# Effect of calorie labelling in the out-of-home food sector on adult obesity prevalence, cardiovascular mortality, and social inequalities in England: a modelling study

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## Summary

**Background** England implemented a menu calorie labelling policy in large, out-of-home food businesses in 2022. We aimed to model the likely policy impact on population-level obesity and cardiovascular disease mortality, as well as the socioeconomic equity of estimated effects, in the adult population in England.

**Methods** For this modelling analysis, we built a comparative assessment model using two scenarios: the current implementation scenario refers to actual deployment only in large (≥250 employees), out-of-home food businesses, whereas the full implementation scenario refers to deployment in every out-of-home food business. We compared each scenario with a counterfactual: the scenario in which no intervention is implemented (ie, baseline). For both scenarios, we modelled the impact of the policy through assumed changes in energy intake due to either consumer response or product reformulation by retailers. We used data from the Office for National Statistics and the National Diet and Nutrition Survey 2009–19, and modelled the effect over 20 years (ie, 2022–41) to capture the long-term impact of the policy and provided mid-period results after 10 years. We used the Monte Carlo approach (2500 iterations) to estimate the uncertainty of model parameters. For each scenario, the model generated the change in obesity prevalence and the total number of deaths prevented or postponed.

**Findings** The current implementation scenario was estimated to reduce obesity prevalence by 0·31 percentage points (absolute; 95% uncertainty interval [UI] 0·10–0·35), which would prevent or postpone 730 cardiovascular disease deaths (UI 430–1300) of the 830 000 deaths (UI 600 000–1 200 000) expected over 20 years. However, the health benefits would be increased if calorie labelling was implemented in all out-of-home food businesses (2·65 percentage points reduction in obesity prevalence [UI 1·97–3·24] and 9200 cardiovascular disease deaths prevented or postponed [UI 5500–16 000]). Results were similar in the most and the least deprived socioeconomic groups.

**Interpretation** This study offers the first modelled estimation of the impact of the menu calorie labelling regulation on the adult population in England, although we did not include a cost-effectiveness analysis. Calorie labelling might result in a reduction in obesity prevalence and cardiovascular disease mortality without widening health inequalities. However, our results emphasise the need for the government to be more ambitious by applying this policy to all out-of-home food businesses to maximise impact.

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## Introduction

Population-level diet policies offer an evidence-based approach to substantial and rapid reductions in the burden of obesity and non-communicable diseases.[1,2] On April 6, 2022, as part of a national obesity strategy, the UK Government implemented mandatory energy labelling in out-of-home businesses in England that serve food and have at least 250 employees.[3–5] This regulation requires businesses to label energy information (in kcal) for items (excluding alcoholic beverages) on in-store menus, online menus, third-party applications, food-delivery platforms, and food labels at each point a customer is making their food and drink choices.[3,4,6] Because out-of-home businesses tend to serve high-energy meals[7–9] associated with increased energy intake and higher BMI,[7] the policy might reduce obesity prevalence and thus cardiovascular disease mortality. Indeed, menu energy labelling can lead to a small decrease in energy purchased by consumers in the out-of-home food sector.[10–13] A 2018 Cochrane systematic review and meta-analysis of three randomised controlled trials done in real-world settings found a reduction of 47 kcal (95% CI 15–78) ordered per meal due to menu energy labelling.[10] Similarly, a pooled analysis of 12 randomised controlled experiments published in 2023 showed about a 50 kcal reduction (99·5% CI 18–82) in the energy content of selections,[14] and a large quasi-experimental study in fast-food restaurants from nationwide chains in the southern USA published in 2021 found that franchise labelling

