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What is the cost-effectiveness of menu calorie labelling on reducing obesity-associated cancer burdens? An economic evaluation of a federal policy intervention among 235 million adults in the USA

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ABSTRACT

Objective To assess the impact of menu calorie labelling on reducing obesity-associated cancer burdens in the USA.
Design Cost-effectiveness analysis using a Markov cohort state-transition model.
Setting Policy intervention.
Participants A modelled population of 235 million adults aged ≥20 years in 2015–2016.
Interventions The impact of menu calorie labelling on reducing 13 obesity-associated cancers among US adults over a lifetime was evaluated for: (1) effects on consumer behaviours; and (2) additional effects on industry reformulation. The model integrated nationally representative demographics, calorie intake from restaurants, cancer statistics and estimates on associations of policy with calorie intake, dietary change with body mass index (BMI) change, BMI with cancer rates, and policy and healthcare costs from published literature.
Main outcome measures Averted new cancer cases and cancer deaths and net costs (in 2015 US$) among the total population and demographic subgroups were determined. Incremental cost-effectiveness ratios from societal and healthcare perspectives were assessed and compared with the threshold of US$150 000 per quality-adjusted life year (QALY) gained. Probabilistic sensitivity analyses incorporated uncertainty in input parameters and generated 95% uncertainty intervals (UIs).
Results Considering consumer behaviour alone, this policy was associated with 28 000 (95% UI 16 300 to 39 100) new cancer cases and 16 700 (9610 to 23 600) cancer deaths averted, 111 000 (64 800 to 158 000) QALYs gained, and US$1480 (884 to 2080) million saved in cancer-related medical costs among US adults. The policy was associated with net cost savings of US$1460 (864 to 2060) million and US$1350 (486 to 2260) million from healthcare and societal perspectives, respectively. Additional industry reformulation would substantially increase policy impact. Greater health gains and cost savings were predicted among young adults, Hispanic and non-Hispanic Black individuals.
Conclusions Study findings suggest that menu calorie labelling is associated with lower obesity-related cancer burdens and reduced healthcare costs. Policymakers may prioritise nutrition policies for cancer prevention in the USA.

STRENGTHS AND LIMITATIONS OF THIS STUDY

- ⇒ Our study populated a Markov cohort state-transition model among 32 subgroups based on the nationally representative distributions of age, sex and race/ethnicity.
- ⇒ This cost-effectiveness evaluation incorporated data input parameters from established resources, and the evidence was robust to different policy scenarios.
- ⇒ However, given the nature of modelling research, this study does not provide a real-world evaluation of the impact of policy implementation on health and economic outcomes.
- ⇒ We modelled only the impact of menu calorie labelling on calories, although the policy may also result in potential changes in the nutritional quality of the restaurant meals.

INTRODUCTION

Obesity affects one in three Americans and is an established risk factor for 13 types of cancer, such as endometrial, liver, breast, prostate and colorectal cancers.[1] Obesity-associated cancer represents 40% of all newly diagnosed cancer cases and contributes to 43.5% of total direct cancer care expenditures, estimated at US$35.9 billion in 2015.[1–7] Rates of obesity-associated cancers are also rising disproportionately among young adults.[5 8] Substantial health and economic burdens highlight the need to prioritise cost-effective strategies to reduce obesity-associated cancers in the USA.

Diet is one of the few modifiable factors for both obesity and obesity-associated cancers.[2 9] Restaurant meals account for one in five calories consumed by US adults, including 9% of calories from full-service restaurants and 12% from fast-food restaurants,[10] and therefore, can be an important target for improving population diet. Restaurant meals can have very high calories, with a mean energy of 1362 kcal/meal and 969 kcal/meal in popular meals from randomly selected full-service and fast-food restaurants, respectively.[11] Consistently, individuals who cook less frequently at home consume more daily calories than those who cook more at home.[12] Thus, reducing calories consumed from restaurant meals has the potential to reduce daily calorie intake and subsequent obesity and obesity-related cancer burdens.

To help consumers make lower-calorie choices, the Affordable Care Act mandated that all chain restaurants with 20 or more outlets post calorie information on menus and menu boards for all standard menu items.[13] The Food and Drug Administration (FDA) published the final rules for this policy in 2016, which was subsequently implemented in 2018. A meta-analysis of 14 interventional studies, including five randomised controlled trials (RCTs) and a recent quasi-experimental longitudinal study among 104 restaurants, demonstrated that menu calorie labelling resulted in a reduction of 7.3% in caloric intake per meal and a 60 kcal (4%) reduction in calorie purchased per transaction, respectively.[14 15] Such policy can also motivate restaurant reformulation to lower calorie contents or introduce healthier food options.[16–21] Prior cost-effectiveness analyses suggest that this policy is associated with substantial health gains and is a cost-saving strategy for reducing obesity and obesity-related diseases.[22 23] It was estimated that the menu calorie labelling on fast foods was associated with a 25 kJ (6 kcal) reduction in mean daily energy intake, leading to a −0.2 kg change in mean body weight, a gain of 63 492 health-adjusted life-years, and net savings of half a billion (2010 Australian dollars) among Australians aged ≥2 years over their lifetime.[22] Researchers in the USA have demonstrated that this policy would prevent a large number of incident cardiovascular diseases (135 781) and type 2 diabetes (99 736) and net savings of over US$10 billion (2018 US dollars) among US adults over a lifetime.[22 23] However, the health and economic benefits of the policy for obesity-associated cancers have not been evaluated. This study aimed to address the knowledge gap by evaluating the cost-effectiveness of the federal menu calorie labelling policy and obesity-associated cancer burdens among US adults.

METHODS

Study overview

The Diet and Cancer Outcome (DiCOM), a probabilistic cohort state-transition model,[24] was used to perform an economic evaluation of the menu calorie labelling and obesity-associated cancer rates among 235 million US adults aged 20 years and older (US census), by comparing a policy scenario (menu calorie label) with the status quo (no policy), over a simulated lifetime starting from 2015. The model consists of (1) four health states: healthy without cancer, initial diagnosis and treatment for 13 types of obesity-related cancer, continuous care for each of the 13 cancers, and death (from 13 cancers or other causes); (2) the annual likelihood of changes in health and (3) the lifetime consequences of such changes on health outcomes and economic cost (online supplemental figure 1). The DiCOM model integrated independent parameters from different data sources, including nationally representative population demographics, dietary intake and cancer statistics, association estimates of policy intervention with diet, diet change with body mass index (BMI) and BMI with cancer risks; and policy and health-related costs from established sources (table 1). This study used de-identified datasets and was exempt from institutional review board review and follows the Consolidated Health Economic Evaluation Reporting Standards (CHEERS) guidelines.

Simulated US population

Because FDA's final rules on menu calorie labelling were published in 2016 and implemented in 2018, considering that some restaurants had implemented this policy before 2016 given that the law was passed in 2010, we used 2015–2016 as the baseline and assumed a closed cohort for this analysis. The projected population size of US adults aged ≥20 in 2015–2016 was obtained from the US census data.[25] We combined the 2013–2016 National Health and Nutrition Examination Survey (NHANES) to approximate the baseline and simulate the nationally representative US adult population aged ≥20 years in 32 subgroups stratified by age (20–44, 45–54, 55–64, ≥65), sex (male, female), and race/ethnicity (non-Hispanic White, non-Hispanic Black, Hispanic, Other) (online supplemental table 1). This closed cohort of US adults was modelled from baseline through their lifetime up to 80 years or until death.

Calorie consumption from restaurants

Mean calorie consumption from full-service and fast-food restaurants, demographics and prevalence of overweight or obesity were estimated using data collected from NHANES participants with at least one valid 24-hour diet recall, in every 32 strata. Following FDA's estimates,[13] we assumed that policy would affect 56.5% of calories consumed at full-service restaurants and 100% at fast-food restaurants. The National Cancer Institute method was used to estimate the usual intake distribution by statistically adjusting for within versus between variance in

Table 1 Key input parameters and data sources in the Dietary Cancer Outcome Model (DiCOM)

Model input	Outcome	Estimates	Distribution	Comments	Data source
1. Simulated population	Population	Mean consumption of calories was 332 kcal/day from full-service or fast-food restaurants (online supplemental tables 1, 8 and 9)	Gamma	Stratified by age, sex, race/ethnicity; 32 subgroups	NHANES 2013–2016
2. Policy effect*					
a. Consumer behaviour	Policy effect	7.3% (95% CI 4.4% to 10.1%) (online supplemental appendix 1 and appendix table 1)	Beta	One-time effect	Meta-analysis of labelling interventions on reducing calorie intake, Shangguan *et al*, 2019[15]
b. Industry response	Policy effect	5% (online supplemental appendix 1 and appendix table 2)	Beta	Assumption: no reformulation in the first year of policy intervention; restaurants will replace the high-calorie menu items with low-calorie options or reformulate the menu items in years 2 to 5 of the intervention to achieve a 5% reduction in calorie content	Calorie changes in large chain restaurants from 2008 to 2015[18]; higher-calorie menu items eliminated in large-chain restaurants[19]
3. Effect of change in calorie intake on BMI change (kg/m^2)*	Dietary effect	Among individuals with: BMI <25: 0.0015 per kcal BMI ≥25: 0.003 per kcal	Normal	Assumption: 55 kcal per day reduction in calorie intake would lead to one pound weight loss within 1 year, with no further weight loss in the future	Hall *et al*, 2018[30]; Hall *et al*, 2011[29]
4. Etiologic effect of BMI on cancer outcomes*	Cancer outcome	RRs ranged from 1.05 to 1.50 (online supplemental table 2)	Log normal	BMI change and cancer incidence	Continuous update project (CUP) conducted by the World Cancer Research Fund (WCRF)/American Institute for Cancer Research (AICR)
5. Cancer statistics*	Cancer incidence‡ and survival	online supplemental tables 3 and 4 and appendices 2 and 3, appendix tables 3 and 4	Beta	Stratified by age, sex and race/ethnicity	NCI's Surveillance, Epidemiology, and End Results Programme (SEER) Database; CDC's National Programme of Cancer Registries (NPCR) Database
6. Healthcare-related costs*†	Medical expenditures, productivity loss and patient time costs	online supplemental tables 6 and 7, appendix 6 and appendix table 7	Gamma	Stratified by age and sex	NCI's cancer prevalence and cost of care projections; published literature
7. Policy costs*†	For government and industry	online supplemental appendix 5 and appendix tables 5 and 6	Gamma	Administration and monitoring costs for government; compliance and reformulation costs for industry	FDA's budget report; Nutrition Review Project; and FDA's Regulatory Impact Analysis
8. Health-related quality of life (HRQoL)*	For 13 types of cancer	Ranged from 0.64 to 0.86 (online supplemental table 5 and appendix 4)	Beta	EQ-5D§ data from published literature by cancer type	Published literature

*Uncertainty distributions were incorporated in the probabilistic sensitivity analyses. Uncertainties in each parameter are presented in supplemental materials (online supplemental appendix table 5 and online supplemental tables 2–9).
†If the source did not provide uncertainty estimates, we assumed the standard errors were 20% of the mean estimate to generate gamma distribution.
‡Time-varying input parameter, for which the model accounted for the secular trends. Details are provided in the Supplements.
§EQ-5D is a standardised instrument developed by the EuroQol Group as a measure of health-related quality of life that can be used in a wide range of health conditions and treatments.
BMI, body mass index; CDC, Centers for Disease Control and Prevention; FDA, Food and Drug Administration; NCI, National Cancer Institute; NHANES, National Health and Nutrition Examination Survey.

dietary recalls.[26–28] The complex survey design was incorporated in all statistical analyses to ensure the representativeness of study findings to the non-institutionalised US adults.

Policy association with calorie consumption

Policy association with consumer behaviours was obtained from a systematic review and meta-analysis of 13 interventional studies (5 RCTs) with 19 interventions conducted in fast-food, full-service, cafeterias, and laboratories between 2000 and 2015 that evaluated the effectiveness of menu calorie labelling on consumers' calorie consumption per meal (online supplemental appendix 1 and appendix table 1).[15] The study results showed a 7.3% (95% CI 4.4% to 10.1%) reduction in calories consumed per meal following calorie labelling. We assumed that the policy would have a one-time effect over 1 year, with no further change over time.

Policy intervention may stimulate industries to reformulate their products to lower the calorie content. Potential policy impact on industry reformulation was derived from studies of restaurant menu items following the passage and initial period of partial implementation of the final rules (online supplemental appendix table 2). Between 2012 and 2014, among 66 of the 100 largest US chain restaurants, replacing higher-calorie menu items with lower-calorie items led to a 1–5% calorie reduction per menu item.[19,20] Among 44 chain restaurants with menu calorie information available in 2008, the calories per menu item fell by 7% between 2008 and 2015.[18] Based on the evidence, we chose 5% as the mid-point for the potential policy impact on industry response, which may include discontinuation of existing high-calorie menu items and/or introduction of lower-calorie menu items. We assumed that no reformulation occurs in the first year of policy intervention, and restaurants will replace the high-calorie menu items with low-calorie options or reformulate the menu items in years 2 to 5 of the intervention to achieve a 5% reduction in calorie content, with no change thereafter. Combining the effect on consumer behaviours with the effect on industry response, the policy would lead to a 12.3% reduction in calories consumed per meal.

In addition, we conservatively assumed that there would be some compensatory increased calorie intake outside of restaurants so that only half of all calories reduced from restaurant meals would translate into long-term reductions in daily calories (compensation rate=50%). Therefore, the reduction in calorie consumption from fast-food or full-service restaurants among the simulated population was computed using the baseline consumption times the policy effect estimates, and then times the compensation rate.

Calorie reduction and obesity-associated cancer risk

To estimate the relationships between calorie intake and obesity-associated cancers, we associated the multivariate-adjusted association of change in calorie intake (kcal/day) with change in BMI (kg/m^2) and the estimates of BMI and cancer risks. Based on an established energy–weight dynamic model that accounted for the long-term impacts of calorie reduction on weight and metabolic expenditure, we assumed that each 55 kcal/day calorie reduction leads to one pound weight loss over 1 year among overweight or obese adults, with no further reduction thereafter.[29,30] Because long-term observational studies suggest that weight change for an equivalent change in dietary intake is about twice as large in overweight or obese adults than normal-weight adults,[31,32] we conservatively applied half of this estimate to individuals with normal weight. For each of the 13 obesity-related cancers, the estimated change in risk for each 5 kg/m^2 change in BMI was derived from the systematic reviews and meta-analyses of multivariable-adjusted prospective cohort studies conducted by the World Cancer Research Fund/American Institute for Cancer Research Continuous Update Project (CUP) and the International Agency for Research on Cancer (online supplemental table 2).[2]

Cancer incidence, mortality and health-related quality of life

The incidences of age-adjusted cancer in 2015 were obtained from the National Programme of Cancer Registries and the Surveillance, Epidemiology, and End Results (SEER) programme. We projected the cancer incidence from 2015 to 2030 based on the 2006–2014 trend using the average annual percent change method.[33] We then combined the projected incidence rates with the projected US population from the national interim projections[34] to account for changes in population age distribution over time. We further applied the cohort-period method to estimate cancer incidence in the closed cohort of US adults in each of the 32 groups as they age (online supplemental table 3, appendix 2 and appendix table 3). The 5-year relative survival rates for each cancer were extracted and converted to an annual probability of death (online supplemental table 4, appendix 3 and appendix table 4).[35–37] Health-related quality of life data were obtained from publications that reported the EuroQol-5 dimension utility weights for each cancer among the US patient population (online supplemental table 5 and appendix 4).

Policy and health-related costs

Policy costs included government costs to administer, monitor and evaluate the policy, and industry costs to comply with the policy and reformulate their products (in scenario 2). Government costs were estimated from FDA's budget report and Nutrition Review Project (online supplemental appendix 5 and appendix tables 5 and 6).[38,39] Industry compliance and reformulation costs were based on the FDA's regulatory impact analysis that included initial and recurring nutrition analysis of standard menu items and menu replacement, provision of nutrition information, employee training and legal review, and accounted for restaurant size and type, reformulation type and compliance period.[13]

Direct medical costs for cancer care were extracted from the SEER–Medicare linked database for three phases of cancer care: initial (12 months after diagnosis), continuing, and end-of-life (the last year of life) (online supplemental tables 6 and 7, appendix 6 and appendix table 7).[33,40] For individuals without cancer, the direct medical costs were estimated based on Medical Expenditure Panel Survey (MEPS) data and insurance claims.[24,41,42] Indirect costs including productivity loss due to disability or missed work days and patient time costs were derived from publications using MEPS data.[43–46]

Cost-effectiveness analysis

Following the guidelines on cost-effectiveness in health and medicine,[47] we evaluated the policy impact by projecting the numbers of new cancer cases and cancer deaths averted and quality-adjusted life-years (QALYs) gained and cost-effectiveness from both healthcare and societal perspectives. Net costs from the healthcare perspective were assessed as the difference between government costs for implementing the policy and the direct medical costs of cancer care. Net costs from the societal perspective were assessed as the difference between total policy costs (including both government and industry costs) and health-related costs saved (including direct and indirect costs of cancer care). All costs were inflated to 2015 US dollars using the Consumer Price Index or Personal Healthcare Index, with all costs and QALYs discounted at 3% annually.[47] Incremental cost-effectiveness ratios (ICERs) were calculated as net costs divided by the difference in QALYs between policy versus no policy. ICERs falling below a willingness-to-pay threshold of US$150 000 per QALY gained were considered to be cost-effective.[48 49] Cost-effectiveness analysis was further conducted among population subgroups by age, sex and race/ethnicity to evaluate policy associations with health disparities.

