%
IMD1 (most deprived)		NA	20%	NA	21%
Healthy weight^		NA	33%	36%	35%
BMI 25-30 kg/m^2 ^		NA	36%	37%	36%
BMI > =30 kg/m^2 ^		NA	30%	28%	29%
Out-of-home consumption (takeaways or meals out at least once per month)	Whole population	NA	NA	85%	85%
	NSSEC1 (Higher managerial, administrative and professional occupations)	NA	NA	90%	90%
	NSSEC2 (Lower managerial, administrative and professional occupations)	NA	NA	84%	85%
	NSSEC3 (Intermediate occupations)	NA	NA	86%	84%
	NSSEC4 (Small employers and own account workers)	NA	NA	84%	82%
	NSSEC5 (Lower supervisory and technical, semi-routine, and routine occupations)	NA	NA	78%	77%
	Never worked, unemployed and unclassified	NA	NA	83%	84%
Mean age (SD)		NA	47.6 (17.8)	41.0 (19.3)	44.6 (18.3)
Mean BMI (SD)		NA	28.0 (5.8)	27.5 (5.5)	27.7 (5.8)

Baseline demographic and clinical characteristics of the simulated English population aged 13–79 (N = 200,000). Values represent the summary characteristics of the synthetic cohort generated via microsimulation, weighted to be representative of the adult population in England. Data are presented as means (SD) for continuous variables and % for categorical variables. IMD, Index of Multiple Deprivation; BMI, Body Mass Index. ^ Estimated for sample over age of 18 only.

aged 13–79. The stability assessment demonstrated that lifetime incremental net benefit was stabilised at sample sizes exceeding 100,000 individuals, but a larger sample size was required to achieve stability in short-term estimates (Supplementary Figure S5). Changes to daily calorie intake were used to modify simulated weight trajectories based on an approximation of the Hall et al. calorie-to-weight conversion (43). While the conversion is traditionally used to estimate weight loss, it is applied here to project how curbing calorie consumption

TABLE 2 Estimated change in average calories from behavioural change and menu changes in base case.

Input parameter	Mean	95% Confidence Interval	Source
Base case change in calories per day for behavioural effects	−2 kcal	−35.9 to 33.1 kcal	Kalbus et al. (28)
Base case change in calories per dish on menu	−9 kcal	−1 to −16 kcal	Essman et al. (29)
Base case occasions per week purchase occasions per week from out-of-home sector chains	1.56	NA^	Author's own analysis *
Year 1 implementation cost	£25,000	Assumed standard error: 10% of mean	Impact Assessment (40)
Ongoing enforcement costs (per year)	£100,000	Assumed standard error: 10% of mean	Impact Assessment (40)
SA 3: Male and low SES purchase occasions per week from out-of-home sector chains	1.50	NA^	Author's own analysis *
SA 3: Male and high SES purchase occasions per week from out-of-home sector chains	1.65	NA^	Author's own analysis*
SA 3: Female and low SES purchase occasions per week from out-of-home sector chains	1.43	NA^	Author's own analysis*
SA 3: Female and high SES purchase occasions per week from out-of-home sector chains	1.57	NA^	Author's own analysis*
SA 4: Menu change for IMD1 (most deprived)	−20.22 kcal	−21.44 to −18.99	Unpublished estimates from study reported in Kalbus et al. (30) Calorie labelling and changes in the calorie content of food and drink available for online food delivery over time
SA 4: Menu change for IMD2	−19.07 kcal	−20.43 to −17.70	
SA 4: Menu change for IMD3	−16.25 kcal	−17.82 to −14.67	
SA 4: Menu change for IMD4	−17.13 kcal	−18.81 to −15.45	
SA 4: Menu change for IMD5 (least deprived)	−16.23 kcal	−17.86 to −14.60	
SA 7: change in calories per dish for behavioural effects	−47 kcal	−15 to −78	Crocket et al. (13)
SA 7: change in calories per dish on menu	−15 kcal	−8 to −23	Zlatevska et al. (15)

This table summarizes the baseline values and distribution parameters used to simulate the health and economic impacts of the calorie labelling policy. All parameters were derived from existing literature and real-world evidence from the 2022 policy implementation in England. ^ Standard errors for mean number of occasions per week could not be estimated with sample weights. * Authors' analysis of World panel by Numerator's OOH Purchase panel, 47 weeks ending 27 November 2022 (28).