## Research in context

### Evidence before this study

We searched PubMed using the search terms "((Energy OR kcal* OR calorie* OR kilojoule*) AND (label*)) AND (menu)", on Dec 7, 2023, for papers published from database inception to date on menu energy labelling, with no language restrictions but applying the species filter for human research only. We identified 276 publications. A 2018 Cochrane systematic review and meta-analysis of three randomised controlled trials done in real-world settings found a significant mean reduction of 47 kcal (95% CI 15–78) ordered per meal due to menu energy labelling. A pooled analysis published in 2023 found that menu energy labelling was associated with about a 50 kcal reduction (99·5% CI 18–82) in the energy content of selections. Furthermore, large quasi-experimental studies in fast-food restaurants in the southern USA published between 2020 and 2023 found that franchise labelling resulted in a 54 kcal reduction per transaction (95% CI 42–67), whereas nationwide labelling led to a 73 kcal reduction per transaction (95% CI 65–81). In addition, findings from a meta-analysis indicate that retailers are likely to reduce the average product energy content by 15 kcal (95% CI 8–23) due to the implementation of the policy. To date, only a few studies have modelled the long-term effect of menu energy labelling on obesity and related outcomes in an adult population: one in Kenya and three in the USA. According to these studies, the implementation of menu energy labelling in US restaurants was estimated to prevent 14 698 new cases of cardiovascular disease, including 1575 cardiovascular disease deaths, and 21 522 new cases of type-2 diabetes over 5 years, gaining 8749 quality-adjusted life-years. Another modelling study done in children in the USA estimated that menu energy labelling in US restaurants could reduce cases of childhood obesity by 41 015 over a 10-year period (2015–25). No studies have examined the impact of the menu energy labelling policy implemented in 2022 in England.

### Added value of this study

This is the first evaluation of the likely impact of the menu calorie labelling regulation in the out-of-home food sector implemented in 2022 in England. Our model estimates that the current calorie labelling policy might result in a reduction in obesity prevalence and cardiovascular diseases mortality, but that benefits would be increased if the policy was applied to all out-of-home food businesses. The finding did not suggest that calorie labelling could widen health inequalities.

### Implications of all the available evidence

Calorie labelling interventions might result in a small reduction in obesity prevalence and cardiovascular mortality. However, results emphasise that governments might need to be more ambitious by applying this policy to all out-of-home food businesses to maximise impact.

resulted in a 54 kcal reduction per transaction (95% CI 42–67), whereas the nationwide labelling implementation was associated with a 73 kcal reduction per transaction (95% CI 65–81).[13]

Menu energy labelling leads consumers to make better informed and healthier food choices.[4] It can probably induce food industry reformulation of out-of-home foods, as menu energy labelling implementation is associated with an average reduction in product energy content by 15 kcal (95% CI 8–23),[11] sodium by 9% (95% CI 1–17), and artificial trans-fat by 64% (95% CI 38–91).[12]

Currently, there is little evidence available on the long-term effects of menu energy labelling policies on obesity and associated outcomes, such as cardiovascular disease mortality, and whether the policy results in equitable benefits across the population. To our knowledge, four studies have modelled the effect of menu energy labelling in an adult population, including three in the USA[15–17] and one in Kenya,[18] of which one is on obesity-associated cancers.[16] On the basis of consumer response alone, implementing the menu energy labelling law in US restaurants was estimated to gain 8749 quality-adjusted life-years over 5 years by preventing new cases of cardiovascular disease and diabetes.[15] An additional modelling study on children estimated that menu energy labelling in US restaurants would reduce childhood obesity cases by 41 015 over 10 years (2015–25).[19]

As such, it is important to estimate the impact of this new menu calorie labelling policy in England, particularly because an extension beyond just largest businesses could be a possible option and because Wales and Scotland are actively considering implementing similar calorie labelling regulations.[20,21]

In the present study, we aimed to model the likely impact of the calorie labelling regulation in the out-of-home food sector on population-level obesity and cardiovascular disease mortality, as well as the socioeconomic equity of predicted effects in the adult English population.

## Methods

### Model overview

We built a comparative risk assessment model to quantify the estimated effects of the implementation of the mandatory menu energy labelling policy in England: an adaptation of the IMPACT Food Policy Model.[22] Although the change in energy intake has an almost immediate impact on the change in bodyweight and BMI, the change in bodyweight and BMI does not immediately impact cardiovascular disease mortality.[23] As such, we modelled the effect over 20 years (ie, 2022–41) to capture the long-term impact of the policy and provided mid-period results after 10 years.