One-way sensitivity analyses were performed by varying input parameters, including reducing the outside-the-restaurant calorie compensation level to 25% or increasing it to 75%, altering coverage of the FDA's final rule to all calories from full-service restaurants, reducing the diet–BMI associations to half or doubling the estimates, incorporating an estimated 2% annual increase in medical expenditures associated with cancer care and altering annual discounting rates from 3% to 0% or 5%. We also evaluated impacts at a 10-year time horizon for stakeholders interested in shorter-term health gains and economic benefits. Probabilistic sensitivity analyses were conducted to incorporate uncertainty in all input parameters jointly (table 1). A total of 1000 Monte Carlo simulations were performed, and 95% uncertainty intervals (UIs) were estimated based on the 2.5 and 97.5 percentiles of 1000 simulations. All analyses were conducted using SAS (version 9.4) and R (version 3.3.1).

Patient and public involvement

This study used de-identified datasets and did not involve patients or the public in the design, conduct, reporting or dissemination plans of our research.

RESULTS

Population characteristics

The simulated cohort of US adults in 2015–2016 had a mean age of 47.8 years, with 65.0% being non-Hispanic White adults and 71.4% being overweight or obese (online supplemental tables 8 and 9). A mean of 332 daily calories was consumed from full-service or fast-food restaurants. Higher levels were consumed among younger adults aged 20–44 years (425 kcal/day), men (388 kcal/day), non-Hispanic black (361 kcal/day) and Hispanic (367 kcal/day) adults, in comparison with other corresponding subgroups.

Health gains

The menu calorie labelling was estimated to reduce calories consumed from restaurants by a mean of 24 kcal/day among US adults, and total daily calories by 12 kcal/day. Accounting for potential industry reformulation would reduce the mean intake by an additional 16 kcal/day, and total daily calories by 8 kcal/day.

Based on changes in consumer behaviour alone, the policy was associated with a reduction of 28 000 (95% UI 16 300 to 39 100) new cancer cases and 16 700 (9610 to 23 600) cancer deaths, and a gain of 111 000 (64 800 to 158 000) QALYs among 235 million US adults over a median follow-up of 34.4 years (table 2 and figure 1). By cancer type, the greatest numbers of new cancer cases averted were cancers of endometrial (5700 (95% UI 2380 to 9190)), liver (5180 (2800 to 7730)), kidney (5090 (2670 to 7470)), postmenopausal breast (4840 (2010 to 8230)), and pancreas (1400 (756 to 2100)). The greatest numbers of prevented cancer deaths were estimated for cancers of the liver (4530 [2410 to 6760)), postmenopausal breast (3080 (862 to 5650)), endometrial (2060 (957 to 3220)), kidney (1980 (1080 to 2920)), and pancreas (1230 (661 to 1830)).

Based on additional industry response, the total estimated health gains approximately doubled, preventing 47 300 (35 400-59 100) new cancer cases and 28 200 (21 100 to 35 300) cancer deaths, and gaining 189 000 (140 000 to 236 000) QALYs, with similar rankings of the types of new cancer cases and cancer deaths prevented.

Economic impacts

Implementing the policy would cost the government US$19 (95% UI 15 to 25) million and the restaurant industry, US$820 (762 to 889) million in compliance costs over a lifetime (table 2). The policy was associated with savings of US$1480 (884 to 2080) million in direct medical costs, US$608 (363 to 865) million in productivity loss costs and US$102 (62 to 144) million in patient time costs. Potential industry reformulation would cost the restaurant industry an additional US$296 (249 to 353) million to implement but would also result in greater healthcare savings, including US$2500 (1900 to 3090) million, US$1030 (780 to 1290) million and US$172 (131 to 216) million in reduced direct medical, productivity loss, and patient time costs, respectively.

From both the healthcare and social perspectives, implementing the menu calorie labelling policy among US adults over a lifetime would be cost saving. With changes in consumer behaviour alone, the net cost savings were estimated to be US$1460 (864 to 2060) million and US$1350 (486 to 2260) million from the healthcare and

Table 2 Estimated health gains and costs of the federal menu calorie labelling policy on reducing the obesity-related cancer burdens in the USA over 10 years and a lifetime (US population=235 162 844)*

	Menu calorie labelling policy			
	10 Years		Lifetime	
	Consumer behaviour Median (2.5% to 97.5%)	Consumer behaviour+industry response Median (2.5% to 97.5%)	Consumer behaviour Median (2.5% to 97.5%)	Consumer behaviour+ industry response Median (2.5% to 97.5%)
New cancer cases averted, N (95% UI)				
Endometrial cancer	692 (276 to 1100)	1130 (716 to 1550)	5700 (2380 to 9190)	9920 (6630 to 13 600)
Liver cancer	366 (144 to 615)	626 (386 to 887)	5180 (2800 to 7730)	8550 (5960 to 11 300)
Kidney cancer	584 (290 to 884)	980 (689 to 1280)	5090 (2670 to 7470)	8620 (6200 to 11 000)
Breast cancer (postmenopausal)	670 (256 to 1110)	1080 (658 to 1520)	4840 (2010 to 8230)	8520 (5610 to 12 200)
Pancreatic cancer	170 (83 to 257)	273 (183 to 367)	1400 (756 to 2100)	2380 (1690 to 3140)
Oesophageal adenocarcinoma	179 (56 to 304)	286 (159 to 411)	1350 (485 to 2230)	2330 (1440 to 3280)
Colorectal cancer	189 (97 to 284)	319 (225 to 418)	1050 (561 to 1600)	1780 (1230 to 2370)
Multiple myeloma	75 (37 to 117)	122 (81 to 169)	690 (384 to 1090)	1150 (775 to 1630)
Stomach cancer (cardia)	54 (6 to 109)	98 (51 to 165)	647 (261 to 1140)	1090 (644 to 1660)
Thyroid cancer	105 (58 to 161)	176 (123 to 243)	516 (206 to 914)	951 (576 to 1420)
Advanced prostate cancer	66 (17 to 118)	107 (57 to 162)	339 (138 to 561)	577 (352 to 836)
Gallbladder cancer	29 (16 to 42)	46 (34 to 60)	314 (213 to 438)	512 (399 to 648)
Ovarian cancer	33 (15 to 56)	53 (33 to 78)	147 (44 to 282)	254 (110 to 420)
Total	3300 (1750 to 4720)	5230 (3870 to 6790)	28 000 (16 300 to 39 100)	47 300 (35 400 to 59 100)
Cancer deaths prevented, N (95% UI)				
Liver cancer	168 (59 to 287)	287 (174 to 410)	4530 (2410 to 6760)	7510 (5200 to 9980)
Breast cancer (postmenopausal)	68 (33 to 106)	111 (74 to 149)	3080 (862 to 5650)	5590 (3230 to 8310)
Endometrial cancer	52 (20 to 86)	87 (55 to 121)	2060 (957 to 3220)	3520 (2390 to 4700)
Kidney cancer	70 (29 to 110)	114 (74 to 154)	1980 (1080 to 2920)	3320 (2430 to 4300)
Pancreatic cancer	88 (38 to 138)	143 (93 to 195)	1230 (661 to 1830)	2080 (1480 to 2740)
Oesophageal adenocarcinoma	76 (21 to 131)	122 (69 to 178)	1150 (403 to 1930)	1990 (1210 to 2820)
Colorectal cancer	34 (17 to 53)	57 (40 to 77)	706 (369 to 1080)	1200 (839 to 1600)
Stomach cancer (cardia)	22 (2 to 48)	40 (19 to 68)	541 (230 to 947)	907 (538 to 1400)
Multiple myeloma	18 (8 to 30)	29 (18 to 42)	420 (239 to 662)	691 (481 to 980)
Gallbladder cancer	13 (7 to 20)	21 (15 to 28)	267 (181 to 369)	436 (341 to 551)
Advanced prostate cancer	9 (3 to 15)	13 (7 to 19)	163 (65 to 280)	273 (163 to 404)
Ovarian cancer	8 (3 to 15)	13 (7 to 20)	107 (39 to 191)	181 (94 to 290)
Thyroid cancer	1 (1 to 2)	2 (1 to 3)	23 (11 to 38)	38 (24 to 58)

Continued

Table 2 Continued

	Menu calorie labelling policy			
	10 Years		Lifetime	
	Consumer behaviour Median (2.5% to 97.5%)	Consumer behaviour+industry response Median (2.5% to 97.5%)	Consumer behaviour Median (2.5% to 97.5%)	Consumer behaviour+ industry response Median (2.5% to 97.5%)
Total	654 (320 to 970)	1080 (746 to 1400)	16 700 (9610 to 23 600)	28 200 (21 100 to 35 300)
Life-years gained	678 (288 to 1040)	1120 (738 to 1490)	76 400 (43 400 to 109 000)	130 000 (96 900 to 162 000)
QALYs gained	4280 (2170 to 6250)	7030 (4960 to 9090)	1 11 000 (64 800 to 158 000)	189 000 (140 000 to 236 000)
Changes in health-related costs (US$, millions)‡§				
Healthcare (medical) cost	−192 (−277 to −100)	−319 (−403 to −227)	−1480 (−2080 to −884)	−2500 (−3090 to −1900)
Patient time cost	−7.33 (−10.9 to −3.56)	−12.2 (−15.8 to −8.39)	−102 (−144 to −62.2)	−172 (−216 to −131)
Productivity loss	−48.7 (−70.1 to −24.5)	−80.4 (−102 to −56.7)	−608 (−865 to −363)	−1030 (−1290 to −780)
Policy implementation costs (US$, millions)‡§				
Total	518 (493 to 548)	644 (612 to 680)	839 (780 to 908)	1140 (1060 to 1220)
Government cost	13.2 (11.4 to 15.9)	13.1 (11.4 to 15.7)	18.5 (14.5 to 25.1)	18.5 (14.4 to 25.5)
Administration	9.08 (8.59 to 9.60)	9.07 (8.64 to 9.50)	9.07 (8.61 to 9.56)	9.09 (8.62 to 9.55)
Monitoring	4.09 (2.40 to 6.74)	4.00 (2.35 to 6.63)	9.40 (5.45 to 16.1)	9.38 (5.30 to 16.3)
Industry cost	505 (480 to 535)	631 (599 to 667)	820 (762 to 889)	1120 (1040 to 1210)
Compliance	505 (480 to 535)	506 (480 to 533)	820 (762 to 889)	823 (757 to 889)
Reformulation	-	124 (107 to 146)	-	296 (249 to 353)
Net costs (US$, millions)‡§¶				
Societal perspective	270 (156 to 389)	233 (119 to 356)	−1350 (−2260 to −486)	−2570 (−3460 to −1650)
Healthcare perspective	−179 (−263 to −86.3)	−305 (−390 to−-214)	−1460 (−2060 to −864)	−2480 (−3070 to −1880)
ICER (US$/QALY)†				
Societal perspective	64 500 (26 100 to 187 000)	33 600 (13 300 to 72 400)	Dominant	Dominant
Healthcare perspective	Dominant	Dominant	Dominant	Dominant

*Values are the median estimates (95% uncertainty intervals) of each distribution of 1000 simulations.
†ICER threshold was evaluated at US$150 000/QALY. Dominant represents less costly and more effective than the "no-policy" intervention.
‡Health-related costs were inflated to 2015 US$ using the Personal Healthcare (PHC) Index. Policy intervention costs were inflated to 2015 US dollars using the Consumer Price Index. Negative costs represent savings.
§Costs are medians from 1000 simulations so may not add up to totals.
¶Net costs were calculated as policy costs minus health-related costs from reduced cancer burden. The societal perspective includes healthcare costs, patient time costs, productivity costs and policy implementation costs; the healthcare perspective included policy costs relevant to policy implementation and programme monitoring and evaluation and medical costs.
ICER, incremental cost-effectiveness ratio; QALY, quality-adjusted life-years; UI, uncertainty interval.

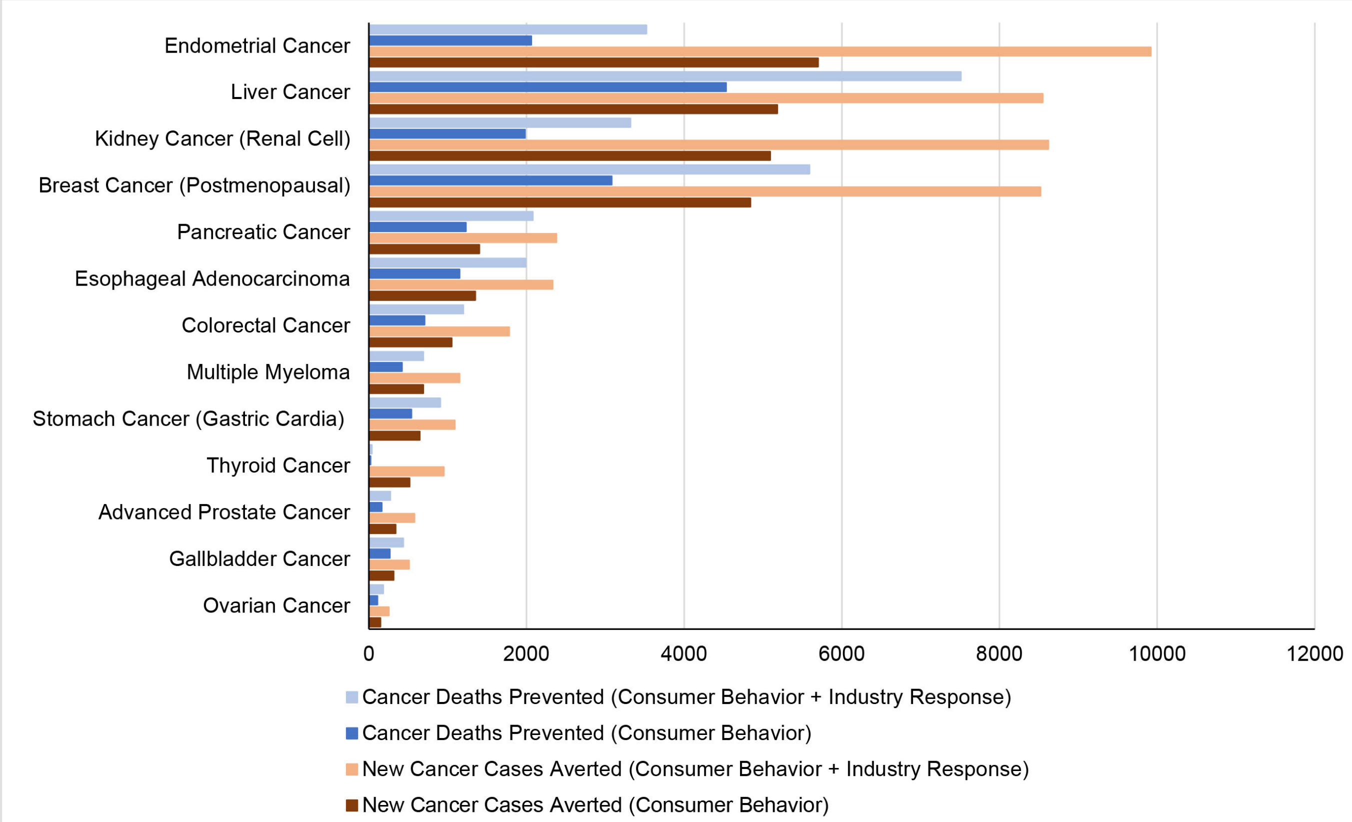

Figure 1 Estimated new cancer cases and deaths prevented by federal menu calorie labelling policy in the USA by cancer type over a lifetime.

societal perspective, respectively. With additional industry response, estimated cost savings increased to US$2480 ($1880 to 3070) million from the healthcare perspective and US$2570 (1650 to 3460) million from the societal perspective.

Policy impacts among population subgroups

Among population subgroups, the consumer response to the policy was estimated to result in greater health gains per 100 000 individuals among adults aged 20–44 years (15 new cancer cases averted) and 55–64 years (16 new cancer cases averted) than older age groups (aged ≥65 years; 6 new cancer cases averted); Hispanic and non-Hispanic Black individuals than Non-Hispanic White group (22 vs 9 and 17 vs 9 new cancer cases averted) (table 3). The numbers of cancer deaths averted, life-years and QALYs gained, health-related costs saved and net costs among population subgroups followed a similar pattern (online supplemental tables 10 and 11 and figures 2–5). For instance, the policy was associated with more cancer deaths prevented per 100 000 individuals among younger adults aged 20–44 years than older adults aged ≥65 years (10 vs 3 cancer deaths averted) and Hispanic and non-Hispanic Black adults than non-Hispanic White individuals (14 vs 5 and 11 vs 5 cancer deaths averted). Adding potential industry reformulations resulted in larger health gains among adults aged 45–54 (128% increase in new cancer cases averted) and non-Hispanic White adults (84% increase in new cancer cases averted).

Sensitivity analyses

In probabilistic sensitivity analyses, based on consumer responses alone, the menu calorie labelling was cost saving over a lifetime in 93% of 1000 simulations and cost-effective (<$150,000/QALY) in the remaining 7% from the societal perspective, and was cost saving in over 98% of 1000 simulations from the healthcare perspective. Adding the additional industry response increased the probability of cost savings to nearly 100% of the simulations for both the societal and healthcare perspectives (figure 2).

Evaluating health gains, costs and cost-effectiveness at 10 years, the policy remained cost saving from the healthcare perspective and was cost-effective from the societal perspective, with an ICER of US$64 500 (26 100 to 187 000) per QALY based on consumer response alone and US$33 600 (13 300 to 72 400) per QALY with additional industry response. The cost-effectiveness of this policy was most sensitive to varied assumptions of the diet–BMI estimates and annual discounting rates (online supplemental tables 12,13 and figure 6).