attenuates weight gain. Natural history weight and height trajectories were simulated using age trends identified within HSE. Heterogeneity in growth rates was captured by recording each individual's baseline percentile within their specific age-and-sex category. This baseline rank was then used to project their subsequent height and weight trajectories across subsequent age categories. Long-term trajectories for other metabolic risk factors (HbA1c, systolic blood pressure, total cholesterol, HDL cholesterol) were simulated based on analyses of existing UK cohort studies and a UK prospective diabetes study in patients with recently diagnosed type 2 diabetes (41, 44, 45). Major health events related to obesity and diabetes were simulated conditional on sociodemographic risk factors and BMI, systolic blood pressure, HbA1c and cholesterol. Type 2 diabetes diagnosis was simulated using the QDiabetes risk equations (46), first cardiovascular event was simulated from the QRISK2 risk equation (47), heart disease from the Framingham risk equation (48), microvascular complications from the UKPDS risk equations (49), cancer risk was associated with BMI using a meta-analysis of prospective observational studies (50), colorectal cancer risk estimated from the European Prospective Investigation Into Cancer and Nutrition (EPIC) cohort and dementia from UK risk equations (51). Cardiovascular disease, cancer, dementia, and end stage kidney failure increase the risk of mortality and all-cause mortality was conditional on age and sex based on population life tables (52). Full details of the model, including parameter inputs are provided in the Supplementary material.

The microsimulation assigns costs to healthcare utilisation throughout the life course of the simulated population. General Practitioner (GP) attendance, diabetes diagnosis, medication and monitoring, hypertension treatment, statin use all incur healthcare costs from recommended UK costing sources (31). Major health events such as cardiovascular disease, cancer, osteoarthritis and dementia incur healthcare costs identified from costing studies

(53–55). Social care costs were estimated for individuals aged over 65 years, and were conditional on age and BMI (56).

Statistical uncertainty and sensitivity analyses

In accordance with standard health economic modelling recommendations (57), parameter uncertainty was characterised within a decision-theoretic framework using probabilistic sensitivity analysis (PSA). Statistical distributions were fitted to the summary statistics of the model parameters. Monte Carlo simulation (1,000 iterations) was used to propagate these input distributions through the decision model, generating 95% Uncertainty Intervals (95% UIs) based on the 2.5th and 97.5th percentiles of the simulated outcomes. Details on the form of distribution are provided in sections 3–9 of the Supplementary material. Subgroup analyses were stratified by index of Multiple Deprivation (IMD) quintiles due to ongoing interest in the sociodemographic impacts of the policy (39) and in line with interest from project stakeholders and public participants. Two sensitivity analyses (SA) estimated the impact of consumer behaviour and menu changes separately (SA1 and SA2, respectively). All other sensitivity analyses (SA 3–11) were conducted with a sample of 100,000 due to computation time. Two sensitivity analyses tested the sensitivity of the results to variation in the effectiveness of the intervention by socioeconomic status (SA3 and SA4). In SA3, the policy effects were stratified by sex and occupational social class to incorporate estimations from an analysis that predicted larger, but non-significant, behavioural response for high occupational social class women and more frequent out-of-home consumption for high occupational social class men (28). The analysis was conducted as part of a previous study but not previously reported (see Supplementary material) (30). In SA4, menu changes were estimated from changes in average calories between June 2022 and June 2023 on two online delivery service platforms stratified by IMD (based on where restaurants deliver to). The analysis identified greater calorie reductions on menus in areas of greater deprivation, indicating greater potential for reductions in calorie consumption in low socioeconomic groups (30). Two further sensitivity analyses varied discount rates to 0 and 5% (SA5 and SA6). Another sensitivity analysis utilised alternative sources of evidence for consumer effects from a meta-analysis of evidence indicating significant reductions in consumer behaviour [SA7–47 kcal per meal (13), SA8–11 kcal per meal (14)] and larger menu change effects (−15 kcal per meal) than in the base case. In SA9, a three-year delay to the menu change effects was simulated reflecting observations that menu change is more likely driven by new lower calorie menu items rather than reformulating existing items, extending the time for consumers to change their habits (58). SA10 included an indirect effect on blood pressure, cholesterol and HbA1c via changes in weight (59). Finally, we varied the method for converting calories to weight in SA11 (60).