The policy legally requires large (≥250 employees) out-of-home food businesses, which represent 18% of the number of outlets in the out-of-home food sector in

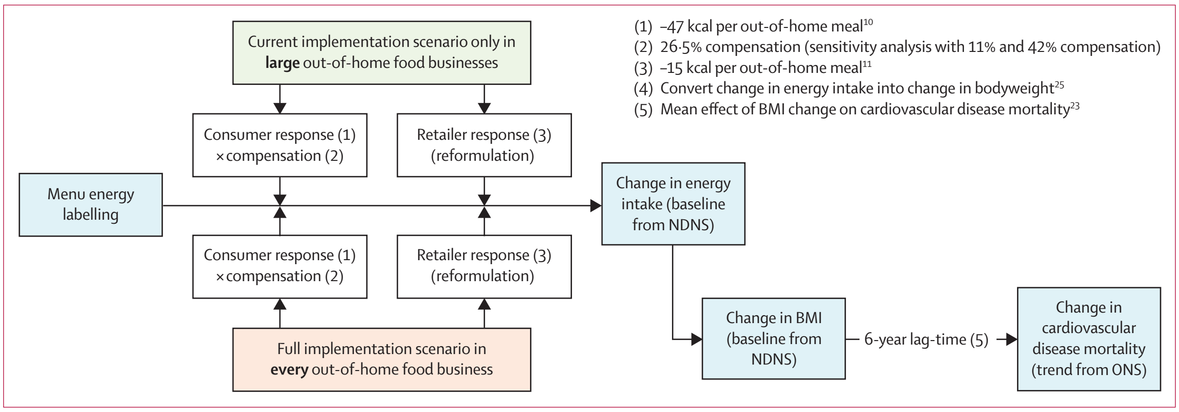


***Figure:*** **Logic diagram of the impact of menu energy labelling on obesity prevalence and cardiovascular disease mortality**
NDNS=National Diet and Nutrition Survey. ONS=Office for National Statistics.

England in 2022 and 47% of this sector's turnover,[24] to display energy information for non-prepacked food and soft drinks.[4] Therefore, we modelled two main scenarios: the current implementation scenario, which reflects the actual policy deployment plan in England (only large food businesses), and the full implementation scenario, which models the deployment of the policy in every out-of-home food business in England (appendix pp 3–7). We compared each scenario with a counterfactual: the scenario in which no intervention is implemented (ie, baseline).

## Policy effects

Menu energy labelling affects people's diet through both consumer response and retailer response (ie, reformulation of out-of-home food by retailers; figure).

*Effect on consumer response*

We assumed that the implementation of menu energy labelling would reduce energy consumption by 47 kcal (95% CI 15–78) for each out-of-home meal, on the basis of the estimates from Crockett and colleagues' Cochrane review and meta-analysis of randomised controlled trials.[10] Due to no evidence to the contrary, we assumed that the effect menu energy labelling has on consumer behaviour is consistent over time. We also assumed that part of the reduction in energy intake because of consumer response would be compensated through other meals throughout the day.[26,27] Specifically, systematic reviews have suggested that the amount of compensation later in the day would be 42% of the energy that was reduced when people consume less food (in volume)[26] and 11% when people select meals that are lower in energy density.[27] Therefore, we assumed a 26·5% energy compensation (average) and did sensitivity analyses with 11% and 42% compensation. We assumed no differential policy effects by sex, age, or socioeconomic position on the basis of the current literature.[7,14]

*Effect on energy content reformulation*

For the menu energy labelling effects on out-of-home food reformulation, we used meta-analytic estimates that retailers reduced the energy content of menu items by 15 kcal on average (95% CI 8–23) following labelling.[11] Because we had no information about the number of items eaten, we conservatively assumed a 15 kcal (95% CI 8–23) reduction for a meal.

## Estimating model uncertainty

See Online for appendix

We used the Monte Carlo approach (2500 iterations) to estimate the uncertainty of model parameters. The sources of uncertainty we considered were the sampling errors of baseline energy intakes, the uncertainty of the relative risk of coronary heart disease and stroke based on BMI, the uncertainty of mortality forecasts, and the uncertainty of the menu energy labelling effect. We summarised the output distributions by reporting the medians and 95% uncertainty intervals (UIs).