DISCUSSION

This study estimated that the federal menu calorie labelling policy, based on consumer response alone, was

Table 3 Estimated new cancer cases and deaths prevented by the federal menu calorie labelling project in the USA by age, sex and race/ethnicity, over a lifetime*

	Consumer behaviour		Consumer behaviour+Industry response	
	N (95% UI)	Per 100 000 individuals (95% UI)	N (95% UI)	Per 100 000 individuals (95% UI)
New cancer cases averted				
Age				
20–44	15 700 (6170 to 25 100)	15.0 (5.89 to 24.0)	28 000 (18 000 to 37 500)	26.7 (17.2 to 35.8)
45–54	2810 (–2110 to 8030)	6.61 (–4.97 to 18.9)	6420 (1390 to 11 600)	15.1 (3.27 to 27.2)
55–64	6330 (3540 to 9400)	15.7 (8.76 to 23.3)	8640 (5790 to 11 800)	21.4 (14.3 to 29.1)
≥65	2740 (795 to 4650)	5.77 (1.68 to 9.80)	4060 (2070 to 5950)	8.55 (4.36 to 12.6)
Sex				
Female	15 100 (6650 to 24 000)	12.5 (5.51 to 19.8)	25 900 (17 400 to 34 900)	21.4 (14.4 to 28.9)
Male	12 500 (4920 to 20 100)	10.9 (4.30 to 17.6)	21 100 (13 500 to 29 100)	18.4 (11.8 to 25.4)
Race/Ethnicity				
Non-Hispanic White	14 300 (4310 to 24 500)	9.16 (2.77 to 15.7)	26 300 (16 000 to 36 700)	16.9 (10.3 to 23.6)
Non-Hispanic Black	4720 (1820 to 8100)	16.6 (6.37 to 28.4)	7630 (4750 to 11 100)	26.8 (16.7 to 38.9)
Hispanic	7700 (3560 to 11 500)	21.5 (9.93 to 32.2)	11 200 (7060 to 15 300)	31.3 (19.7 to 42.6)
Other	1150 (–240 to 2440)	7.60 (–1.59 to 16.2)	1990 (652 to 3310)	13.2 (4.33 to 22.0)
Cancer deaths prevented				
Age				
20–44	10 200 (4170 to 16 400)	9.73 (3.98 to 15.7)	18 100 (11 700 to 24 500)	17.3 (11.2 to 23.4)
45–54	1730 (–853 to 4240)	4.07 (–2.01 to 9.97)	3650 (1040 to 6240)	8.58 (2.44 to 14.7)
55–64	3320 (1760 to 4930)	8.21 (4.36 to 12.2)	4480 (2890 to 6090)	11.1 (7.15 to 15.1)
≥65	1200 (285 to 2130)	2.53 (0.60 to 4.48)	1800 (848 to 2720)	3.79 (1.79 to 5.73)
Sex				
Female	7810 (3290 to 12 600)	6.47 (2.73 to 10.5)	13 400 (8850 to 18 500)	11.1 (7.33 to 15.3)
Male	8510 (3500 to 13 900)	7.44 (3.06 to 12.1)	14 400 (9300 to 20 000)	12.6 (8.13 to 17.5)
Race/ethnicity				
Non-Hispanic White	7920 (2180 to 13 900)	5.08 (1.40 to 8.94)	14 700 (8770 to 20 900)	9.45 (5.64 to 13.5)
Non-Hispanic Black	3010 (1000 to 5370)	10.6 (3.51 to 18.8)	4990 (2950 to 7380)	17.5 (10.4 to 25.9)
Hispanic	4960 (2360 to 7560)	13.8 (6.58 to 21.1)	7190 (4480 to 9870)	20.0 (12.5 to 27.5)
Other	565 (–246 to 1350)	3.75 (–1.63 to 8.97)	1070 (273 to 1870)	7.12 (1.81 to 12.4)

*Values are the median estimates (95% uncertainty intervals) of each distribution of 1000 simulations.

associated with a reduction of approximately 28 000 new cancer cases and 16 700 cancer deaths among US adults over a lifetime, and net savings of US$1350 and US$1460 million from societal and healthcare perspectives, respectively. Incorporating additional modest industry responses, these health and economic gains were approximately doubled. Greater health gains were expected among younger, middle-aged subgroups, Hispanic, and non-Hispanic Black individuals than for other subgroups. Findings were robust to a range of probabilistic and one-way sensitivity analyses.

Our study findings supported the hypothesis that nutrition policies can have meaningful health and economic impacts on cancer prevention in the USA. In this case, a modest change in mean calorie consumption, distributed across the population, was estimated to achieve important reductions in obesity-related cancer burdens among US adults. Using the best available estimates, our study further suggested that the federal menu calorie labelling policy is cost-effective in the short term and cost saving in the long term in reducing obesity-associated cancer burdens. Many preventive medical screenings are cost-effective, but none of them achieve net savings. For example, among a large cohort of women born in the 1960s over a lifetime, mammography screening starting at age 45 years was estimated to have an ICER of US$40 135/QALY.[50] Colonoscopy screening starting at age 45 years among US adults achieved an ICER of US$33 900/QALY.[51] Prostate-specific antigen screening had an ICER of US$70 831 to US$136 332/QALY among US men beginning at 40 years of age over a lifetime.[52] In contrast, population-based nutrition interventions could be a cost-saving strategy for cancer prevention. Cost-effectiveness analyses showed that a penny-per-ounce tax on sugar-sweetened beverages would be a highly cost-effective strategy for cancer prevention among US adults, with an

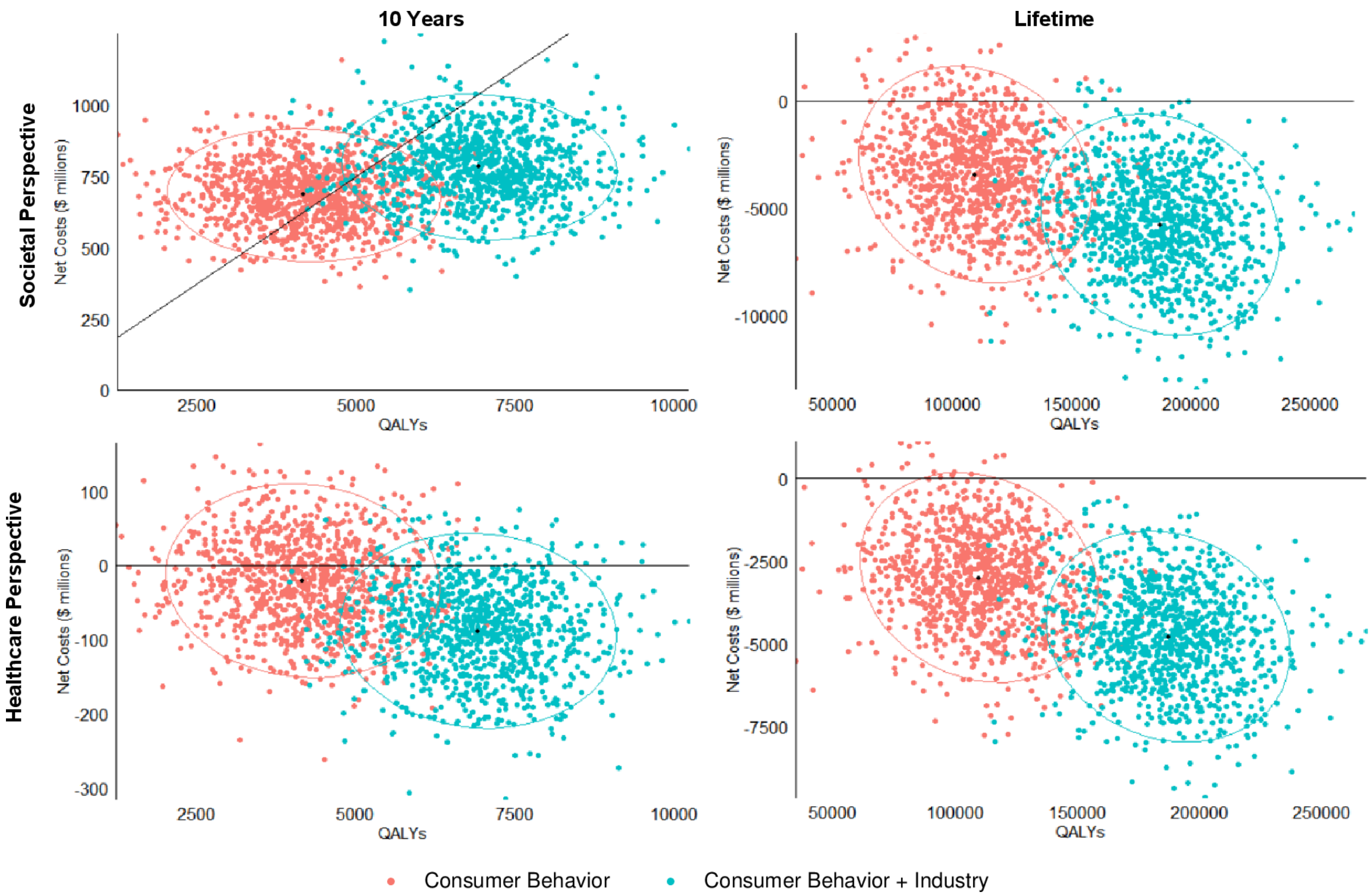

Figure 2 Probabilistic sensitivity analyses for cost-effectiveness of the federal menu calorie labelling project over 10 years and a lifetime. Values are presented in cost-effectiveness planes of net costs ($millions) versus incremental quality-adjusted life years (QALYs). For each policy scenario, each coloured dot represents one of the 1000 simulations, with the largest dot showing the median incremental cost-effectiveness ratio (ICER, US$/QALY); and the ellipse representing the 95% uncertainty intervals. Results are presented from the societal perspective and the healthcare perspective. Negative values indicate cost savings.

ICER of US$13 220, the nutrition facts added sugar labelling would prevent 30 000 incident obesity-related cancer cases and 17 100 cancer deaths and be associated with a net saving of US$704 million, and processed meat taxes would avert 77 000 colorectal cancer cases and 12 500 stomach cancer cases and save US$4.5 billion, all from the societal perspective.[24 53 54] Thus, while we shall continue the efforts of increasing the screening rates, we also need to consider population-based strategies to improve nutrition for cancer prevention in the USA.

Our findings also indicated the importance of assessing potential industry response, which could nearly double health and economic benefits. The additional impacts of industry reformulation in response to nutrition-related policies have been reported in other studies focused on obesity-associated cancer, diabetes and cardiovascular diseases.[23 54–56] Our new findings build on this recent work and highlight the importance of potential strategies to encourage industry reformulation under the federal menu calorie labelling framework to further improve the health benefits and cost-effectiveness of such policies.

In addition, our results showed that population-based nutrition policies such as menu calorie labelling can potentially narrow diet-associated cancer disparities. We found greater health gains and economic impacts among racial/ethnic minorities compared with non-Hispanic Whites, probably due to higher diet-associated cancer burdens among minorities.[57] However, labelling policies may have fewer effects on food purchasing behaviours among minorities or socioeconomically disadvantaged groups. Prior studies reported that individuals with higher education and income attainment were more likely to notice and use the menu calorie labels when ordering foods in fast-food or full-service restaurants compared with socioeconomically disadvantaged groups,[58–60] and multiracial individuals were less likely to notice and use menu calorie labels in fast food restaurants than non-Hispanic Whites.[58] Previous studies also showed that literacy or numeracy could be a barrier to label use.[61 62] Thus, it is important for labelling policies to be paired with nutrition education to effectively reduce diet-associated health disparities.

Potential limitations should be considered. First, as a modelling study, our investigation does not provide the impact of real-world policy implementation on the health and economic outcomes of federal menu calorie labelling. However, conducting randomised controlled trials of national nutrition policy interventions is extremely difficult and often implausible, whereas simulation modelling can provide complementary evidence with the flexibility to assess different policy scenarios that help inform policymaking. Second, this evaluation did not include the potential benefits of menu calorie labelling on other health outcomes, such as diabetes and cardiovascular diseases. Considering such outcomes is likely to be associated with greater health gains and cost savings.[23 63 64] Third, menu calorie labelling could have a greater effect among subgroups with higher levels of income and education and non-Hispanic White adults[58–60] and thus exacerbate health disparities. Owing to the lack of consistent policy effect sizes among populations with different socioeconomic statuses, we were unable to integrate this into our modelling. Fourth, we modelled only the impact of menu calorie labelling on calories, although the policy might also result in potential changes in the nutritional quality of restaurant meals. The majority of current restaurant meals consumed by American adults—70% of meals consumed from fast-food restaurants and 50% consumed from full-service restaurants—are of poor nutritional quality, and the remainder are only of intermediate nutritional quality, with very few being ideal.[10] If the policy also improves the quality of restaurant meals, the total reduction in obesity-associated cancer burdens could be greater than our current estimates.

CONCLUSIONS

Study findings suggest that menu calorie labelling is associated with lower obesity-related cancer rates and reduced costs. Policymakers may prioritise nutrition policies for cancer prevention in the USA.

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REFERENCES

1 Lauby-Secretan B, Scoccianti C, Loomis D, *et al*. Body fatness and cancer - viewpoint of the IARC working group. *N Engl J Med* 2016;375:794–8.
2 World Cancer Research Fund/American Institute for Cancer Research. *Continuous update project expert report 2018, body fatness and weight gain and the risk of cancer*. 2018.
3 Steele CB, Thomas CC, Henley SJ, *et al*. Vital signs: trends in incidence of cancers associated with overweight and obesity-United States, 2005-2014. *MMWR Morb Mortal Wkly Rep* 2017;66:1052–8.
4 Fryar CD, Carroll MD, Ogden CL. *Prevalence of overweight, obesity, and severe obesity among children and adolescents aged 2–19 years: United States, 1963–1965 through 2015–2016*. 2018.
5 Hales CM, Fryar CD, Carroll MD, *et al*. Trends in obesity and severe obesity prevalence in US youth and adults by sex and age, 2007-2008 to 2015-2016. *JAMA* 2018;319:1723–5.
6 Centers for Disease Control and Prevention NCfCDPaHP. Health and economic cost of chronic diseases 2019. Available: https://www.cdc.gov/chronicdisease/about/costs/index.htm [Accessed 26 Jan 2020].
7 Hong Y-R, Huo J, Desai R, *et al*. Excess costs and economic burden of obesity-related cancers in the United States. *Value Health* 2019;22:1378–86.
8 Koroukian SM, Dong W, Berger NA. Changes in age distribution of obesity-associated cancers. *JAMA Netw Open* 2019;2:e199261.
9 Rock CL, Thomson C, Gansler T, *et al*. American Cancer Society guideline for diet and physical activity for cancer prevention. *CA Cancer J Clin* 2020;70:245–71.
10 Liu J, Rehm CD, Micha R, *et al*. Quality of meals consumed by US adults at full-service and fast-food restaurants, 2003-2016: persistent low quality and widening disparities. *J Nutr* 2020;150:873–83.