Results

The simulation predicted a reduction in obesity [−71,414 cases (95% UI -618,881 to 547,492)] for the English population aged 13–79 in the first 12 months of the policy (Table 3) and modest reductions in diabetes (−3,684 95% UI -17,175 to 4,300), myocardial infarction (−136 95% UI -1,808 to 1,588) and cardiovascular deaths (−92 95% UI -1,582 to 1,130) after 10 years.

The base case simulation of mean gain in lifetime QALYs and reduction in lifetime costs results in an incremental net benefit of £50.23 at a willingness-to-pay threshold of £20,000 per QALY (Table 4). Parameter uncertainty in the simulated cost-effectiveness indicates a high probability that the policy is cost-effective in the base case with 94% of simulated iterations below the £20,000 per QALY threshold. The scatter plot in Figure 1A highlights that there is uncertainty in the incremental cost-effectiveness estimates, but the majority of the points lie below the £20,000 per QALY threshold. Stratification of the policy effects by socioeconomic status (Index of Multiple Deprivation) indicated that the lifetime QALYs per person are greatest in IMD 1 and 2 groups (more deprived groups), due to the younger age of this group. The incremental effects on health and heath care cost savings were greatest in the most deprived group (Table 5). As such, in the base case, the policy predicts greater health gains in the most deprived groups after accounting for the greater out-of-home consumption among less deprived and greater risk of disease in more deprived individuals.

Table 3 also reports the reduction in obesity for SA1 (behaviour change only: −36,346 95% UI -596,658 to 591,134) and SA2 (menu

TABLE 3 Incremental health impact of policy for the English population aged 13–79 years (N = 45,198,512).

Simulation scenarios	Difference in number with BMI > 30 kg/m^2 after 1 year	Change in cases of diabetes after 10 years	Changes in myocardial infarction events after 10 years	Changes in stroke events after 10 years	Change in cardiovascular mortality after 10 years
Combined behavioural and menu changes	−71,414 (−618,881, 547,492)	−3,684 (−17,175, 4,300)	−136 (−1,808, 1,588)	−113 (−1,582, 904)	−92 (−1,582, 1,130)
SA1. Behavioural calorie effect	−36,346 (−596,658, 591,134)	−360 (−9,503, 9,497)	−18 (−904, 902)	−18 (−904,684)	2 (−910, 904)
SA2. Menu changes	−34,832 (−61,771, −12,053)	−3,298 (−10,853, 452)	−128 (−1,582, 1,355)	−100 (−1,356, 904)	−91 (−1,356, 904)

This table presents the projected health outcomes for the English population scaled to N = 45,198,512 at two distinct follow-up intervals following the April 2022 policy implementation. The Base Case utilizes primary estimates for both consumer response and industry menu change. Sensitivity Analysis 1 (SA1): Consumer behavioural response only. Sensitivity Analysis 2 (SA2): industry menu change only. 95% Uncertainty Intervals reported within brackets; SA Sensitivity Analysis.

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TABLE 4 The lifetime discounted costs and QALYs per person (simulated England population aged 13–79 years) for calorie labelling with 95% uncertainty intervals.

Simulation scenario	Discounted policy cost per person	Lifetime health care discounted costs per person	Lifetime discounted QALY per person	Incremental total costs vs. no intervention per person	Incremental QALYs vs. No intervention per person	Incremental net monetary benefit per person	% Chance cost-effective at £20,000 per QALY
No intervention							
Average per person effects (Simulated Cohort)	£0	£24,220 (£16,885, £38,310)	15.3269 (14.9178, 15.6777)	–	–	–	
Combined consumer and industry effects							
Average per person effects (Simulated Cohort)	£0.06 (£0.05, £0.07)	£24,211 (£16,845, £38,307)	15.3290 (14.9194, 15.6789)	-£9.15 (−£31.63, £2.90)	0.0021 (−0.0008, 0.0048)	£50.23 (−£16.41, £74.68)	93.6%
SA1: Consumer purchases effects							
Average per person effects (Simulated Cohort)	£0.06 (£0.05, £0.07)	£24,220 (£16,853, £38,309)	15.3267 (14.9182, 15.6780)	-£0.19 (−£10.51, £10.67)	−0.0002 (−0.0025, 0.0008)	-£3.91 (−£42.18, £10.46)	53.9%
SA2: Industry menu change effects							
Average per person effects (Simulated Cohort)	£0.06 (£0.05, £0.07)	£24,211 (£16,847 £38,308)	15.3292 (14.9190, 15.6786)	-£8.91 (−£27.90, £0.08)	0.0023 (0.0002, 0.0044)	£54.48 (£3.49, £73.50)	98.5%