As previously detailed, we did a sensitivity analysis using lower (11%) and higher (42%) compensation later in the day. Furthermore, we considered turnover to estimate the share of large businesses in the out-of-home food sector in England affected by the policy (19% for current implementation and 69% for full implementation). Finally, we explored estimating energy from out-of-home prepared meals, excluding energy underreporters, using the Black approach.[28]

## Model engine

Through reducing energy intake, menu energy labelling is hypothesised to reduce the bodyweight of the population (ie, BMI), which in turn is thought to change the risk of cardiovascular disease mortality (figure; appendix p 4). Briefly, the change in energy consumption was calculated by subtracting consumption after the intervention from baseline consumption for each year. Then, we converted changes in the energy intakes into changes in bodyweight, based on the principles of energy conservation and using the Christiansen and Garby prediction formula (appendix p 5).[25] We also did a sensitivity analysis using Hall and colleagues' dynamic simulation model.[29] On the basis of the estimated change

| | Change in prevalence of obesity, percentage points* | CVD deaths prevented or postponed | |
|---|---|---|---|
| | | 10 years† | 20 years |
| **Consumer response** | | | |
| Current implementation | –0·27 (–0·34 to –0·07) | 200 (60 to 350) | 630 (200 to 1200) |
| Full implementation | –2·38 (–2·81 to –0·80) | 2500 (800 to 4500) | 7900 (2500 to 15 000) |
| **Reformulation** | | | |
| Current implementation | –0·07 (–0·10 to –0·04) | 120 (50 to 230) | 400 (150 to 900) |
| Full implementation | –1·56 (–1·93 to –0·64) | 1500 (630 to 2900) | 5000 (2000 to 10 000) |
| **Combined** | | | |
| Current implementation | –0·31 (–0·35 to –0·10) | 230 (140 to 380) | 730 (430 to 1300) |
| Full implementation | –2·65 (–3·24 to –1·97) | 2900 (1700 to 4800) | 9200 (5500 to 16 000) |

All results are median (95% UI), unless otherwise stated. CVD=cardiovascular diseases. UI=uncertainty interval. *Equal results for 10 and 20 years as we did not model any trend in BMI over time. †Results from 2022 to 2031.

*Table 1:* **Estimated change in obesity prevalence and CVD mortality in adults in England (2022–41), according to different menu energy labelling implementation scenarios**

in bodyweight, we calculated the estimated change in BMI, thus allowing us to estimate the change in obesity prevalence. Finally, these changes in BMI lead to changes in the risk of cardiovascular disease mortality with a 6-year lag-time (appendix p 5).[23] This information was then used to estimate new mortality rates and, consequently, the number of deaths projected.

### Model outputs

For each scenario, the model generated the change in obesity prevalence and the total number of deaths prevented or postponed (DPPs). We examined the equity impact of the intervention by calculating the ratio between the most and least deprived quintile groups (using the Index of Multiple Deprivation or IMD). We present the results for adults in England aged 30–94 years from 2022 to 2041, rounded to two significant figures for mortality and two decimal points for the obesity prevalence.

### Data sources

The England population projections were from the Office for National Statistics (appendix p 6), and we projected mortality trends on the basis of cardiovascular disease deaths observed in England from 1981 to 2016 (appendix pp 6–9).

Trends in energy intake from meals prepared out of home and BMI were obtained from the nationally representative National Diet and Nutrition Survey 2009–19. We assumed that the trends in out-of-home energy intake and BMI observed in the past 10 years in England will continue in the future. As no significant trend was observed for BMI, we conservatively assumed that the prevalence of obesity would not change in the next 20 years for the modelled baseline scenario.

All data management and statistical analyses were conducted using R (version 4.1.1). We used the demography package[30] for forecasting mortality and the bw package for obtaining the weight change from Hall and colleagues' model.[31]

### Role of the funding source

The funder of the study had no role in the study design, data collection, data analysis, data interpretation, writing of the report, or the decision to submit this work for publication.

## Results

The current implementation scenario in England (ie, only in large out-of-home food businesses) was estimated to reduce obesity prevalence by 0·27 percentage points (absolute; 95% UI 0·07–0·34; table 1) in the next 20 years when considering consumer response (ie, change in energy intake) alone. Reformulation of the energy content of the products sold was estimated to lower obesity prevalence in adults by a further 0·07 percentage points for the current implementation scenario (95% UI 0·04–0·10; table 1). In England, combining these factors would result in a reduction of 0·31 percentage points in obesity prevalence among adults (95% UI 0·10–0·35).