11 Roberts SB, Das SK, Suen VMM, *et al*. Measured energy content of frequently purchased restaurant meals: multi-country cross sectional study [BMJ (Clinical research ed) 2018;363:k4864]. *BMJ* 2018;363:k4864.
12 Wolfson JA, Bleich SN. Is cooking at home associated with better diet quality or weight-loss intention? *Public Health Nutr* 2015;18:1397–406.
13 Food and Drug Administration. *Food labeling; nutrition labeling of standard menu items in restaurants and similar retail food establishments; calorie labeling of articles of food in vending machines; final rule in: department of health and human services, ed*. 2014.
14 Petimar J, Zhang F, Cleveland LP, *et al*. Estimating the effect of calorie menu labeling on calories purchased in a large restaurant franchise in the southern United States: quasi-experimental study. *BMJ* 2019;367:l5837.
15 Shangguan S, Afshin A, Shulkin M, *et al*. A meta-analysis of food labeling effects on consumer diet behaviors and industry practices. *Am J Prev Med* 2019;56:300–14.
16 Block JP, Roberto CA. Potential benefits of calorie labeling in restaurants. *JAMA* 2014;312:887–8.
17 Namba A, Auchincloss A, Leonberg BL, *et al*. Exploratory analysis of fast-food chain restaurant menus before and after implementation of local calorie-labeling policies, 2005-2011. *Prev Chronic Dis* 2013;10:E101.
18 Bleich SN, Wolfson JA, Jarlenski MP. Calorie changes in large chain restaurants from 2008 to 2015. *Prev Med* 2017;100:112–6.
19 Bleich SN, Moran AJ, Jarlenski MP, *et al*. Higher-calorie menu items eliminated in large chain restaurants. *Am J Prev Med* 2018;54:214–20.
20 Bleich SN, Wolfson JA, Jarlenski MP. Calorie changes in large chain restaurants: declines in new menu items but room for improvement. *Am J Prev Med* 2016;50:e1–8.
21 Bleich SN, Wolfson JA, Jarlenski MP, *et al*. Restaurants with calories displayed on menus had lower calorie counts compared to restaurants without such labels. *Health Aff (Millwood)* 2015;34:1877–84.
22 Ananthapavan J, Sacks G, Brown V, *et al*. Priority-setting for obesity prevention-the assessing cost-effectiveness of obesity prevention policies in Australia (ACE-obesity policy) study. *PLoS One* 2020;15:e0234804.
23 Liu J, Mozaffarian D, Sy S, *et al*. Health and economic impacts of the national Menu Calorie Labeling Law in the United States: a microsimulation study. *Circ Cardiovasc Qual Outcomes* 2020;13:e006313.
24 Kim DD, Wilde PE, Michaud DS, *et al*. Cost effectiveness of nutrition policies on processed meat: implications for cancer burden in the U.S. *Am J Prev Med* 2019;57:e143–52.
25 United States Census Bureau. National population projections tables: main series. 2017. Available: https://www.census.gov/data/tables/2017/demo/popproj/2017-summary-tables.html [Accessed 3 Jul 2019].
26 Freedman LS, Midthune D, Carroll RJ, *et al*. Adjustments to improve the estimation of usual dietary intake distributions in the population. *J Nutr* 2004;134:1836–43.
27 Herrick KA, Rossen LM, Parsons R, *et al*. Estimating usual dietary in take from national health and nutrition examination survey data using the National Cancer Institute method. Vital and health statistics series 2, data evaluation and methods research. 2018:1–63.
28 Dodd KW, Guenther PM, Freedman LS, *et al*. Statistical methods for estimating usual intake of nutrients and foods: a review of the theory. *J Am Diet Assoc* 2006;106:1640–50.
29 Hall KD, Sacks G, Chandramohan D, *et al*. Quantification of the effect of energy imbalance on bodyweight. *Lancet* 2011;378:826–37.
30 Hall KD, Schoeller DA, Brown AW. Reducing calories to lose weight. *JAMA* 2018;319:2336–7.
31 Mozaffarian D, Hao T, Rimm EB, *et al*. Changes in diet and lifestyle and long-term weight gain in women and men. *N Engl J Med* 2011;364:2392–404.
32 Micha R, Peñalvo JL, Cudhea F, *et al*. Association between dietary factors and mortality from heart disease, stroke, and type 2 diabetes in the United States. *JAMA* 2017;317:912–24.
33 Mariotto AB, Yabroff KR, Shao Y, *et al*. Projections of the cost of cancer care in the United States: 2010-2020. *J Natl Cancer Inst* 2011;103:117–28.
34 United States Census Bureau. National population projections tables. 2014. Available: https://www.census.gov/data/tables/2014/demo/popproj/2014-summary-tables.html [Accessed 3 Jul 2019].
35 Brenner H. Long-term survival rates of cancer patients achieved by the end of the 20th century: a period analysis. *Lancet* 2002;360:1131–5.
36 Brenner H, Hakulinen T. Up-to-date and precise estimates of cancer patient survival: model-based period analysis. *Am J Epidemiol* 2006;164:689–96.
37 Brenner H, Hakulinen T. Up-to-date cancer survival: period analysis and beyond. *Int J Cancer* 2009;124:1384–90.
38 Food and Drug Administration. *Justification of estimates for appropriations committees fiscal year*. 2012.
39 Food and Drug Administration. *The nutrition review project. report to the director, center for food safety and applied nutrition*. 2014.
40 Martin AB, Hartman M, Washington B, *et al*. National health care spending in 2017: growth slows to post-great recession rates; share of GDP stabilizes. *Health Aff (Millwood)* 2019;38:101377hlthaff201805085.
41 French EB, McCauley J, Aragon M, *et al*. End-of-life medical spending in last twelve months of life is lower than previously reported. *Health Aff (Millwood)* 2017;36:1211–7.
42 Hogan C, Lunney J, Gabel J, *et al*. Medicare beneficiaries' costs of care in the last year of life. *Health Aff (Millwood)* 2001;20:188–95.
43 Yabroff KR, Davis WW, Lamont EB, *et al*. Patient time costs associated with cancer care. *J Nat Cancer Inst* 2007;99:14–23.
44 Yabroff KR, Guy GP, Ekwueme DU, *et al*. Annual patient time costs associated with medical care among cancer survivors in the United States. *Med Care* 2014;52:594–601.
45 Zheng Z, Yabroff KR, Guy GP, *et al*. Annual medical expenditure and productivity loss among colorectal, female breast, and prostate cancer survivors in the United States. *J Natl Cancer Inst* 2016;108:djv382.
46 Guy GP, Ekwueme DU, Yabroff KR, *et al*. Economic burden of cancer survivorship among adults in the United States. *J Clin Oncol* 2013;31:3749–57.
47 Sanders GD, Neumann PJ, Basu A, *et al*. Recommendations for conduct, methodological practices, and reporting of cost-effectiveness analyses: second panel on cost-effectiveness in health and medicine. *JAMA* 2016;316:1093–103.
48 Neumann PJ, Cohen JT, Weinstein MC. Updating cost-effectiveness--the curious resilience of the $50,000-per-QALY threshold. *N Engl J Med* 2014;371:796–7.
49 Greenberg D, Earle C, Fang C-H, *et al*. When is cancer care cost-effective? A systematic overview of cost-utility analyses in oncology. *J Natl Cancer Inst* 2010;102:82–8.
50 Tina Shih Y-C, Dong W, Xu Y, *et al*. Assessing the cost-effectiveness of updated breast cancer screening guidelines for average-risk women. *Value Health* 2019;22:185–93.
51 Ladabaum U, Mannalithara A, Meester RGS, *et al*. Cost-effectiveness and national effects of initiating colorectal cancer screening for average-risk persons at age 45 years instead of 50 years. *Gastroenterology* 2019;157:137–48.
52 Roth JA, Gulati R, Gore JL, *et al*. Economic analysis of prostate-specific antigen screening and selective treatment strategies. *JAMA Oncol* 2016;2:890–8.
53 Du M, Griecci CF, Kim DD, *et al*. Cost-effectiveness of a national sugar-sweetened beverage tax to reduce cancer burdens and disparities in the United States. *JNCI Cancer Spectr* 2020;4:pkaa073.
54 Du M, Griecci CF, Cudhea FF, *et al*. Cost-effectiveness analysis of nutrition facts added-sugar labeling and obesity-associated cancer rates in the US. *JAMA Netw Open* 2021;4:e217501.
55 Wilde P, Huang Y, Sy S, *et al*. Cost-effectiveness of a US national sugar-sweetened beverage tax with a multistakeholder approach: who pays and who benefits. *Am J Public Health* 2019;109:276–84.
56 Huang Y, Kypridemos C, Liu J, *et al*. Cost-effectiveness of the US Food and Drug Administration added sugar labeling policy for improving diet and health. *Circulation* 2019;139:2613–24.
57 Zhang FF, Cudhea F, Shan Z, *et al*. Preventable cancer burden associated with poor diet in the United States. *JNCI Cancer Spectr* 2019;3:pkz034.
58 Feng W, Fox A. Menu labels, for better, and worse? Exploring socio-economic and race-ethnic differences in menu label use in a national sample. *Appetite* 2018;128:223–32.
59 Green JE, Brown AG, Ohri-Vachaspati P. Sociodemographic disparities among fast-food restaurant customers who notice and use calorie menu labels. *J Acad Nutr Diet* 2015;115:1093–101.
60 Lee-Kwan SH, Pan L, Maynard LM, *et al*. Factors associated with self-reported menu-labeling usage among US adults. *J Acad Nutr Diet* 2016;116:1127–35.
61 Malloy-Weir L, Cooper M. Health literacy, literacy, numeracy and nutrition label understanding and use: a scoping review of the literature. *J Hum Nutr Diet* 2017;30:309–25.
62 Nogueira LM, Thai CL, Nelson W, *et al*. Nutrition label numeracy: disparities and association with health behaviors. *Am J Health Behav* 2016;40:427–36.

63 Gortmaker SL, Wang YC, Long MW, *et al*. Three interventions that reduce childhood obesity are projected to save more than they cost to implement. *Health Aff (Millwood)* 2015;34:1932–9.

64 Kuo T, Jarosz CJ, Simon P, *et al*. Menu labeling as a potential strategy for combating the obesity epidemic: a health impact assessment. *Am J Public Health* 2009;99:1680–6.

Title Cost-Effectiveness Analysis of the Federal Menu Calorie Labeling and Obesity-Associated Cancer Burdens in the United States

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Appendix 1. Estimate the association between menu calorie labeling policy and calorie intake from restaurant meals

To understand the effects of the federal menu calorie labeling policy, we performed a comprehensive literature search and reviewed the evidence on how the policy affected consumer behaviors and industry.

To estimate the policy effect on consumer behavior alone, we reviewed individual studies in both real-world and experimental settings as well as meta-analyses (**Appendix Table 1**). A meta-analysis of natural experimental studies showed that menu calorie labeling was associated with a 7.3% (95% CI: 4.4% to 10.1%) reduction in calories per meal consumed/purchased.[1] This effect estimate is corresponding to an average reduction of 23.5 kcal per meal consumed by NHANES participants from 56.5% of full-service restaurants[2] and all fast-food restaurants. This estimate was consistent with evidence from a previous meta-analysis and a recent real-world study.[3, 4] A previous meta-analysis estimated that the menu calorie labeling would lead to about an 18 kcal reduction ordered per meal.[3] A recent longitudinal study used data from a large restaurant franchise in the southern U.S. and estimated that, after labeling implementation, a decrease of 60 kcal per transaction was observed in the first year, followed by an increasing trend of 0.71 kcal per transaction per week over two years.[4] These together attenuated the calorie reduction to 23 kcal per transaction by the end of the third year of the policy implementation.[5] Compared to other studies, the 7.3% calorie reduction per meal represents a more conservative estimate. It was reported in a cross-sectional study that customers at the labeled full-service restaurants purchased food with 151 fewer calories.[6] One meta-analysis of studies that evaluated energy ordered in a real-world setting showed that the calorie labeling policy would lead to a mean reduction of 77.8 in calories purchased per meal.[7] In a laboratory setting, there was a significant reduction of 115.3 kcal per meal ordered.[8] Integrating both the real-world and experimental studies, the policy was estimated to generate a significant reduction of 100.3 in calories purchased.[7] Therefore, we decided to use a reduction of calorie intake per meal by 7.3% (95% CI: 4.4% to 10.1%) as the model input given it is the most updated and conservative estimate supported by existing evidence. This policy effect on consumer behavior alone was assumed to take effect during the first year of implementation and no further reduction thereafter.

Based on the published literature, we estimated that there was a 5% reduction in calories consumed per meal from chain restaurants due to industry reformulation, the introduction of new low-calorie menu items, or the replacement of menu items high in calories with low-calorie menu options. [9-13] Bleich et al. estimated the calorie changes in chain restaurants' menu items using data from the largest chain restaurants in the U.S. [9-13] Using the estimated mean calorie per menu item from the two published studies shown in **Appendix Table 2**,[11, 12] we calculated the mean change in calories per menu item before and after the policy implementation. Given the national law was announced in 2010, using data from the trend analysis, we treated the mean calorie per menu item measured in 2008 as the baseline and found there was an 11% reduction in calories per menu item two years after the affordable care act was enacted. The change decreased to 7% in 2015, one year after the FDA announced the final rule for the industry to comply with. In the study evaluated the calorie content in current menu items, eliminated menu items, and newly introduced menu items, we estimated that there was a 1% reduction in mean per-item calories in 2013-2014 compared to that in 2012, and the reduction increased to 5% in 2015. Based on this de novo analysis, we chose a reduction in calories per meal consumed by 5% to represent a modest industry reformulation in response to the federal menu calorie labeling by chain restaurants. We assumed no industry response in the first year, then the reformulation activities would occur in the rest of the years over the model lifetime, resulting in a net reduction of 5% in calories consumed per meal.

Appendix Table 1. Policy impact of menu calorie labeling on consumer behaviors

Study	Design	Year, country	Estimate size mean (95% CI)	Comment
Shangguan et. al., 2019[1] A Meta-Analysis of Food Labeling Effects on Consumer Diet Behaviors and Industry Practices	Meta-analysis 13 studies (5 RCTs) with 19 interventions on changes in calorie intake per meal, among children and adults	2000 to 2015, US, Canada, UK, Sweden	-7.3% (-10.1%, -4.4%) in calorie intake per meal	Corresponds to a 23.5 kcal per meal consumed by NHANES participants from 56.5% of full-service restaurants[2] and all fast-food restaurants
Petimar et. al., 2019[4] Estimating the effect of calorie menu labeling on calories purchased in a large restaurant franchise in the southern United States: quasi-experimental study	Quasi-experimental longitudinal study Transaction data from 104 restaurants of a national fast food company with three different restaurant chains located in the Louisiana, Texas, and Mississippi in the US	2015 to 2018 (pre-labeling: April 2015 to April 2017; post-labeling: April 2017 to April 2018), US	-60 (-48, -72) kcal in calorie purchased per transaction, followed by a post-implementation increasing trend of 0.71 kcal per transaction per week	Because of the post-implementation increase, the estimated reduction in calorie per transaction was 23 kcal lower than the counterfactual.
Cantu-Jungles et. al., 2017[8] A Meta-Analysis to Determine the Impact of Restaurant Menu Labeling on Calories and Nutrients (Ordered or Consumed) in U.S. Adults	Meta-analysis 14 studies that evaluated menu calorie labeling on changes in calorie chosen in laboratory and away-from-home settings, among children and adults	1996 to 2014	-115.2 (-130.87, -99.5) kcal in calorie ordered or consumed per meal in laboratory setting	N/A
Littlewood et. al., 2016[7] Menu labelling is effective in reducing energy ordered and consumed: a systematic review and meta-analysis of recent studies	Systematic review and meta-analysis 12 studies (6 RCTs) on changes in calorie consumed, ordered, or selected in both real-world and experimental settings, among children and adults	2011 to 2014, US, Canada, Australia,	-100.3 (-146.6, -54.0) kcal in calorie consumed in both settings per meal or transaction (3 studies) -77.8 (-121.6, -34.1) kcal in calorie purchased per meal or transaction in real-world setting (5 studies)	N/A
Long et. al., 2015[3] Systematic Review and Meta-analysis of the Impact of Restaurant Menu Calorie Labeling	Systematic review and meta-analysis 19 studies (11 RCTs, 8 natural experiments) on changes in calorie purchased per meal or per transaction, among children and adults	2008 to 2013, US	-18.1 (-33.6, -2.70) kcal in calorie purchased per meal or per transaction When stratifying by restaurant and non-restaurant settings (RCTs), the changes were -6.7 (-20.21, 6.81) kcal and -58.2 (-102.4, -13.9) kcal in calorie	N/A

Du M, *et al. BMJ Open* 2023; 13:e063614. doi: 10.1136/bmjopen-2022-063614

			purchased per meal or per transaction	
Auchincloss et. al., 2013[6] Customer responses to mandatory menu labeling at full-service restaurants	Cross-sectional study 648 customer surveys and transaction receipts at 7 restaurant outlets of 1 large full-service restaurant chain (2 outlets with menu calorie labels and 5 without), among adults	2011, US	-151 kcal (-270, -33) for foods purchased from full-service restaurants (per meal)	Was included in the meta-analysis conducted by Cantu-Jungles et. al., 2017[8]

Appendix Table 2. Policy impact of menu calorie labeling on restaurant industry response

Study		Year				
		2008	2012	2013	2014	2015
Bleich et. al., 2017[11] Calorie changes in large chain restaurants from 2008 to 2015 44 of the 100 largest chain restaurants	# of menu items (n)	6,601	9,526	10,278	10,654	11,034
	mean per-item calories (kcal)	368.0	329.1	330.1	337.2	340.6
	diff. (%)		2012 vs. 2008 -38.9 (-11%)			2015 vs. 2008 -27 (-7%)
Bleich et. al., 2018[12] Higher-Calorie Menu Items Eliminated in Large Chain Restaurants 66 of the 100 largest chain restaurants	# of menu items (n)		14,705	17,219 (2013-2014)		13,920
	mean per-item calories (kcal)		374.4	370.9		357.4
	diff. (%)			2013-2014 vs. 2012 -3.52 (-1%)		2015 vs. 2012 -17.05 (-5%)

Appendix 2. Baseline cancer incidence and methods of cancer incidence projections for 13 types of cancers

We estimated the cancer incidence rate projections for the defined 32 demographic subgroups as inputs for the DiCOM model. We first obtained age-adjusted incidence rates from 2006 to 2015 from the United States Cancer Statistics combining data from the Surveillance, Epidemiology, and End Results (SEER) database and the Centers for Disease Control and Prevention's National Program of Cancer Registries (NPCR) database.[14]

Based on the trends from 2006 to 2015, we projected age-adjusted cancer incidence rates in the next 15 years from 2016 to2030 using the average annual percent change (AAPC) method.[15, 16] Because longer-term projections may not be valid, we chose to hold age-adjusted cancer incidence rates constant from 2030 to 2095. Specifically, the annual percent change was calculated for each cancer site in each of the 32 subgroups by fitting a regression line to the natural logarithm of the age-adjusted rates (I) in the years 2006 through 2015 (y). The equation for AAPC: $\ln(I) = \alpha + \beta y$, where α and β were coefficients to be estimated and y is the calendar year.[15, 16] We then combined the AAPC projected cancer incidence rates with the projected US population to account for the change in population age distribution over time. The projected US population in each of the 32 subgroups from 2016 to 2060 were extracted from the National Interim Projections of the US population.[17] Because projections were only available through 2060, further projections after 2060 were not considered. We further applied the cohort-period method to estimate cancer incidence in each of the 32 subgroups in the closed cohort of US adults from 2015 to 2095 as they age. Details were illustrated in **Appendix Table 3** using colon and rectum cancer incidence among non-Hispanic white females (NHWF) as an example.