This table presents the expected projected lifetime Healthcare savings and Quality Adjusted Life Years (QALY) per person following the April 2022 policy implementation. The Base Case utilizes primary estimates for both consumer response and industry menu change. Sensitivity Analysis 1 (SA1): Consumer behavioural response only. Sensitivity Analysis 2 (SA2): industry menu change only. () 95% Uncertainty Intervals SA Sensitivity Analysis. Net Monetary Benefit = (Incremental QALY*£20,000 willingness to pay) – incremental costs.

change only: −34,832 95% UI -61,771, −12,053). The higher uncertainty in the effects of the policy to change consumer behaviour has a notable impact on the uncertainty intervals for the base case and SA1 scenarios. In SA1, the behavioural effects of the intervention are found to reduce expected lifetime healthcare costs by £0.19 per person, and reduce expected lifetime QALYs with considerable uncertainty (Table 4). The overall effect on the incremental net benefit is negative, suggesting that the policy is not cost-effective based on expected behavioural impacts alone. Negative QALYs were attributed to non-linearity observed in the model, in which weight gain generates greater losses to QALYs than an equivalent weight loss. QALY losses occur in individuals with baseline BMI>25 kg/m^2 and full baseline health, as weight regain causes long-term HRQoL decline without initial HRQoL gains. When menu change effects were simulated in isolation (SA2), the analysis estimated £9 reduction in lifetime costs per person, and 0.0023 gains to incremental lifetime QALYs.

In SA3 we observed that stratifying effects by socioeconomic position (Table 5) did not change the pattern of incremental health gains across socioeconomic groups, which is mainly due to the dominating effects of menu changes on lifetime benefits. In SA4 an alternative source of evidence was used for menu change effects, stratified by IMD quintiles. In this analysis, the overall benefits were larger than the base case, with nearly twice as large incremental QALYs estimated for the most deprived group compared to least deprived. Sub-group analysis by other key characteristics did not identify substantial variation in health economic outcomes (Supplementary Table S33).

Additional sensitivity results varying individual data inputs and modelling assumptions are reported in Supplementary Table S34 and illustrated in Figure 1B. These indicate that the sensitivity analyses report positive incremental net benefit results, with the exception of SA1 which describes the cost-effectiveness if only behavioural effects are incorporated.

Discussion

This health economic evaluation finds the calorie labelling policy in England is cost-effective only if it encourages restaurants to reduce the calories of their standard menu items. While the policy's impact on individual customer choices is too small and uncertain to provide a significant economic return, modest industry-wide menu changes apply to customers automatically, which can generate health gains. These small, universal reductions in calorie intake are predicted to