Implementing the policy in every out-of-home business was estimated to have a larger impact and reduce obesity prevalence by 2·65 percentage points overall (95% UI 1·97–3·24; combined full implementation scenario; table 1).

Without any policy, the current cardiovascular disease mortality trends were estimated to result in approximately 830 000 deaths (95% UI 600 000–1 200 000) in English adults by 2041.

The current implementation scenario was estimated to result in 630 cardiovascular disease DPPs (95% UI 200–1200; table 1) over 20 years due to changes in consumer response: 0·08% of the expected cardiovascular disease deaths (95% UI 0·03–0·11). Retailers' reformulation in energy content would result in 400 cardiovascular disease DPPs (95% UI 150–900), around 0·05% of the expected cardiovascular disease deaths (95% UI 0·02–0·08). For both factors combined, the current implementation of the policy would be estimated to result in 730 cardiovascular disease DPPs (95% UI 430–1300) over 20 years: 0·09% of the expected cardiovascular disease deaths (95% UI 0·06–0·13).

However, implementing mandatory energy labelling in all out-of-home food businesses in England was estimated to result in a much higher reduction in mortality than that achieved by implementing the policy only in large out-of-home food businesses, due to changes in consumer responses (7900 DPPs [95% UI 2500–15 000]) and retailer responses (5000 DPPs [95% UI 2000–10 000]), representing 1·00% (95% UI 0·35–1·40) and 0·62% (95% UI 0·27–0·96) of the expected cardiovascular disease deaths in the next 20 years. Overall, cardiovascular disease mortality reduction is estimated to be almost 13 times higher for the combined full implementation scenario: 9200 DPPs (95% UI

5500–16 000; table 1), around 1·10% of the expected cardiovascular disease deaths (95% UI 0·71–1·60).

The current implementation scenario was estimated to reduce obesity prevalence by 0·31 percentage points in the most deprived group and 0·44 percentage points in the least deprived group, and yield 170 cardiovascular disease DPPs (95% UI 100–300) in the most deprived group and 140 (80–250) in the least deprived group (table 2). Note that the uncertaintly intervals were unreliable for prevalence of obesity for the current implementation scenario due to the small effect size of the policy and the small number of people in these groups. The full implementation scenario was estimated to reduce obesity prevalence by 3·00 percentage points in the most deprived group and 3·00 percentage points in the least deprived group, and yield 2200 cardiovascular disease DPPs (1300–3700) in the most deprived group and 1700 (1000–3000) in the least deprived group (table 2).

The obesity prevalence ratios between the most and the least deprived groups without calorie labelling (1·26) and with calorie labelling (current implementation: 1·27 [95% UI 1·25–1·28]; full implementation: 1·29 [1·24–1·34]) were constant, indicating no evidence of the policy widening inequality in obesity, under the assumptions of the same policy effect across the socioeconomic spectrum.

The cardiovascular disease mortality ratios between the most and the least deprived groups also remained similar, suggesting that the policy did not widen inequality in cardiovascular disease mortality (ratios 1·29 [95% UI 1·29–1·29] without labelling; 1·21 [1·04–1·44] with the current implementation; and 1·27 [1·10–1·49] with the full implementation), under the assumptions of same policy effect across the socioeconomic spectrum.

A larger effect of the current implementation scenario is estimated when using turnover rather than number of outlets to estimate the share of large businesses in the out-of-home food sector in England (appendix p 11). Thus, the expansion of the policy to all food businesses (full implementation scenario) was estimated to yield slightly lower results. Other sensitivity analyses excluding the adults identified as energy under-reporters (appendix p 11), using different compensation levels (appendix p 12), and using a different formula to link energy change and bodyweight (appendix p 13) produced similar findings to the primary analysis.