Appendix Table 3. Estimating "crude" incidence after applying cohort-period method

EXAMPLE: Colon and Rectum Cancer, Non-Hispanic White Females														
Age	2015		2016				2017				2018			
	Baseline Incidence Rate	Population Size	AAPC Predicted Incidence	US Census Predicted Population Size	Cancer Cases Predicted	Age Shifted "crude" Incidence	AAPC Predicted Incidence	US Census Predicted Population Size	Cancer Cases Predicted	Age Shifted "crude" Incidence	AAPC Predicted Incidence	US Census Predicted Population Size	Cancer Cases Predicted	Age Shifted "crude" Incidence
20	8.531	30523184	8.694	1134235		10.154	8.859	1126079		11.694	9.028	1117775		13.182
21	8.531		8.694	1156761	100565		8.859	1137549			9.028	1129379		
22	8.531		8.694	1177144	102337		8.859	1159788	102748		9.028	1140620		
23	8.531		8.694	1196469	104017		8.859	1180122	104550		9.028	1162784	104976	
24	8.531		8.694	1238910	107707		8.859	1199459	106263		9.028	1183136	106813	
25	8.531		8.694	1283513	111585		8.859	1241739	110009		9.028	1202329	108546	
26	8.531		8.694	1294013	112497		8.859	1286229	113950		9.028	1244499	112353	
27	8.531		8.694	1250740	108735		8.859	1296475	114858		9.028	1288797	116352	
28	8.531		8.694	1232421	107143		8.859	1253062	111012		9.028	1298770	117252	
29	8.531		8.694	1216039	105719		8.859	1234519	109369		9.028	1255161	113315	
30	8.531		8.694	1228929	106839		8.859	1217844	107892		9.028	1236330	111615	
31	8.531		8.694	1244281	108174		8.859	1230337	108999		9.028	1219312	110079	
32	8.531		8.694	1205955	104842		8.859	1245249	110320		9.028	1231390	111169	
33	8.531		8.694	1226950	106667		8.859	1206736	106908		9.028	1246013	112489	
34	8.531		8.694	1226234	106605		8.859	1227540	108751		9.028	1207377	109001	
35	8.531		8.694	1217701	105863		8.859	1226721	108678		9.028	1228051	110868	
36	8.531		8.694	1228467	106799		8.859	1218141	107918		9.028	1227199	110791	
37	8.531		8.694	1160971	100931		8.859	1228796	108862		9.028	1218528	110008	
38	8.531		8.694	1139547	99069		8.859	1161267	102879		9.028	1229044	110958	
39	8.531		8.694	1127605	98030		8.859	1139679	100967		9.028	1161414	104852	
40	8.531		8.694	1088875	94663		8.859	1127530	99891		9.028	1139635	102886	
41	8.531		8.694	1130467	98279		8.859	1088644	96446		9.028	1127272	101770	
42	8.531		8.694	1101345	95747		8.859	1129951	100105		9.028	1088229	98245	
43	8.531		8.694	1130264	98262		8.859	1100615	97506		9.028	1129228	101946	
44	8.531		8.694	1210411	105229		8.859	1129268	100045		9.028	1099713	99282	
45	41.269	14238423	41.919	1319769	553230	43.775	42.579	1208976	514771	45.825	43.250	1128045	487878	47.459
46	41.269		41.919	1346596	564476		42.579	1317806	561110		43.250	1207332	522169	
47	41.269		41.919	1292274	541705		42.579	1344191	572344		43.250	1315541	568969	
48	41.269		41.919	1264917	530237		42.579	1289694	549140		43.250	1341533	580211	
49	41.269		41.919	1295410	543019		42.579	1262140	537408		43.250	1286923	556592	
50	41.269		41.919	1325816	555765		42.579	1292230	550220		43.250	1259139	544576	
51	41.269		41.919	1432079	600309		42.579	1322198	562980		43.250	1288813	557410	
52	41.269		41.919	1489756	624487		42.579	1427705	607904		43.250	1318321	570172	
53	41.269		41.919	1510286	633093		42.579	1484805	632216		43.250	1423107	615492	
54	41.269		41.919	1532940	642589		42.579	1504858	640755		43.250	1479608	639928	
55	59.736	15111568	58.496	1575080	921363	65.864	57.283	1526976	874691	71.195	56.094	1499151	840934	75.804
56	59.736		58.496	1579128	923731		57.283	1568482	898466		56.094	1520747	853048	
57	59.736		58.496	1554236	909170		57.283	1572018	900492		56.094	1561581	875954	
58	59.736		58.496	1566074	916095		57.283	1546788	886040		56.094	1564631	877664	
59	59.736		58.496	1559941	912507		57.283	1558015	892471		56.094	1539019	863298	
60	59.736		58.496	1509257	882859		57.283	1551289	888618		56.094	1549572	869217	
61	59.736		58.496	1507776	881993		57.283	1500225	859367		56.094	1542165	865062	
62	59.736		58.496	1469467	859583		57.283	1497943	858060		56.094	1490621	836149	
63	59.736		58.496	1428612	835685		57.283	1458963	835731		56.094	1487453	834372	
64	59.736		58.496	1384020	809600		57.283	1417465	811960		56.094	1447782	812119	
65	147.246	20639658	140.189	1344027	1884181	140.189	133.471	1372210	1831501	133.471	127.075	1405568	1786119	127.075
66	147.246		140.189	1307657	1833194		133.471	1331467	1777121		127.075	1359584	1727685	
67	147.246		140.189	1291598	1810681		133.471	1294222	1727410		127.075	1318007	1674851	
68	147.246		140.189	1292613	1812104		133.471	1277026	1704458		127.075	1279794	1626292	
69	147.246		140.189	1382868	1938632		133.471	1276471	1703717		127.075	1261379	1602891	
70	147.246		140.189	987587	1384490		133.471	1363827	1820312		127.075	1259177	1600093	
71	147.246		140.189	982267	1377032		133.471	972764	1298357		127.075	1343441	1707171	
72	147.246		140.189	972611	1363496		133.471	966021	1289357		127.075	956905	1215982	
73	147.246		140.189	1012982	1420091		133.471	954967	1274603		127.075	948632	1205469	
74	147.246		140.189	874564	1226044		133.471	992594	1324824		127.075	936077	1189515	
75	147.246		140.189	796574	1116711		133.471	855200	1141443		127.075	970797	1233635	
76	147.246		140.189	747848	1048402		133.471	777087	1037185		127.075	834495	1060430	
77	147.246		140.189	706707	990727		133.471	727604	971140		127.075	756255	961007	
78	147.246		140.189	679404	952451		133.471	685495	914936		127.075	705976	897115	
79	147.246		140.189	625026	876219		133.471	656756	876578		127.075	662851	842315	
80	147.246		140.189	595777	835215		133.471	601790	803215		127.075	632555	803816	
81	147.246		140.189	572977	803252		133.471	571026	762154		127.075	577004	733225	
82	147.246		140.189	512332	718234		133.471	546330	729192		127.075	544674	692142	
83	147.246		140.189	496976	696707		133.471	485519	648027		127.075	517986	658228	
84	147.246		140.189	475655	666817		133.471	467692	624233		127.075	457134	580901	
85	147.246		140.189	452173	633898		133.471	444106	592752		127.075	436898	555186	
86	147.246		140.189	428834	601179		133.471	418526	558610		127.075	411316	522678	
87	147.246		140.189	383933	538233		133.471	393130	524714		127.075	383961	487917	
88	147.246		140.189	356801	500196		133.471	348261	464827		127.075	356875	453497	
89	147.246		140.189	320644	449508		133.471	319862	426923		127.075	312475	397076	
90	147.246		140.189	278562	390514		133.471	283710	378670		127.075	283306	360010	
91	147.246		140.189	246568	345662		133.471	242960	324281		127.075	247721	314790	
92	147.246		140.189	209022	293026		133.471	211695	282551		127.075	208839	265381	
93	147.246		140.189	169864	238131		133.471	176399	235441		127.075	178878	227308	
94	147.246		140.189	138657	194382		133.471	140691	187782		127.075	146313	185927	
95	147.246		140.189	109277	153195		133.471	112531	150196		127.075	114362	145325	
96	147.246		140.189	80177	112399		133.471	86769	115811		127.075	89499	113730	
97	147.246		140.189	56739	79542		133.471	62172	82982		127.075	67414	85666	
98	147.246		140.189	42046	58944		133.471	42907	57268		127.075	47105	59858	
99	147.246		140.189	27405	38419		133.471	30959	41321		127.075	31659	40231	
100	147.246		140.189	49314	69133		133.471	50716	67691		127.075	52719	66992	

Du M, *et al. BMJ Open* 2023; 13:e063614. doi: 10.1136/bmjopen-2022-063614

Appendix 3. Cancer survival for 13 types of cancers

We estimated the 5-year relative survival for the defined 32 demographic subgroups. We obtained five-year relative survival rates using the period analysis method from the United States Cancer Statistics which incorporates data from the Surveillance, Epidemiology, and End Results (SEER) database.[14] The five-year survival for 2014, which was the most recently available data at the time of analysis, was used. These rates were extracted for each cancer type and by the defined 32 demographic subgroups for each cancer type. The rates are on a scale of 0-1.

Relative survival is a net survival measure representing cancer survival in the absence of other causes of death. Relative survival is defined as the ratio of the proportion of observed survivors in a cohort of cancer patients to the proportion of expected survivors in a comparable set of cancer-free individuals.[18] Relative survival is the preferred method to estimate survival from cancer registry data.

The period analysis is a method that enhances up-to-date monitoring of survival.[19, 20] In contrast to traditional cohort analysis of survival, period analysis derives long-term survival estimates exclusively from the survival experience of patients within some recent calendar period.[19, 20] Three-year intervals were chosen which results in the years 2008-2014 is used to calculate 5-year survival. Using seven years of data to calculate 5-year survival is the standard method used by SEER and used in SEER publications.[21]

The first interval contributed to the one-year survival and used cases diagnosed in 2012-2014, the second interval contributed to the two-year survival and used cases diagnosed in 2011-2013, the third interval contributed to the three-year survival and used cases diagnosed in 2010-2012, the fourth interval contributed to the four-year survival and used cases diagnosed in 2009-2011 and the fifth interval contributed to the five-year survival and used cases diagnosed in 2008-2010.

This analysis, therefore, used 2008-2014 diagnoses to calculate for 5-year relative survival for 2014. The highlighted orange boxes represent survival contributions for each year of diagnosis and year of follow-up (**Appendix Table 4**). The annual probability of death was calculated as 1-exp[ln(5-year relative survival)/5].

Appendix Table 4. Period method for 5-year relative survival for 2014

YEARS OF DIAGNOSIS															
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
1															
2															
3															
4															
5															

Du M, *et al. BMJ Open* 2023; 13:e063614. doi: 10.1136/bmjopen-2022-063614

Appendix 4. **Methods of estimating the health-related quality of life among 13 types of cancers**

Health utility values range from 0 (dead) to 1 (perfect health and were assigned for each cancer type and by phase of care (initial, continuous, end of life), if available. We first searched databases for systematic reviews pertaining to utility weights or HRQOL measures for each cancer type of interest separately. We started with PubMed and searched Google Scholar if needed. The following search string was used for each cancer type : ("health related quality of life" OR "HRQOL" OR "quality of life" OR "QOL" OR "preference weight*" OR “utility weight*” OR “health state utilit*” OR “health utility*”) AND (“cancer of interest”) AND ("cancer" OR “neoplasm*”) AND ("review" OR “systematic review”).

When an appropriate systematic review was identified, we read the articles included in the review and determined if the paper met the following data needs. Data Extraction Hierarchy: 1) cancer type specific to the type of interest; 2) consistent in the instrument used, prefer EQ-5D whenever available; 3) US samples preferred; 4) phase of care (assume same utility weights by phase if the phase of care data were not available). If no systematic reviews were available, we searched for individual studies about the utility weights of the cancer of interest. Additionally, check how often the paper is cited to see if it is a frequently used utility weight.

Appendix 5. Methods of estimating policy implementation costs

We estimated the costs of implementing the federal menu calorie labeling for both government and industry, including government administration costs, monitoring and evaluation costs, industry compliance costs and reformulation costs, based on the FDA's budget report,[22] the Nutrition Review Project report,[23] and FDA's RIA[24] (**Appendix Table 5**).

It was estimated by FDA that approximately 298,600 establishments, organized under 2,130 chains were covered by the menu calorie labeling policy. Among the covered establishments, 115,000 (38.5%) were full-service restaurants and drinking places organized under 530 (24.9%) chains, and 116,200 (38.9%) were limited-service restaurants organized under 540 (25.4%) chains. In total, about 231,200 (77.4%) restaurants organized under 1,070 (50.2%) chains were covered by this policy.[24]

For industry compliance (#3) and reformulation costs (#4), the FDA estimated the costs by the type of establishments. Therefore, we only included the relevant costs incurred by restaurants as this approach generated more conservative estimates. In addition, the industry compliance costs consist of initial costs and recurring costs associated with new chains. In FDA's RIA, the initial costs were presented as a one-time cost, while the recurring costs associated with new chains were presented as annual costs and assumed to be incurred for 20 years starting from the 2nd year of policy implementation. According to FDA, 20 years is more appropriate for interventions that play out over long periods and whose effects deal with chronic conditions. Similarly, the reformulation costs (#4) estimated by FDA were presented as annual costs in FDA's RIA using the same assumption. We followed the same assumption and presented the annual compliance costs (#3) and annual reformulation costs (#4) incurred by restaurants in **Appendix Table 5**.

Du M, *et al. BMJ Open* 2023; 13:e063614. doi: 10.1136/bmjopen-2022-063614

The cost of implementing the menu calorie labeling is fixed by the government. Uncertainty for the costs associated with government administration (#1) and government monitoring and evaluation (# 2) was not provided in the source materials.[22, 23] We assumed that uncertainty is 20% around these costs.

For annual costs, namely the government monitoring and evaluation costs (#2) and the recurring costs in industry compliance (part of #3), and the reformulation costs (#4), we applied a 3% discounting rate recommended by the Second Panel on cost-effectiveness in health and medicine[4] to reflect the present value of future costs of government monitoring and evaluation, industry compliance and industry reformulation. The model is a closed cohort model, so we computed the discounted present value of per-person costs and total national costs for persons alive at implementation who remained alive in each subsequent year (not for the larger total US population in each year, which also has growth from immigration and new persons reaching the threshold age). The year-specific discounting factor is estimated by 1/(1+3%)^(t-1) (t is the number of years of policy intervention, t=1, 2, 3, …, lifetime). As our model estimated the costs and health outcomes based on a closed cohort and the population size decline over time, we need to express the annual costs in proportion to the population at risk. The population at risk was estimated based on the proportion of death ($P_{dt,}$ t=1, 2, 3, …) in each year. We first obtained the proportion of people who are alive each year by calculating 1-P_{dt} (t=1, 2, 3, …). Then we multiplied the baseline population size of 235 million by the proportion of people who are alive each year (**Appendix Table 6**).

We then estimated the per-person annual cost for cost categories #2, #3 (annual part), and #4, by dividing the annual cost estimated in the second year of implementing the policy among all US populations by the population size in the second year. Specifically, for government monitoring and evaluation, the per person annual cost is estimated $503,648/233,719,989=$0.00215, the per person annual cost for industry compliance recurring component is $/233,719,989=$, and that for reformulation is \$662,800,000 /233,719,989=\$2.83587. Taken together, to estimate the discounted annual cost of #2, #3 (annual part), and #4, we multiplied the population at risk, the per person annual cost estimated at year-2, and the year-specific discounting factor, using: discounted annual cost = population at risk x per-person annual cost x 1/(1+3%)^(t-1).

Appendix Table 5. Implementation cost estimates for the federal menu calorie labeling policy (in 2015 US dollars)

Policy Effect	Cost Category	One-time Cost*	Annual Cost*	Source	Major Elements
Consumer behavior	1. Government administration#	$9,073,620 ($7,258,896 to $10,888,344)	N/A	FDA FY 2012 Budget Report[22]	1) Costs for outreach, education, review of regulatory issues, developing training for inspectors, etc.
	2. Government monitoring and evaluation#	N/A	$503,648 ($402,918 to $604,378) (starting from 2nd year and last for a lifetime)	Nutrition Review Project report[23]	1) Monitor industry compliance 2) Evaluate the accuracy, usefulness, and health impact of the policy intervention
	3. Industry compliance	$276,632,470 ($225,552,530 to $327,205,740)	$27,648,591 ($16,756,003 to $38,649,212) (starting from 2nd year and last for a lifetime)	FDA's RIA[24] Table 4-8	1) Collecting and managing records of nutritional analysis for each standard menu item (initial cost + recurring cost associated with new chains) 2) Revising or replacing existing menus, menu boards, and providing full written nutrition information (initial cost + recurring cost associated with new chains) 3) Training employees to understand the nutrition information to help ensure compliance with the final requirements (initial cost + recurring cost associated with new chains) 4) Legal review (initial cost + recurring cost associated with new chains)
Industry response^	4. Industry reformulation	N/A	$15,059,100 ($5,791,900 to $24,124,700) (starting from 2nd year and last for a lifetime)	FDA's RIA[24] Table 4-8	1) Annually recurring costs of nutrition analysis refer to the nutrition cost that will be incurred by the covered establishments due to the introduction of a new standard or reformulated standard menu items in their menus and the cost that will be incurred by new chains entering the industry 2) Annually recurring changes to menus or menu boards will be tied to new or reformulated standard menu items. In general, these future changes to menus will be incorporated into the natural menu

					replacement cycle, so there will be no additional recurring menu update costs. However, all chain retail food establishments will need to provide additional written nutrition information for the reformulated or newly introduced menu items Average formula count, 6 new menu items, and 6 reformulated items per year FDA reformulation cost model

*Policy intervention costs were inflated to 2015 US (December) dollars using the Consumer Price Index.
Given no range of uncertainty was provided in source materials, we assumed 20% uncertainty around these costs.
^Some chains or establishments may respond to increased consumer interest in caloric content standard menu items by reformulating existing menu items or by introducing new, lower-calorie items. The change in manufacturing costs associated with reformulating these items has not been included in the cost estimation, the FDA includes the cost associated with analyzing the nutrition information of new or reformulated items.

Appendix Table 6. The population size of people who are alive each year over a lifetime (in millions)

Year	Population Size (Million)
1	235.2
2	233.7
3	232.1
4	230.4
5	228.2
⋮	⋮
67	5.832
68	4.348
69	3.157
70	2.233

Du M, *et al. BMJ Open* 2023; 13:e063614. doi: 10.1136/bmjopen-2022-063614

Appendix 6. Annual health-related costs among cancer patients and the general population without cancer

The annual health-related costs data include: 1) medical expenditure, 2) productivity loss from missed workdays or disability, and 3) patient time cost associated with receiving care for cancer survivors by age (under 65 vs. above 65 years old) and phase of care (initial, continuing, end-year of life); 4) medical expenditure, 5) productivity loss, and 6) patient time cost for individuals without cancer by age and status of end year of life. The description of the data source and data structure were provided in **Appendix Table 7**.