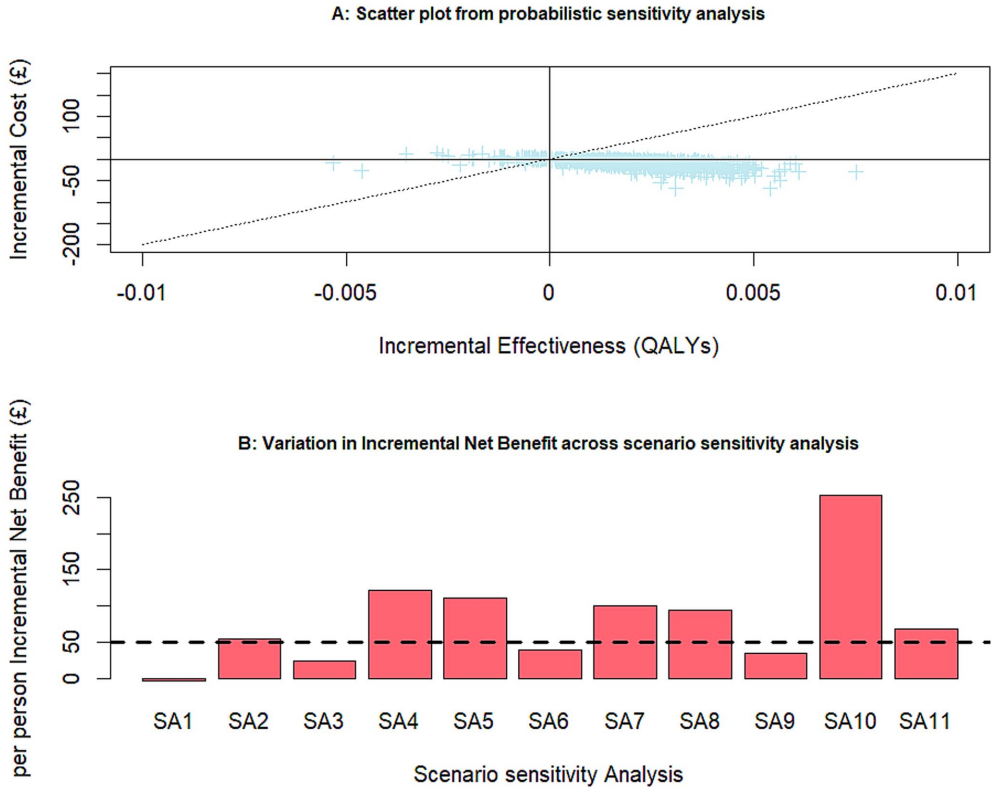


FIGURE 1
Results of sensitivity analyses. **(A)** Scatter plot showing the results of a probabilistic sensitivity analysis, illustrating the incremental cost versus incremental effectiveness (QALYs). The dashed line represents the willingness-to-pay threshold. **(B)** Bar chart depicting the variation in per-person incremental net benefit across different sensitivity analyses (SA1 to SA11). The dashed horizontal line indicates the average per-person incremental net benefit for the base case analysis. SA1: Behavioural effect only; SA2: Menu change effect only; SA3: Effects stratified by sex and occupational socio-economic status; SA4: Alternative menu change effect by IMD quintile e; SA5: Discount rate 0%; SA6: Discount rate 5%; SA7: Alternative evidence from international meta-analysis evidence; SA8: Evidence from alternative updated international meta-analysis evidence; SA9: Delayed menu change effect; SA10: Add in weight effects on cardiometabolic health; SA11: Alternative calorie to weight model.

generate approximately 90,000 QALY gains and £400 million in cost savings over the lifetime of the simulated population. However, there remains notable uncertainty in these outcomes due to underlying assumptions regarding the decay in consumer responses, as well as the assumption that menu changes are permanent. In a health economic evaluation framework small, uncertain effects can be cost-effective if it represents likely health gains for the investment required. However, policymakers should treat these results as a signal to either monitor implementation closely or refine the intervention's delivery to ensure those projected health gains are realised.

The long-term benefits from menu change are expected to be spread across IMD quintiles, with the most deprived IMD groups benefiting most due to greater risks of long-term conditions. This pattern is robust to sensitivity analyses including when effects on behavioural responses differ by high occupational social class, and the effects of menu change are delayed.

Real world evidence from England suggests that policy is less effective than previously observed consumer purchases analyses (13), though comparable to an updated meta-analysis (14). Studies outside of England estimated menu changes led to a pooled reduction of 15 kcal on average (95% CI 8 to 23), which was more effective than the base case and tested in sensitivity analysis (15). Consequently, the projected impact on the prevalence of obesity and mortality are lower than those predicted in a previous modelling study in England (18). Using policy effects from a global meta-analysis (13), the authors estimated a − 0.31 (95% UI -0·10 to −0·35) percentage point change in obesity over 10 years and 230 (140 to 380) fewer cardiovascular deaths after 10 years (18). We find in our base case an approximately −0.15 (95% UI -1.36 to 1.26) percentage point change in obesity at 12 months and 92 fewer cardiovascular deaths after 10 years. Therefore, there is consistency in the direction of health benefits but the uncertainty in the long-term effectiveness of the calorie reduction has a notable impact on the model results.