| | Prevalence of obesity | CVD deaths predicted | CVD deaths prevented or postponed |
|---|---|---|---|
| **Q1 (most deprived)** | | | |
| No policy | 29·7 | 187 000 (136 000–271 000) | NA |
| Current implementation | 29·3* | .. | 170 (100–300) |
| Full implementation | 26·6 (26·3–26·9) | .. | 2200 (1300–3700) |
| **Q2** | | | |
| No policy | 32·9 | 176 000 (129 000–251 000) | NA |
| Current implementation | 32·5* | .. | 150 (80–270) |
| Full implementation | 31·3 (29·2–31·5) | .. | 2000 (1200–3600) |
| **Q3** | | | |
| No policy | 27·1 | 177 000 (130 000–253 000) | NA |
| Current implementation | 27·0* | .. | 170 (95–300) |
| Full implementation | 25·5 (24·9–26·2) | .. | 2000 (1200–3600) |
| **Q4** | | | |
| No policy | 25·2 | 166 000 (121 000–239 000) | NA |
| Current implementation | 24·9* | .. | 160 (90–300) |
| Full implementation | 21·6 (21·3–22·6) | .. | 2000 (1100–3600) |
| **Q5 (least deprived)** | | | |
| No policy | 23·5 | 145 000 (105 000–210 000) | NA |
| Current implementation | 23·1* | .. | 140 (80–250) |
| Full implementation | 20·5 (20·0–21·6) | .. | 1700 (1000–3000) |

All results are median (95% UI), unless otherwise stated. CVD=cardiovascular disease. IMD=Index of Multiple Deprivation. NA=not applicable. UI=uncertainty interval. *The uncertainty intervals for the current implementation estimates were unreliable due to the small effect of the policy in this scenario and the small number of people in this group.

***Table 2:*** **Estimated change in obesity prevalence and CVD mortality in adults in England (2022–41), according to IMD quintile groups and different menu energy labelling implementation scenarios**

## Discussion

This study is the first modelled estimation of the likely impact of the calorie labelling regulation in the out-of-home food sector on the adult population in England. Our study suggests that the current calorie labelling legislation, applying only to large, out-of-home food businesses, is estimated to reduce obesity prevalence slightly by 0·31 percentage points and prevent or postpone 730 deaths over 20 years, under specific assumptions (eg, constant effect of the policy; energy intake equally distributed across businesses, large or small; continuation of the consumption trends observed during 2009–19). There was no evidence that the current policy would widen existing health inequalities in obesity prevalence or cardiovascular disease-related deaths, on the assumption that the policy effect will be the same across sexes, ages, and socioeconomic positions. However, we estimated that the population health benefits of energy labelling in the out-of-home food sector would be markedly increased if the policy was implemented in all out-of-home food businesses in England.

Our results are of a similar magnitude to previous modelling studies estimating the effect of population-level dietary policies on obesity prevalence.[32,33] However, to the best of our knowledge, only Gortmaker and colleagues modelled the impact of the menu calorie labelling policy on obesity and only on children.[19]

Our results on cardiovascular disease mortality are consistent with a microsimulation of the impact of menu labelling in the adult population in the USA, which estimated that the implementation of the restaurant menu energy labelling law would prevent 1575 cardiovascular disease deaths over 5 years (2018–23),[15] on the basis of a consumer response of a 7·3% energy reduction.[12] Additionally, the study found that the mortality benefits would be twice as large when assuming reformulation of the products as well as consumer response,[15] compared with our study estimating 1·2-times larger benefits. This discrepancy might be due to different reformulation hypotheses (–15 kcal per meal for the present study *vs* 5% reduction energy for the US study). Interestingly, this study found no evidence that the menu energy labelling policy widened inequalities, which is consistent with our findings.[15]

Our study has several strengths. First, we used an adaptation of a previously validated model that has been used to model the effects of specific dietary policies (eg, fiscal policy on sugar-sweetened beverages).[22] In addition, we implemented the latest population-level estimates and included lag-times between changes in bodyweight and changes in cardiovascular disease risks.[23] Finally, robust sensitivity analyses were done to account for uncertainty in the modelling assumptions.

However, the present study also has limitations. First, because we used the effect size from Crockett and colleagues, which was based on three US randomsied controlled trials with a high risk of bias, the results might not be transferable to the population in England despite its similarity with other recent estimates.[13,14] The same limitation applies to the effects of reformulation. Modelled effects of menu calorie labelling were based on meta-analyses that provided absolute effects (eg, kcal reduction per visit), because proportional effect estimates (eg, percentage reduction in kcal per visit) were unavailable.