We extracted the raw data for each of the costing components from the published literature.[15, 25-29] The overall assumptions for data extraction include: 1) health-related costs for breast cancer among postmenopausal females, advanced prostate cancer, esophageal adenocarcinoma, and stomach cardia cancer, by age, sex, and phase of cancer care, were the same as those for breast cancer, prostate cancer, esophagus cancer, and stomach cancer; 2) if no data available for a specific cancer type, we assumed the costs for that cancer type were the same as the estimates of costs for all-cancer sites, e.g., medical expenditure for all-cancer sites were used to replace the medical expenditures for multiple myeloma, gallbladder, liver, and thyroid cancers; 3) we extracted the costs for end-year of life due to cancer death and assumed that death due to other causes is not a competing outcome; 4) we assumed that the end-year life medical expenditure for individuals without cancer does not vary by the 32 subgroups.

If a specific costing component was not reported directly in the raw data, we calculated the cost for that component based on available data. For example, the annual productivity loss for colorectal cancer was reported as a percentage of total health-related costs.[29] We multiplied the percentage and the total health-related costs to obtain the productivity loss for colorectal cancer. We also performed data imputation for unavailable data. For instance, the annual productivity loss for all-cancer sites was reported by time interval since cancer diagnosis (diagnosed within one year vs. diagnosed greater than one year).[25] To obtain this costing component by the defined phases of care, we calculated the weighted means which was used as the annual productivity loss for the continuous phase. We then assumed that the productivity loss in the initial phase and end-of-life phase of cancer care are 1.3 times and 4 times the mean estimates based on available data for other cancers.[15, 25] For individuals without cancer, we assumed that the end-of-life productivity loss is 4 times to the mean estimate of the productivity loss. The same rules applied to data imputation for patient time costs.

We then applied the age shifting to keep the expenditures consistent within each age group. Starting from 2021, individuals in the cohort of 55-64 years old have turned into the cohort of 65 years and older. Therefore, we assumed that starting from 2021, the health-related expenditures for individuals who were in the cohort of 55-64 years old would be the same as those for individuals who were in the cohort of 65 years and older at the beginning of the DiCOM model. Based on the same assumption, starting from 2031 and 2047, the health-related expenditures for the cohort of 45-54 years old and those for the cohort of 20-44 years old were projected to be the same as those for the cohort of 65 years and older, respectively. We followed the same rule and applied the age shifting for the health-related expenditures for individuals without cancer. All estimations and projections were performed in SAS 9.4. All health-related expenditures were inflated to 2015 US dollars using the Personal Health Care (PHC) index.

Appendix Table 7. Description of the data source of health-related expenditures

	A. Cancer Survivors		B. Individuals without Cancer	
	Data source (Excess or Total)	Category	Data source	Category
Medical expenditure	Mariotto et al. 2011, SEER-Medicare, in 2010 US dollars (Excess)	-by phase of care[1] -by age (under 65 vs. above 65 years old) -by sex	Kim et al. 2018, MEPS 2013-2014, *in vivo* analysis, in 2014 US dollars (Total)	-Medical expenditure among all US adults -by 32 subgroups stratified by age, sex, and race/ethnicity
			Hogen et al. 2001, SEER-Medicare (65+), in 2001 US dollars (Total)	-Medical expenditure in the end year of life among all US adults
Productivity loss	Zheng et al. 2016, MEPS 2008-2012, data available for colorectal, female breast, and prostate cancers, in 2012 US dollars (Total)	-by age		
	Guy et al. 2013, MEPS 2008-2010, all types of cancer, in 2010 US dollars (Total)	-by age -by time interval since cancer diagnosis (less than 1 year vs. greater than 1 year)[2]	Guy et al. 2013, MEPS 2008-2010, in 2010 US dollars (Total)	-by age
Patient time cost	Yabroff et al. 2014, MEPS 2008-2011, all types of cancer, in 2011 US dollars (Total)	-by age	Yabroff et al. 2014, MEPS 2008-2011, in 2011 US dollars (Total)	-by age

1. The definition of phases of care: 1) initial phase, defined as the first 12 months following diagnosis, 2) end-year of life phase, defined as the final 12 months of life, and 3) the continuing phase, defined as all the months between the initial phase and the end-year of life. The costs of end-year of life varied by cause of death, either cancer-specific death or death due to other causes.
2. Weighted means were calculated based on sample sizes and strata means.

Reference

1. Shangguan S, Afshin A, Shulkin M, et al. A Meta-Analysis of Food Labeling Effects on Consumer Diet Behaviors and Industry Practices. *American journal of preventive medicine*. Feb 2019;56(2):300-314. doi:10.1016/j.amepre.2018.09.024
2. Food and Drug Administration. Food Labeling; Nutrition Labeling of Standard Menu Items in Restaurants and Similar Retail Food Establishments; Calorie Labeling of Articles of Food in Vending Machines; Final Rule In: Department of Health and Human Services, editor. 2014.
3. Long MW, Tobias DK, Cradock AL, Batchelder H, Gortmaker SL. Systematic review and meta-analysis of the impact of restaurant menu calorie labeling. *Am J Public Health*. 2015;105(5):e11-e24. doi:10.2105/AJPH.2015.302570
4. Petimar J, Zhang F, Cleveland LP, et al. Estimating the effect of calorie menu labeling on calories purchased in a large restaurant franchise in the southern United States: quasi-experimental study. *BMJ (Clinical research ed)*. 2019;367:l5837-l5837. doi:10.1136/bmj.l5837
5. Kaur A, researcher, Briggs ADM, academic v. Calorie labelling to reduce obesity. *BMJ (Clinical research ed)*. 2019;367:l6119-l6119. doi:10.1136/bmj.l6119
6. Auchincloss AH, Mallya GG, Leonberg BL, Ricchezza A, Glanz K, Schwarz DF. Customer responses to mandatory menu labeling at full-service restaurants. *American journal of preventive medicine*. 2013;45(6):710-719. doi:10.1016/j.amepre.2013.07.014
7. Littlewood JA, Lourenço S, Iversen CL, Hansen GL. Menu labelling is effective in reducing energy ordered and consumed: a systematic review and meta-analysis of recent studies. *Public Health Nutr*. 2016;19(12):2106-2121. doi:10.1017/S1368980015003468
8. Cantu-Jungles TM, McCormack LA, Slaven JE, Slebodnik M, Eicher-Miller HA. A Meta-Analysis to Determine the Impact of Restaurant Menu Labeling on Calories and Nutrients (Ordered or Consumed) in U.S. Adults. *Nutrients*. 2017;9(10):1088. doi:10.3390/nu9101088
9. Bleich SN, Wolfson JA, Jarlenski MP. Calorie changes in chain restaurant menu items: implications for obesity and evaluations of menu labeling. *American journal of preventive medicine*. Jan 2015;48(1):70-5. doi:10.1016/j.amepre.2014.08.026
10. Bleich SN, Wolfson JA, Jarlenski MP. Calorie Changes in Large Chain Restaurants: Declines in New Menu Items but Room for Improvement. *American journal of preventive medicine*. 2016;50(1):e1-e8. doi:10.1016/j.amepre.2015.05.007
11. Bleich SN, Wolfson JA, Jarlenski MP. Calorie changes in large chain restaurants from 2008 to 2015. *Preventive medicine*. Jul 2017;100:112-116. doi:10.1016/j.ypmed.2017.04.004
12. Bleich SN, Moran AJ, Jarlenski MP, Wolfson JA. Higher-Calorie Menu Items Eliminated in Large Chain Restaurants. *American journal of preventive medicine*. Feb 2018;54(2):214-220. doi:10.1016/j.amepre.2017.11.004
13. Bleich SN, Wolfson JA, Jarlenski MP, Block JP. Restaurants With Calories Displayed On Menus Had Lower Calorie Counts Compared To Restaurants Without Such Labels. *Health affairs (Project Hope)*. 2015;34(11):1877-1884. doi:10.1377/hlthaff.2015.0512
14. Centers for Disease Control and Prevention. NPCR and SEER Incidence – U.S. Cancer Statistics Public Use Databases. United States Department of Health and Human Services, Centers for Disease Control and Prevention and National Cancer Institute. Accessed September 4, 2019. www.cdc.gov/cancer/uscs/public-use
15. Mariotto AB, Yabroff KR, Shao Y, Feuer EJ, Brown ML. Projections of the cost of cancer care in the United States: 2010-2020. *Journal of the National Cancer Institute*. Jan 19 2011;103(2):117-28. doi:10.1093/jnci/djq495
16. Clegg LX, Hankey BF, Tiwari R, Feuer EJ, Edwards BK. Estimating average annual per cent change in trend analysis. *Statistics in medicine*. Dec 20 2009;28(29):3670-82. doi:10.1002/sim.3733
17. United States Census Bureau. 2014 National Population Projections Tables. Accessed July 3, 2019. https://www.census.gov/data/tables/2014/demo/popproj/2014-summary-tables.html

18. National Cancer Institute. Surveillance research Program. Measures of Cancer Survival. https://surveillance.cancer.gov/survival/measures.html
19. Brenner H, Hakulinen T. Up-to-date and precise estimates of cancer patient survival: model-based period analysis. *American journal of epidemiology*. Oct 1 2006;164(7):689-96. doi:10.1093/aje/kwj243
20. Brenner H, Hakulinen T. Up-to-date cancer survival: period analysis and beyond. *International journal of cancer*. Mar 15 2009;124(6):1384-90. doi:10.1002/ijc.24021
21. National Cancer Institute. Surveillance Research Program. Cancer Survival Statistics: Cohort Definition Using Diagnosis Year. https://surveillance.cancer.gov/survival/cohort.html
22. Food and Drug Administration. *Justification of Estimates for Appropriations Committees Fiscal Year 2012*. 2012. https://www.fda.gov/downloads/AboutFDA/ReportsManualsForms/Reports/BudgetReports/UCM243370.pdf
23. Food and Drug Administration. *The Nutrition Review Project. Report to the Director, Center for Food Safety and Applied Nutrition*. 2014. http://www.fdalawblog.net/wp-content/uploads/archives/docs/Nutrition%20Review%20Project.pdf
24. S. FaDAaHH. Food labeling; nutrition labeling of standard menu items in restaurants and similar retail food establishments. Final rule. *Fed Regist*. 2014;79(230):71155-71259.
25. Guy GP, Jr., Ekwueme DU, Yabroff KR, et al. Economic burden of cancer survivorship among adults in the United States. *Journal of clinical oncology : official journal of the American Society of Clinical Oncology*. Oct 20 2013;31(30):3749-57. doi:10.1200/jco.2013.49.1241
26. Hogan C, Lunney J, Gabel J, Lynn J. Medicare beneficiaries' costs of care in the last year of life. *Health affairs (Project Hope)*. Jul-Aug 2001;20(4):188-95. doi:10.1377/hlthaff.20.4.188
27. Yabroff KR, Davis WW, Lamont EB, et al. Patient time costs associated with cancer care. *Journal of the National Cancer Institute*. Jan 3 2007;99(1):14-23. doi:10.1093/jnci/djk001
28. Yabroff KR, Guy GP, Jr., Ekwueme DU, et al. Annual patient time costs associated with medical care among cancer survivors in the United States. *Medical care*. Jul 2014;52(7):594-601. doi:10.1097/mlr.0000000000000151
29. Zheng Z, Yabroff KR, Guy GP, Jr., et al. Annual Medical Expenditure and Productivity Loss Among Colorectal, Female Breast, and Prostate Cancer Survivors in the United States. *Journal of the National Cancer Institute*. May 2016;108(5)doi:10.1093/jnci/djv382

Title Cost-Effectiveness Analysis of the Federal Menu Calorie Labeling and Obesity-Associated Cancer Burdens in the United States

Supplementary Table 1. Defining population and 32 subgroups

Subgroups	Age	Sex	Race/Ethnicity
1	20-44y	Female	NHW
2	20-44y	Female	NHB
3	20-44y	Female	HISP
4	20-44y	Female	OTH
5	20-44y	Male	NHW
6	20-44y	Male	NHB
7	20-44y	Male	HISP
8	20-44y	Male	OTH
9	45-54y	Female	NHW
10	45-54y	Female	NHB
11	45-54y	Female	HISP
12	45-54y	Female	OTH
13	45-54y	Male	NHW
14	45-54y	Male	NHB
15	45-54y	Male	HISP
16	45-54y	Male	OTH
17	55-64y	Female	NHW
18	55-64y	Female	NHB
19	55-64y	Female	HISP
20	55-64y	Female	OTH
21	55-64y	Male	NHW
22	55-64y	Male	NHB
23	55-64y	Male	HISP
24	55-64y	Male	OTH
25	65+y	Female	NHW
26	65+y	Female	NHB
27	65+y	Female	HISP
28	65+y	Female	OTH
29	65+y	Male	NHW
30	65+y	Male	NHB
31	65+y	Male	HISP
32	65+y	Male	OTH

Supplementary Table 2. Relative risk estimates of etiologic relationships between body mass index (BMI) and 13 types of cancers

Cancer Type	No. of Studies	No. of Events	Source	Evidence Grading	RR (95% CI) Per 5 kg/m^2	Statistical Heterogeneity
Endometrial	26	18,717	CUP, 2013	Convincing ↑risk	1.50 (1.42-1.59)	I^2=86.2% P<0.0001
Esophageal (adenocarcinoma)	9	1,725	CUP, 2016	Convincing ↑risk	1.48 (1.35-1.62)	I^2=36.7% P=0.13
Kidney	23	15,575	CUP, 2015	Convincing ↑risk	1.30 (1.25-1.35)	I^2=38.8% P=0.03
Liver	12	14, 311	CUP, 2015	Convincing ↑risk	1.30 (1.16-1.46)	I^2=78.3% P=0.000
Gallbladder	8	6,004	CUP, 2015	Probable ↑risk	1.25 (1.15-1.37)	I^2=52.3% P=0.04
Stomach (cardia)	7	2,050	CUP, 2016	Probable ↑risk	1.23 (1.07-1.40)	I^2=55.6% P=0.04
Breast (post-menopausal)	56	80,404	CUP, 2017	Convincing ↑risk	1.12 (1.09-1.15)	I^2=75% P<0.001
Pancreas	23	9,504	CUP, 2011	Convincing ↑risk	1.10 (1.07-1.14)	I^2=19% P=0.20
Multiple myeloma	20	1,388	IARC, 2016[30]	Sufficient (IRAC) ↑risk	1.09 (1.03-1.16)	Not reported
Prostate (advanced)	24	11,149	CUP, 2014	Probable ↑risk	1.08 (1.04-1.12)	I^2=18.8% P=0.21
Thyroid	22	3,100	IARC, 2016[30]	Sufficient (IARC) ↑risk	1.06 (1.02-1.10)	Not reported
Ovary	25	15,899	CUP, 2013	Probable ↑risk	1.06 (1.02-1.11)	I^2=55.1% P=0.001
Colorectal	38	71,089	CUP, 2017	Convincing ↑risk	1.05 (1.03-1.07)	I^2=74.2% P=0.000

Du M, *et al. BMJ Open* 2023; 13:e063614. doi: 10.1136/bmjopen-2022-063614

Supplementary Table 3. Baseline incidence rates of 13 cancers among US adults by 32 subgroups