Our results are consistent with previous cost-effectiveness analyses that report lifetime cost-savings in response to calorie labelling policies, albeit with slightly lower estimates for cost savings (22). Previous modelling studies have not reported adverse consequences for health inequalities, when exploring the distribution of benefits across social groups. In our sensitivity analyses we incorporate demographic patterns in consumer behaviour and menu change effects. Despite more affluent groups having larger average consumer responses to the policy (SA3), the unequal distribution of underlying health risks for type 2 diabetes and cardiovascular disease in the model compensate for this effect. Therefore, we find greater lifetime QALYs and cost-savings are observed in more deprived IMD quintiles, which is amplified when accounting for greater menu changes in deprived areas.

Menu change effects are key to the cost-effectiveness of this policy, and yet the evidence supporting the menu change scenario has limitations. While two studies have detected changes in menu offerings in

TABLE 5 The lifetime discounted costs and QALYs per person (simulated England population aged 13–79 years) for calorie labelling stratified by socioeconomic groups.

Population subgroup	Discounted policy cost	Lifetime health care discounted costs	Lifetime discounted QALY	Incremental total costs	Incremental QALYs	Incremental net benefit
No intervention						
IMD5 (least deprived)	0	£25,453	15.2561			
IMD4	0	£23,146	15.1280			
IMD3	0	£24,243	15.0959			
IMD2	0	£24,610	15.6450			
IMD1 (most deprived)	0	£26,487	15.5074			
Combined consumer behaviour and menu change effects						
IMD5 (least deprived)	0.06	£25,446	15.2579	-£7.54	0.0019	£44.91
IMD4	0.06	£23,137	15.1300	-£8.35	0.0020	£48.01
IMD3	0.06	£24,234	15.0980	-£9.34	0.0021	£51.98
IMD2	0.06	£24,600	15.6472	-£9.65	0.0021	£52.34
IMD1 (most deprived)	0.06	£26,476	15.5096	-£10.62	0.0022	£53.76
SA3. Combined intervention effect adjusted for SES and sex						
IMD5 (least deprived)	0.06	£25,444	15.2565	-£8.92	0.0004	£16.92
IMD4	0.06	£23,136	15.1286	-£9.20	0.0006	£20.79
IMD3	0.06	£24,233	15.0967	-£9.81	0.0008	£24.94
IMD2	0.06	£24,600	15.6458	-£9.84	0.0008	£26.06
IMD1 (most deprived)	0.06	£26,476	15.5084	-£10.58	0.0010	£31.10
SA4. Combined consumer behaviour and menu change effects stratified by IMD						
IMD5 (least deprived)	0.06	£25,438	15.2600	-£14.92	0.0039	£93.68
IMD4	0.06	£23,127	15.1326	-£18.45	0.0046	£110.35
IMD3	0.06	£24,224	15.1006	-£19.45	0.0047	£112.55
IMD2	0.06	£24,586	15.6505	-£24.11	0.0055	£133.35
IMD1 (most deprived)	0.06	£26,458	15.5135	-£28.86	0.0061	£150.90

This table presents the projected per person lifetime healthcare costs and Quality Adjusted Life Years split by IMD score following the calorie labelling policy. The Base Case utilizes primary estimates for both consumer response and industry menu change. Sensitivity Analysis 3 (SA3): uses stratified consumer response by socioeconomic group. Sensitivity Analysis 4 (SA4): industry menu change stratified by IMD. SA Sensitivity Analysis QALY Quality Adjusted Life Years IMD Index of Multiple Deprivation. Calculations for incremental net benefit are based on unrounded values; minor discrepancies with reported costs and QALYs may occur due to rounding.

response to the calorie labelling policy in England, neither can conclude that changes to menus are due to the policy changes alone and will translate to consumption of less calories consumed. However, similar results were estimated in a meta-analysis (15). The only real-world study to measure calorie intake before and after policy implementation, accounting for behavioural and menu change effects, did not report a reduction in calories consumed (27). However, the study was powered to detect a 7% reduction in calories consumed, which highlights the challenges in detecting small changes in calorie consumption. Two studies have highlighted that menu changes are characterised by the introduction of new lower calorie menu items, rather than a reduction in calorie content of existing products (29, 58). Whereas the post-implementation calorie data collection was conducted 5–9 months after policy implementation, it is possible that menu change effects may take longer to develop as menu offerings and consumer tastes develop over time. Given the sensitivity of the results to menu change effects, ongoing evaluation and monitoring of the policy should focus on whether shifts to lower calorie offerings are maintained, and whether consumers adapt tastes to select these options in the long term.