Although the National Diet and Nutrition Survey is representative, diet data might have a social desirability bias, leading to inaccurate information on the frequency of eating out and energy intake estimates. We assumed current consumption trends will continue, but COVID-19[34,35] or the cost-of-living crisis[36] might result in long-term changes. As the BMI trends in the National Diet and Nutrition Survey were not significant, we modelled no BMI change for the next 20 years. However, If prevalence of obesity increases, the policy will impact on more people at risk of dying from CVD and hence the policy impact will be bigger.

There are also some limitations of the model itself. We used the Levin-like formula to estimate the potential impact fraction, which is known to produce biased estimates when relative risks are adjusted for confounding.[37] In addition, as it often happens in modelling studies, we did not meet all assumptions underlining estimation of the potential impact fraction (appendix p 5). The UIs do not take into account model misspecification bias.

Due to a scarcity of data on calories consumed in specific food businesses, we assumed equal distribution between large and small outlets. If the amount of energy consumed in large businesses is greater than in small ones, we might underestimate the likely impact of the calorie labelling regulation. However, our use of absolute calorie reduction might partially address this limitation.

We did not consider the potential unintended negative effects of menu energy labelling. However, these are a major concern, in particular through triggering or reinforcing eating disorders and hindering recovery, as underlined by a 2023 study in England.[38] Yet no robust evidence exists to quantify this issue, so we have not explored it in our model. In addition, our model only accounts for changes in out-of-home calories consumed based on available evidence.[10] Other potential effects on consumer behaviour (eg, change in the frequency of out-of-home eating) are to be studied and quantified.

We assumed a constant effect of menu energy labelling on consumer behaviour over time, due to no evidence to the contrary. Theoretically, the effect might decrease (ie, habituation to information) or increase (ie, better calorie literacy and awareness) over time, hence our assumption. Finally, if only considered in isolation, our results will underestimate policy benefits because we did not include changes in childhood obesity in our model.

One of the major findings of our study is the relatively low expected impact of the policy as currently applied only to large, out-of-home food sector businesses in England when compared with potential larger effects if the policy was extended to all out-of-home food businesses in England. However, it should be noted that a larger effect of the current implementation is estimated when using turnover (large businesses being around 47% of the out-of-home food sector turnover) instead of the number of outlets (around 18%), suggesting the importance of the definition of large businesses when it comes to assessing effectiveness.

Furthermore, because we found no model-based evidence of widening health inequalities, extending the current menu energy labelling policy to all businesses might be advisable to maximise public health benefits as part of a broader England obesity strategy, combined with other policies to narrow the health inequality gap (eg, soft-drinks industry levy).

More evidence on the empirical impact of menu energy labelling on the consumers and the out-of-home food sector is needed, especially in England, to estimate the long-term impacts of mandatory calorie labelling policies with improved precision.[6,10]

Finally, on the basis of US cost-effectiveness studies, implementing menu calorie labelling in large, chain restaurants appears to be cost-effective with significant health gains and health-care and societal cost-savings,[15–17] and costs are themselves not very high. As such, given the estimated reduction in obesity and mortality, this policy is likely to be cost-effective. However, empirical data on actual individual business costs (especially for small businesses), and implementation and enforcement costs, are needed for England to conduct a proper cost-effectiveness evaluation.

This study offers the first modelled estimation of the impact of the calorie labelling regulation in the out-of-home food sector on the adult population in England. Calorie labelling might result in a small reduction in obesity prevalence and cardiovascular mortality without widening health inequalities. However, results emphasise the need for the government to be more ambitious by applying this policy to all out-of-home food businesses to maximise impact.

**Contributors**

ZC, ER, and MO'F designed the study. ZC and MO'F directly accessed and verified the underlying data reported in this Article. ZC drafted the manuscript, developed the model, and did the analysis. CK and MO'F supervised ZC. All authors contributed to the data interpretation and revised each draft for important intellectual content. All authors had final responsibility for the decision to submit for publication.

**Declaration of interests**

We declare no competing interests. Unrelated to this paper and between 2014 and 2016, ER has been a named investigator on research grants funded by Unilever and the American Beverage Association.

**Data sharing**

Data from the Office for National Statistics and the National Diet and Nutrition Survey are available online. The demography package in R has been used for forecasting mortality, and the bw package has been used to obtain the weight change from the model by Hall and colleagues. Syntax for the generation of derived variables and for the analysis used in this study are available publicly at: https://github.com/zoecolombet/MenuEnergyLabelling_code.

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