Subgroup	Colorectal Cancer		Endometrial Cancer		Esophageal Adeno-carcinoma		Female Breast (Postmeno.)		Gallbladder Cancer		Kidney Cancer		Liver Cancer		Multiple Myeloma		Ovarian cancer		Pancreatic Cancer		Advanced Prostate Cancer		Stomach Cancer (Gastric Cardia)		Thyroid Cancer	
	Rate	SE	Rate	SE	Rate	SE	Rate	SE	Rate	SE	Rate	SE	Rate	SE	Rate	SE	Rate	SE	Rate	SE	Rate	SE	Rate	SE	Rate	SE
1	8.53	0.38	6.54	3.66	0.05	4.18	0.00	0.00	0.05	2.57	3.83	3.16	0.49	4.18	0.38	4.66	4.31	0.27	1.07	3.46	0.00	0.00	0.10	3.82	28.97	0.69
2	7.78	0.74	5.04	0.59	0.03	0.20	0.00	0.00	0.07	2.46	3.57	0.50	0.56	0.20	1.02	0.27	2.98	0.45	1.03	0.26	0.00	0.00	0.09	2.25	13.12	0.95
3	6.09	0.55	7.49	3.32	0.03	3.07	0.00	0.00	0.06	2.48	3.73	3.16	0.42	3.07	0.33	3.71	3.95	0.46	0.86	0.87	0.00	0.00	0.09	2.27	20.97	1.13
4	6.36	1.10	6.56	1.13	0.02	0.15	0.00	0.00	0.07	2.58	1.87	0.40	0.32	0.15	0.38	0.23	4.49	0.70	0.74	0.25	0.00	0.00	0.09	2.36	24.88	2.21
5	9.20	0.39	0.00	0.00	0.42	5.22	0.00	0.00	0.04	0.02	5.91	4.53	0.60	5.22	0.48	5.26	0.00	0.00	1.22	2.06	0.21	0.02	0.43	4.32	6.93	0.34
6	7.94	0.78	0.00	0.00	0.29	0.30	0.00	0.00	0.04	0.02	5.47	0.65	1.17	0.30	1.48	0.34	0.00	0.00	1.00	0.28	0.56	0.09	0.34	3.42	2.36	0.42
7	6.15	0.54	0.00	0.00	0.31	3.85	0.00	0.00	0.04	0.02	4.04	3.82	0.82	3.85	0.57	0.18	0.00	0.00	0.83	0.20	0.13	0.68	0.34	3.53	3.80	0.44
8	6.21	0.85	0.00	0.00	0.31	0.47	0.00	0.00	0.05	0.02	3.68	1.04	1.59	0.47	0.70	1.40	0.00	0.00	0.82	0.29	0.41	0.09	0.36	3.52	5.70	0.84
9	41.27	0.76	38.53	0.73	1.03	0.21	124.56	1.28	0.68	5.99	14.03	0.44	3.10	0.21	3.60	0.22	17.09	0.49	7.70	0.32	0.00	0.00	0.88	6.74	37.84	0.73
10	53.14	1.92	25.73	1.34	0.59	0.60	121.73	2.88	1.54	5.87	16.08	1.06	5.17	0.60	11.29	0.89	11.75	0.90	10.91	0.87	0.00	0.00	0.94	5.38	25.80	1.34
11	33.92	1.78	33.43	1.53	0.59	0.52	77.25	3.45	2.27	1.93	16.00	1.04	3.83	0.52	4.86	0.58	14.57	1.00	6.26	0.66	0.00	0.00	0.81	5.61	37.29	1.84
12	35.77	3.15	35.84	3.07	0.65	0.66	91.82	4.82	1.70	6.05	7.78	1.92	3.27	0.66	2.55	0.70	17.07	1.51	5.17	0.81	0.00	0.00	0.85	5.53	37.73	2.90
13	53.97	0.87	0.00	0.00	5.61	0.36	0.00	0.00	0.36	7.15	29.16	0.64	9.24	0.36	5.09	0.27	0.00	0.00	10.63	0.38	10.88	0.16	3.65	0.23	13.29	0.43
14	61.29	2.20	0.00	0.00	1.50	1.02	0.00	0.00	0.47	5.07	32.82	1.61	13.29	1.02	12.34	0.99	0.00	0.00	14.12	1.05	25.31	0.58	1.90	0.33	6.41	0.71
15	38.05	1.94	0.00	0.00	2.75	1.06	0.00	0.00	0.43	4.83	24.48	1.27	16.38	1.06	5.23	0.60	0.00	0.00	7.95	0.74	6.02	0.38	1.96	0.34	8.56	0.76
16	42.81	3.85	0.00	0.00	2.88	2.28	0.00	0.00	0.37	4.93	18.63	3.06	18.71	2.28	3.70	0.82	0.00	0.00	7.62	1.05	3.70	0.50	2.51	0.17	12.57	1.36
17	59.74	0.89	90.00	1.09	2.12	0.35	305.45	2.02	1.75	0.15	26.14	0.59	9.41	0.35	8.68	0.34	26.19	0.59	21.78	0.54	0.00	0.00	1.72	0.15	34.42	0.67
18	86.11	2.62	83.71	2.60	1.30	1.21	306.22	4.92	4.08	0.57	31.53	1.58	18.22	1.21	23.28	1.37	19.79	1.25	31.37	1.58	0.00	0.00	1.92	0.39	27.72	1.48
19	58.14	2.91	69.51	3.28	1.64	1.33	218.85	7.01	4.59	0.68	29.93	1.73	17.38	1.33	9.33	0.97	21.29	1.45	17.15	1.32	0.00	0.00	1.87	0.34	39.44	1.97
20	52.83	4.48	60.22	4.45	1.49	1.97	233.48	8.33	2.44	0.50	13.91	2.72	12.58	1.97	6.13	0.96	23.98	2.79	13.44	1.43	0.00	0.00	1.57	0.13	41.74	3.08
21	88.14	1.11	0.00	0.00	15.54	0.73	0.00	0.00	0.93	0.11	53.65	0.87	37.93	0.73	13.24	0.43	0.00	0.00	29.95	0.65	47.05	0.34	9.19	0.36	16.24	0.48
22	121.39	3.41	0.00	0.00	4.30	2.72	0.00	0.00	2.06	0.41	69.05	2.57	75.50	2.72	30.69	1.71	0.00	0.00	39.72	1.95	91.41	1.22	4.87	0.68	9.12	0.92
23	84.75	3.65	0.00	0.00	8.01	2.98	0.00	0.00	1.07	0.11	51.05	2.35	61.05	2.98	13.65	1.22	0.00	0.00	23.36	1.58	32.10	1.21	5.15	0.70	11.12	1.09
24	83.77	5.72	0.00	0.00	4.97	4.85	0.00	0.00	1.22	0.11	27.95	3.81	54.13	4.85	10.32	1.39	0.00	0.00	19.14	2.87	22.70	1.31	5.16	0.96	16.04	1.75
25	147.25	1.98	86.90	1.40	4.53	0.62	429.43	3.20	5.87	0.40	42.37	1.02	15.56	0.62	20.59	0.73	38.18	0.97	55.49	1.20	0.00	0.00	4.36	0.34	24.59	0.74
26	155.86	5.74	100.81	4.21	3.10	1.98	398.07	8.74	9.68	1.43	50.03	3.07	20.61	1.98	50.31	3.20	29.78	2.45	71.93	3.94	0.00	0.00	3.41	0.52	22.57	1.98
27	117.47	5.72	66.40	4.47	3.61	3.17	285.07	11.57	11.44	1.75	45.35	3.33	38.69	3.17	24.20	2.52	32.78	2.88	51.54	3.79	0.00	0.00	3.89	0.60	29.50	2.55
28	109.32	10.15	52.12	5.29	3.51	4.72	266.14	14.52	7.02	1.70	26.14	4.17	35.77	4.72	14.41	2.43	23.90	2.89	46.15	5.64	0.00	0.00	4.11	0.28	28.15	3.08
29	181.07	2.47	0.00	0.00	29.02	1.10	0.00	0.00	3.59	0.36	88.69	1.63	40.30	1.10	34.26	1.07	0.00	0.00	72.36	1.53	80.74	0.61	19.38	0.77	17.34	0.69
30	217.23	8.36	0.00	0.00	7.29	3.98	0.00	0.00	6.24	1.14	97.13	5.16	68.31	3.98	69.18	4.66	0.00	0.00	75.66	4.94	130.67	2.34	8.81	1.55	10.03	1.60
31	182.00	9.21	0.00	0.00	15.50	5.01	0.00	0.00	6.79	1.64	87.20	5.26	78.18	5.01	33.10	3.44	0.00	0.00	61.88	4.77	66.33	2.57	11.49	1.78	15.87	2.11
32	144.37	13.43	0.00	0.00	10.56	7.52	0.00	0.00	4.75	1.02	54.45	7.24	79.16	7.52	22.48	3.35	0.00	0.00	51.45	6.82	51.84	2.78	11.34	2.12	13.86	2.28

Du M, *et al. BMJ Open* 2023; 13:e063614. doi: 10.1136/bmjopen-2022-063614

Supplementary Table 4. Baseline 5-year relative survival rates of 13 cancers among US adults by 32 subgroups

Subgroup	Colorectal Cancer		Endometrial Cancer		Esophageal Adeno-carcinoma		Female Breast (Postmeno.)		Gallbladder Cancer		Kidney Cancer		Liver Cancer		Multiple Myeloma		Ovarian Cancer		Pancreatic Cancer		Advanced Prostate Cancer		Stomach Cancer (Gastric Cardia)		Thyroid Cancer	
	Rate	SE	Rate	SE	Rate	SE	Rate	SE	Rate	SE	Rate	SE	Rate	SE	Rate	SE	Rate	SE	Rate	SE	Rate	SE	Rate	SE	Rate	SE
1	0.740	0.012	0.916	0.009	0.223	0.018	0.000	0.000	0.095	0.095	0.953	0.009	0.409	0.057	0.852	0.043	0.780	0.015	0.379	0.038	0.000	0.000	0.477	0.099	1.000	0.001
2	0.652	0.024	0.775	0.027	0.223	0.018	0.000	0.000	0.286	0.064	0.856	0.029	0.144	0.113	0.837	0.048	0.736	0.036	0.530	0.064	0.000	0.000	0.502	0.205	0.993	0.004
3	0.659	0.022	0.900	0.013	0.223	0.018	0.000	0.000	0.309	0.092	0.864	0.021	0.403	0.081	0.713	0.075	0.716	0.024	0.493	0.062	0.000	0.000	0.236	0.116	0.992	0.002
4	0.694	0.027	0.910	0.016	0.223	0.018	0.000	0.000	0.286	0.064	0.819	0.043	0.321	0.077	0.787	0.122	0.737	0.029	0.371	0.076	0.000	0.000	0.667	0.193	1.000	0.002
5	0.682	0.012	0.000	0.000	0.140	0.034	0.000	0.000	0.302	0.117	0.886	0.010	0.251	0.037	0.696	0.041	0.000	0.000	0.275	0.032	0.768	0.057	0.284	0.045	0.997	0.002
6	0.601	0.027	0.000	0.000	0.160	0.031	0.000	0.000	0.357	0.096	0.779	0.027	0.157	0.045	0.606	0.057	0.000	0.000	0.151	0.046	0.780	0.086	0.672	0.274	0.949	0.025
7	0.621	0.022	0.000	0.000	0.330	0.108	0.000	0.000	0.357	0.096	0.847	0.020	0.227	0.047	0.635	0.064	0.000	0.000	0.157	0.044	0.470	0.118	0.152	0.055	0.993	0.007
8	0.635	0.029	0.000	0.000	0.287	0.172	0.000	0.000	0.357	0.096	0.840	0.033	0.152	0.032	0.649	0.108	0.000	0.000	0.230	0.066	0.805	0.180	0.545	0.133	0.992	0.008
9	0.738	0.007	0.889	0.006	0.300	0.065	0.918	0.003	0.153	0.045	0.846	0.011	0.283	0.027	0.682	0.027	0.614	0.012	0.195	0.017	0.000	0.000	0.384	0.060	0.997	0.002
10	0.666	0.015	0.751	0.022	0.290	0.174	0.810	0.009	0.155	0.059	0.834	0.025	0.145	0.035	0.626	0.034	0.497	0.034	0.177	0.029	0.000	0.000	0.457	0.144	0.990	0.008
11	0.725	0.016	0.869	0.012	0.751	0.217	0.881	0.008	0.224	0.062	0.879	0.018	0.242	0.038	0.617	0.047	0.595	0.025	0.209	0.035	0.000	0.000	0.257	0.079	0.983	0.005
12	0.731	0.018	0.893	0.012	0.308	0.060	0.926	0.007	0.210	0.082	0.810	0.037	0.287	0.051	0.686	0.071	0.640	0.027	0.307	0.055	0.000	0.000	0.357	0.152	0.991	0.005
13	0.704	0.007	0.000	0.000	0.255	0.020	0.000	0.000	0.321	0.072	0.790	0.009	0.171	0.011	0.627	0.023	0.000	0.000	0.136	0.012	0.858	0.010	0.253	0.024	0.964	0.007
14	0.612	0.015	0.000	0.000	0.186	0.085	0.000	0.000	0.371	0.127	0.793	0.020	0.117	0.019	0.616	0.037	0.000	0.000	0.138	0.022	0.814	0.020	0.148	0.059	0.970	0.027
15	0.652	0.015	0.000	0.000	0.222	0.050	0.000	0.000	0.151	0.082	0.742	0.019	0.181	0.016	0.640	0.044	0.000	0.000	0.101	0.021	0.729	0.029	0.257	0.060	0.945	0.019
16	0.721	0.017	0.000	0.000	0.308	0.110	0.000	0.000	0.751	0.153	0.799	0.027	0.239	0.023	0.594	0.066	0.000	0.000	0.162	0.039	0.865	0.040	0.298	0.080	0.960	0.018
17	0.694	0.007	0.878	0.004	0.322	0.043	0.918	0.002	0.273	0.035	0.793	0.010	0.208	0.015	0.630	0.019	0.531	0.011	0.117	0.009	0.000	0.000	0.334	0.041	0.994	0.002
18	0.621	0.014	0.667	0.015	0.298	0.039	0.830	0.007	0.151	0.043	0.805	0.022	0.219	0.028	0.609	0.027	0.371	0.028	0.112	0.018	0.000	0.000	0.440	0.113	0.971	0.012
19	0.673	0.016	0.816	0.013	0.241	0.131	0.879	0.006	0.173	0.044	0.769	0.021	0.211	0.025	0.535	0.042	0.473	0.025	0.104	0.019	0.000	0.000	0.279	0.101	0.969	0.009
20	0.714	0.017	0.847	0.013	0.298	0.039	0.911	0.006	0.151	0.061	0.785	0.032	0.288	0.033	0.631	0.051	0.555	0.031	0.164	0.027	0.000	0.000	0.281	0.140	0.987	0.008
21	0.666	0.006	0.000	0.000	0.257	0.013	0.000	0.000	0.190	0.045	0.760	0.008	0.202	0.007	0.603	0.016	0.000	0.000	0.111	0.007	0.878	0.006	0.255	0.016	0.954	0.009
22	0.579	0.013	0.000	0.000	0.178	0.072	0.000	0.000	0.261	0.105	0.758	0.019	0.140	0.012	0.545	0.028	0.000	0.000	0.080	0.014	0.786	0.014	0.148	0.046	0.945	0.039
23	0.628	0.014	0.000	0.000	0.135	0.033	0.000	0.000	0.203	0.081	0.717	0.018	0.170	0.013	0.541	0.037	0.000	0.000	0.078	0.015	0.777	0.017	0.281	0.053	0.899	0.028
24	0.654	0.015	0.000	0.000	0.237	0.082	0.000	0.000	0.148	0.069	0.698	0.025	0.268	0.017	0.485	0.050	0.000	0.000	0.122	0.023	0.885	0.019	0.257	0.061	0.967	0.022
25	0.610	0.005	0.799	0.006	0.182	0.024	0.907	0.003	0.179	0.018	0.679	0.010	0.119	0.010	0.420	0.012	0.323	0.008	0.057	0.003	0.000	0.000	0.231	0.023	0.958	0.005
26	0.551	0.012	0.552	0.016	0.170	0.143	0.806	0.008	0.217	0.043	0.709	0.024	0.097	0.020	0.407	0.022	0.210	0.021	0.059	0.009	0.000	0.000	0.264	0.068	0.894	0.023
27	0.579	0.013	0.699	0.017	0.190	0.073	0.858	0.008	0.125	0.023	0.677	0.022	0.087	0.014	0.353	0.027	0.298	0.022	0.049	0.009	0.000	0.000	0.257	0.060	0.889	0.020
28	0.599	0.013	0.735	0.020	0.180	0.022	0.900	0.007	0.115	0.030	0.614	0.032	0.187	0.017	0.440	0.040	0.356	0.029	0.043	0.008	0.000	0.000	0.187	0.067	0.858	0.023
29	0.615	0.005	0.000	0.000	0.212	0.011	0.000	0.000	0.134	0.025	0.680	0.008	0.119	0.007	0.402	0.011	0.000	0.000	0.075	0.004	0.717	0.007	0.220	0.013	0.935	0.015
30	0.498	0.014	0.000	0.000	0.164	0.069	0.000	0.000	0.209	0.076	0.705	0.024	0.134	0.019	0.459	0.027	0.000	0.000	0.049	0.011	0.569	0.017	0.174	0.052	0.810	0.068
31	0.544	0.013	0.000	0.000	0.155	0.035	0.000	0.000	0.144	0.046	0.668	0.020	0.107	0.012	0.398	0.028	0.000	0.000	0.066	0.011	0.674	0.017	0.141	0.032	0.786	0.048
32	0.625	0.013	0.000	0.000	0.126	0.049	0.000	0.000	0.263	0.071	0.653	0.026	0.182	0.014	0.431	0.037	0.000	0.000	0.080	0.013	0.733	0.020	0.255	0.042	0.800	0.039

Supplementary Table 5. Health-related quality of life among US cancer patients aged 20 years or older, by cancer type and phase of care

Cancer Type	Cancer Phase	Health Related Quality of Life mean (SE)	Source
Endometrial	Overall	0.80 (0.14)	Naik et al.[31]
Esophageal Adenocarcinoma	Overall	0.69 (0.26)	Wildi et al.[32]
Kidney	Overall	0.78 (0.14)	Pickard et al.[33]
Liver	Overall	0.79 (0.19)	Naik et al.[31]
Gallbladder	Overall	0.79 (0.19)	Naik et al.[31]
Stomach (gastric cardia)	Initial: Continuous: End of Life:	0.84 (0.25) 0.86 (0.24) 0.65 (0.33)	Zhou et al.[34]
Female Breast (post-menopausal)	Initial: Continuous: End of Life:	0.78 (0.19) 0.81 (0.20) 0.64 (0.16)	Yabroff et al.[35]
Pancreas	Overall	0.65 (0.30)	Müller-Nordhorn et al.[36]
Multiple myeloma	Overall	0.79 (0.19)	Naik et al.[31]
Advanced Prostate	Initial: Continuous: End of Life:	0.78 (0.20) 0.76 (0.19) 0.59 (0.15)	Yabroff et al.[35]
Thyroid	Overall	0.85 (0.13)	Naik et al.[31]
Ovary	Overall	0.77 (0.17)	Pickard et al.[33]
Colorectal	Initial: Continuous: End of Life:	0.760 (0.19) 0.835 (0.20) 0.643 (0.26)	Färkkilä et al.[37]

Du M, *et al. BMJ Open* 2023; 13:e063614. doi: 10.1136/bmjopen-2022-063614

Supplementary Table 6. Baseline medical costs, productivity loss, and patient time costs among US cancer patients aged 20 years or older, by cancer type