The health economic model translates change in calories to obesity and its complications, but does not consider the broader aspects of health,

such as mental health, potential harms for people with disordered eating, and lost productivity (61). Furthermore, the analysis took a public sector perspective in line with national guidelines (31), so does not account for the additional costs incurred by industry to prepare for policy implementation. Taking account of these wider societal effects may mitigate some of the benefits of the policy. The model does not include some obesity related illnesses, such as liver disease, some cancers, and the positive societal benefits from avoidance of obesity-related complications, so the overall societal impact may be underestimated. We also acknowledge that there are methodological challenges in the design of real-world public health policy evaluation using controlled interrupted time series methods due to underlying limitations in data and study design (28).

Our analysis indicates that even small effects on calorie consumption through menu changes would justify the cost of the policy from a public sector perspective. Both our behavioural response and menu change response are predicted to lead to only a 2 kcal reduction in daily calories. Whereas the menu change effects produce more favourable estimates in the health economic modelling because the changes are maintained over time and the estimate was statistically significant. As a consequence, there is much less uncertainty in the effects. However, the return on investment indicated in this analysis is lower than predictions that used evidence from meta-analyses of studies conducted prior to implementation in England, and suggest that the policy may not be achieving expected health benefits. There are several reasons why the policy is having limited effect on calories. First, the policy only requires calorie labelling in large chain outlets with more than 250 employees, some of which would have introduced calorie labelling voluntarily prior to implementation. Expanding the policy to more out-of-home outlets could increase the overall impact of the policy. Second, evaluation of the policy has shown that post-implementation compliance was found in 80% of eligible outlets in 2022 and only 15% met government guidelines on labelling (26). Previous research has also found that the effectiveness of a calorie labelling policy is sensitive to the prominence and presentation of the calorie information (12). Qualitative evaluation highlights potential explanations for low compliance, including limited customer interest and limited enforcement (25). Strengthening enforcement may increase policy impact, but may increase the costs of implementation.

Conclusion

Our economic evaluation finds that calorie labelling in the out-of-home sector is likely to be a cost-effective policy from a public sector perspective, conditional on an assumption that the policy leads to modest menu change in the absence of changes in consumer behaviour. Despite previous concerns that the policy may exacerbate health inequalities, our analysis suggests that the policy is unlikely to worsen health inequalities, and may reduce them.

Data availability statement

The data analyzed in this study is subject to the following licenses/restrictions: Access to the Health Survey for England (HSE) and National Diet and Nutrition Survey are datasets accessed via the UK Data Service and protected by data-sharing and licensing frameworks. Requests to access these datasets should be directed to https://ukdataservice.ac.uk/. All analysis and interpretation was conducted independently of Worldpanel by Numerator. Worldpanel cannot independently verify the findings, nor can it endorse the views or findings of this report.

Author contributions

PB: Conceptualization, Formal analysis, Funding acquisition, Methodology, Project administration, Supervision, Writing – original draft, Writing – review & editing. KP: Data curation, Formal analysis, Methodology, Writing – original draft, Writing – review & editing. AK: Conceptualization, Formal analysis, Funding acquisition, Methodology, Writing – original draft, Writing – review & editing. LC: Conceptualization, Funding acquisition, Methodology, Writing – original draft, Writing – review & editing. KB: Funding acquisition, Writing – original draft, Writing – review & editing. SC: Funding acquisition, Methodology, Writing – original draft, Writing – review & editing. DM: Funding acquisition, Writing – original draft, Writing – review & editing. CL: Funding acquisition, Methodology, Writing – original draft, Writing – review & editing. RS: Funding acquisition, Methodology, Writing – original draft, Writing – review & editing. OT: Methodology, Writing – original draft, Writing – review & editing. VE: Methodology, Writing – original draft, Writing – review & editing. CF: Methodology, Writing – original draft, Writing – review & editing. AB: Conceptualization, Formal analysis, Methodology, Writing – original draft, Writing – review & editing.

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Conflict of interest

The author(s) declared that this work was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fnut.2026.1943096/full#supplementary-material

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