Cancer type	Sex	Age	Medical costs			Productivity loss			Patient time cost		
			Initial	Continuous	End-of-life	Initial	Continuous	End-of-life	Initial	Continuous	End-of-life
Esophageal Adenocarcinoma	Female	<65	95439	6853	156417	4884	3757	15027	650	500	2001
		≥65	79532	6853	104278	6984	5372	21489	1187	913	3652
	Male	<65	95787	6450	155612	4884	3757	15027	650	500	2001
		≥65	79822	6450	103742	6984	5372	21489	1187	913	3652
Stomach (Gastric Cardia)	Female	<65	85291	3977	155636	4884	3757	15027	650	500	2001
		≥65	71076	3977	103758	6984	5372	21489	1187	913	3652
	Male	<65	94144	4282	160695	4884	3757	15027	650	500	2001
		≥65	78453	4282	107130	6984	5372	21489	1187	913	3652
Liver	Female	<65	40173	5859	95782	4884	3757	15027	650	500	2001
		≥65	40173	5859	95782	6984	5372	21489	1187	913	3652
	Male	<65	41161	7363	97473	4884	3757	15027	650	500	2001
		≥65	41161	7363	97473	6984	5372	21489	1187	913	3652
Pancreatic	Female	<65	112154	8672	164911	4884	3757	15027	650	500	2001
		≥65	93462	8672	109941	6984	5372	21489	1187	913	3652
	Male	<65	112911	11697	169673	4884	3757	15027	650	500	2001
		≥65	94092	11697	113115	6984	5372	21489	1187	913	3652
Advanced Prostate	Male	<65	23652	3201	93363	3715	2858	11432	650	500	2001
		≥65	19710	3201	62242	6549	5038	20152	1187	913	3652
Colorectal	Female	<65	61593	3159	126778	10330	7946	31784	650	500	2001
		≥65	51327	3159	84519	7479	5753	23012	1187	913	3652

	Male	<65	62174	4595	128507	10330	7946	31784	650	500	2001
		≥65	51812	4595	85671	7479	5753	23012	1187	913	3652
Endometrial	Female	<65	32129	1535	105262	4884	3757	15027	650	500	2001
		≥65	26775	1535	70175	6984	5372	21489	1187	913	3652
Ovarian	Female	<65	98788	8296	149573	4884	3757	15027	650	500	2001
		≥65	82324	8296	99715	6984	5372	21489	1187	913	3652
Gallbladder	Female	<65	40173	5859	95782	4884	3757	15027	650	500	2001
		≥65	40173	5859	95782	6984	5372	21489	1187	913	3652
	Male	<65	41161	7363	97473	4884	3757	15027	650	500	2001
		≥65	41161	7363	97473	6984	5372	21489	1187	913	3652
Kidney (Renal Cell)	Female	<65	46077	6255	110765	4884	3757	15027	650	500	2001
		≥65	38397	6255	73843	6984	5372	21489	1187	913	3652
	Male	<65	46048	6018	117123	4884	3757	15027	650	500	2001
		≥65	38374	6018	78082	6984	5372	21489	1187	913	3652
Breast (Postmenopausal)	Female	<65	27693	2207	94284	5985	4604	18416	650	500	2001
		≥65	23078	2207	62856	4752	3655	14620	1187	913	3652
Thyroid	Female	<65	40173	5859	95782	4884	3757	15027	650	500	2001
		≥65	40173	5859	95782	6984	5372	21489	1187	913	3652
	Male	<65	41161	7363	97473	4884	3757	15027	650	500	2001
		≥65	41161	7363	97473	6984	5372	21489	1187	913	3652
Multiple Myeloma	Female	<65	40173	5859	95782	4884	3757	15027	650	500	2001
		≥65	40173	5859	95782	6984	5372	21489	1187	913	3652

Male	<65	41161	7363	97473	4884	3757	15027	650	500	2001
	≥65	41161	7363	97473	6984	5372	21489	1187	913	3652

Du M, *et al. BMJ Open* 2023; 13:e063614. doi: 10.1136/bmjopen-2022-063614

Supplementary Table 7. Baseline medical costs, productivity loss, and patient time cost among general population aged 20 years or older in the US, by 32 subgroups

Age group, years	Sex	Race/ethnicity	Medical costs		Productivity loss		Patient time cost	
			Annual general costs	End-of-life costs	Annual general costs	End-of-life costs	Annual general costs	End-of-life costs
20-44	Female	NHW	4020	40000	2040	8160	226	904
		NHB	3100	40000	2040	8160	226	904
		Hispanic	2355	40000	2040	8160	226	904
		Other	2617	40000	2040	8160	226	904
	Male	NHW	2022	40000	2040	8160	226	904
		NHB	2279	40000	2040	8160	226	904
		Hispanic	1145	40000	2040	8160	226	904
		Other	1803	40000	2040	8160	226	904
							226	904
45-54	Female	NHW	5371	40000	2040	8160	226	904
		NHB	5712	40000	2040	8160	226	904
		Hispanic	3196	40000	2040	8160	226	904
		Other	4082	40000	2040	8160	226	904
	Male	NHW	3812	40000	2040	8160	226	904
		NHB	3639	40000	2040	8160	226	904
		Hispanic	3612	40000	2040	8160	226	904
		Other	2560	40000	2040	8160	226	904
							226	904
55-64	Female	NHW	7300	40000	2040	8160	226	904
		NHB	5479	40000	2040	8160	226	904
		Hispanic	4607	40000	2040	8160	226	904
		Other	3951	40000	2040	8160	226	904
	Male	NHW	6519	40000	2040	8160	226	904
		NHB	6455	40000	2040	8160	226	904
		Hispanic	5077	40000	2040	8160	226	904
		Other	6320	40000	2040	8160	226	904
≥65	Female	NHW	8997	40000	4409	8160	607	904
		NHB	9585	40000	4409	8160	607	904
		Hispanic	8847	40000	4409	8160	607	904
		Other	8625	40000	4409	8160	607	904
	Male	NHW	9334	40000	4409	8160	607	904
		NHB	7367	40000	4409	8160	607	904
		Hispanic	5640	40000	4409	8160	607	904
		Other	7461	40000	4409	8160	607	904

Du M, *et al. BMJ Open* 2023; 13:e063614. doi: 10.1136/bmjopen-2022-063614

Supplementary Table 8. Characteristics of US adults aged 20 years or older participated in the NHANES, 2013-2016

Characteristics (N=10064)		**Calorie Consumption**, kcal/day
Age, years	47.8 ± 0.41	
Age groups, years, N (%)		
20-44	4319 (44.5)	425 ± 4.38
25-54	1704 (18.3)	315 ± 5.39
55-64	1725 (17.3)	271 ± 4.90
≥65	2316 (19.9)	192 ± 3.83
Sex, N (%)		
Male	4829 (48.3)	388 ± 4.53
Female	5235 (51.7)	279 ± 4.04
Race/ethnicity, N (%)		
Non-Hispanic White	3944 (65.0)	320 ± 4.76
Non-Hispanic Black	2069 (11.2)	361 ± 6.55
Hispanic	2668 (14.9)	367 ± 4.44
Other	1383 (8.90)	325 ± 8.12
Education, N (%)		
Less than high school graduate	2178 (14.2)	311 ± 5.14
High school graduate	2249 (21.6)	332 ± 5.72
Some college	3070 (33.1)	341 ± 4.92
College graduate	2562 (31.0)	332 ± 7.10
Family income to poverty ratio, N (%)		
<1.30	3862 (28.3)	325 ± 4.87
1.30-1.84	2842 (26.7)	333 ± 4.55
1.85-2.99	1725 (20.4)	344 ± 6.73
≥3.00	1635 (24.5)	328 ± 7.01
Body mass index (BMI), kg/m^2	29.3 ± 0.16	
Weight status, N (%)		
Underweight (BMI<18.5)	145 (1.36)	341 ± 17.5
Normal weight (BMI=18.5-24.9)	2671 (27.2)	327 ± 4.81
Overweight/Obese (BMI≥25)	7163 (71.4)	334 ± 4.01

Du M, *et al. BMJ Open* 2023; 13:e063614. doi: 10.1136/bmjopen-2022-063614

Supplementary Table 9. Consumption of calories from full-service and fast-food restaurants among US adults participated in 2013-2016 NHANES by 32 subgroups

Age group, years	**Sex**	**Race/ethnicity**	**Baseline consumption**, kcal/day (mean ± SE)
20-44	Female	NHW	357 ± 6.47
		NHB	397 ± 8.98
		Hispanic	364 ± 6.77
		Other	334 ± 11.3
	Male	NHW	485 ± 9.00
		NHB	508 ± 12.3
		Hispanic	500 ± 13.7
		Other	466 ± 14.1
45-54	Female	NHW	270 ± 9.38
		NHB	266 ± 7.85
		Hispanic	265 ± 9.11
		Other	228 ± 14.6
	Male	NHW	374 ± 11.3
		NHB	388 ± 17.4
		Hispanic	355 ± 15.0
		Other	338 ± 20.2
55-64	Female	NHW	231 ± 5.25
		NHB	249 ± 9.58
		Hispanic	234 ± 7.99
		Other	216 ± 10.2
	Male	NHW	315 ± 9.55
		NHB	314 ± 18.3
		Hispanic	307 ± 9.90
		Other	298 ± 11.1
≥65	Female	NHW	164 ± 4.71
		NHB	156 ± 6.07
		Hispanic	158 ± 5.27
		Other	137 ± 5.43
	Male	NHW	235 ± 7.43
		NHB	220 ± 7.07
		Hispanic	218 ± 8.07

	Other	198 ± 20.0

Supplementary Table 10. Estimated new cancer cases averted by the federal menu calorie labeling in the US by age, sex, race/ethnicity, and cancer type, over lifetime (U.S. population=235,162,844)[1]

Cancer Type	Policy Scenario	20-44 y		45-54 y		55-64 y		65 + y	
		Female	Male	Female	Male	Female	Male	Female	Male
Endometrial									
Age	*consumer behavior*	3300 (696 to 6090)		591 (-990 to 2160)		1140 (433 to 1940)		656 (107 to 1190)	
	+industry response	5960 (3360 to 8890)		1340 (-208 to 2980)		1600 (928 to 2430)		926 (396 to 1460)	
Race/Ethnicity									
Non-Hispanic White	*consumer behavior*	1630 (-711 to 4080)	0	-136 (-1590 to 1430)	0	757 (140 to 1500)	0	572 (38 to 1070)	0
	+industry response	3080 (829 to 5780)	0	369 (-1100 to 1950)	0	1110 (463 to 1830)	0	780 (245 to 1290)	0
Non-Hispanic Black	*consumer behavior*	763 (-157 to 1710)	0	258 (-23 to 543)	0	283 (73 to 528)	0	47 (-43 to 150)	0
	+industry response	1240 (316 to 2200)	0	372 (93 to 668)	0	355 (146 to 604)	0	77 (-13 to 176)	0
Hispanic	*consumer behavior*	910 (74 to 1790)	0	290 (-48 to 596)	0	42 (-83 to 185)	0	43 (-16 to 102)	0
	+industry response	1460 (580 to 2340)	0	399 (66 to 703)	0	89 (-35 to 233)	0	64 (5 to 122)	0
Other	*consumer behavior*	19 (-312 to 402)	0	165 (41 to 319)	0	54 (3 to 109)	0	-6 (-26 to 14)	0
	+industry response	150 (-174 to 546)	0	191 (68 to 344)	0	68 (18 to 124)	0	0 (-21 to 21)	0
Breast (Postmenopausal)									
Age	*consumer behavior*	2530 (263 to 5040)		373 (-1070 to 1950)		1210 (480 to 2130)		742 (137 to 1380)	
	+industry response	4670 (2330 to 7350)		1040 (-390 to 2680)		1710 (1010 to 2640)		1040 (433 to 1700)	
Race/Ethnicity									
Non-Hispanic White	*consumer behavior*	1370 (-659 to 3750)	0	-224 (-1570 to 1210)	0	832 (170 to 1670)	0	660 (57 to 1280)	0
	+industry response	2660 (490 to 5220)	0	234 (-1130 to 1770)	0	1200 (535 to 2040)	0	902 (291 to 1570)	0
Non-Hispanic Black	*consumer behavior*	567 (-110 to 1300)	0	182 (-34 to 431)	0	267 (89 to 487)	0	43 (-40 to 136)	0

	+industry response	912 (240 to 1680)	0	271 (55 to 536)	0	329 (149 to 554)	0	71 (-13 to 166)	0
Hispanic	*consumer behavior*	581 (44 to 1200)	0	231 (-14 to 474)	0	32.9 (-72 to 154)	0	42 (-12 to 100)	0
	+industry response	934 (368 to 1600)	0	312 (71 to 563)	0	76 (-34 to 198)	0	61 (6 to 123)	0
Other	*consumer behavior*	1 (-310 to 384)	0	182 (40 to 353)	0	74 (9 to 148)	0	-7 (-35 to 22)	0
	+industry response	128 (-187 to 541)	0	210 (71 to 386)	0	94 (29 to 170)	0	1 (-27 to 31)	0
Kidney (Renal Cell)									
Age	*consumer behavior*	2930 (864 to 5040)		581 (-364 to 1540)		1180 (526 to 1810)		428 (28 to 805)	
	+industry response	5240 (3110 to 7390)		1230 (244 to 2210)		1590 (941 to 2250)		651 (248 to 1030)	
Race/Ethnicity									
Non-Hispanic White	*consumer behavior*	338 (-137 to 844)	1040 (-536 to 2790)	-42 (-332 to 273)	53 (-791 to 884)	172 (34 to 339)	677 (88 to 1240)	147 (18 to 280)	192 (-170 to 536)
	+industry response	646 (173 to 1180)	2020 (410 to 3750)	58 (-236 to 383)	379 (-452 to 1250)	251 (109 to 420)	898 (326 to 1470)	199 (72 to 335)	320 (-35 to 661)
Non-Hispanic Black	*consumer behavior*	170 (-35 to 384)	88 (-454 to 620)	60 (-5 to 128)	136 (-96 to 410)	79 (26 to 139)	85 (-81 to 258)	13 (-12 to 40)	44 (9 to 79)
	+industry response	280 (69 to 502)	343 (-202 to 898)	87 (22 to 157)	203 (-30 to 475)	97 (43 to 157)	119 (-45 to 295)	21 (-4 to 48)	56 (22 to 90)
Hispanic	*consumer behavior*	267 (21 to 527)	895 (-21 to 1920)	92 (-4 to 184)	230 (-25 to 503)	14 (-27 to 60)	94 (8 to 196)	15 (-6 to 36)	9 (-29 to 50)
	+industry response	425 (166 to 697)	1290 (371 to 2320)	123 (27 to 218)	305 (49 to 570)	29 (-12 to 76)	127 (41 to 232)	22 (2 to 44)	21 (-17 to 63)
Other	*consumer behavior*	5 (-47 to 66)	75 (-103 to 274)	34 (12 to 59)	3 (-64 to 77)	13 (2 to 25)	33 (10 to 58)	-1 (-6 to 4)	8 (-18 to 37)
	+industry response	27 (-26 to 89)	147 (-29 to 347)	38 (17 to 64)	17 (-52 to 91)	16 (5 to 28)	41 (19 to 67)	1 (-4 to 6)	11 (-15 to 40)
Liver									
Age	*consumer behavior*	3210 (1000 to 5540)		701 (-200 to 1760)		1000 (477 to 1580)		275 (17 to 551)	
	+industry response	5560 (3130 to 8130)		1340 (397 to 2480)		1340 (804 to 1950)		432 (174 to 719)	
Race/Ethnicity									

Non-Hispanic White	*consumer behavior*	170 (-125 to 597)	1150 (-258 to 3130)	18 (-168 to 236)	-82 (-844 to 807)	113 (36 to 227)	520 (108 to 1020)	75 (6 to 155)	116 (-110 to 365)
	+industry response	367 (53 to 855)	2120 (498 to 4300)	78 (-105 to 319)	215 (-537 to 1150)	159 (77 to 280)	668 (287 to 1220)	100 (35 to 189)	198 (-26 to 454)
Non-Hispanic Black	*consumer behavior*	143 (-27 to 346)	85 (-678 to 1050)	53 (2 to 120)	213 (-146 to 705)	51 (14 to 100)	118 (-112 to 393)	7 (-7 to 26)	37 (-4 to 88)
	+industry response	231 (53 to 458)	429 (-312 to 1460)	74 (24 to 147)	306 (-41 to 823)	63 (28 to 115)	163 (-58 to 447)	12 (-2 to 32)	52 (11 to 107)
Hispanic	*consumer behavior*	239 (19 to 570)	1150 (93 to 2490)	99 (3 to 215)	321 (15 to 703)	14 (-30 to 72)	113 (19 to 233)	17 (-5 to 41)	8 (-33 to 54)
	+industry response	384 (132 to 756)	1600 (529 to 3050)	132 (36 to 257)	409 (106 to 820)	31 (-13 to 90)	150 (55 to 276)	25 (3 to 50)	20 (-19 to 70)
Other	*consumer behavior*	2 (-56 to 82)	99 (-125 to 379)	38 (9 to 77)	-1 (-101 to 125)	15 (0 to 34)	38 (5 to 76)	0 (-8 to 7)	9 (-28 to 53)
	+industry response	26 (-32 to 108)	183 (-31 to 483)	43 (15 to 85)	18 (-80 to 152)	19 (5 to 40)	48 (17 to 91)	2 (-5 to 10)	14 (-23 to 59)
Pancreatic									
Age	*consumer behavior*	764 (262 to 1340)		81.6 (-186 to 388)		404 (193 to 651)		148 (21 to 286)	
	+industry response	1350 (820 to 1990)		269 (4 to 595)		540 (327 to 793)		227 (96 to 370)	
Race/Ethnicity									
Non-Hispanic White	*consumer behavior*	121 (-44 to 367)	247 (-120 to 768)	-48 (-159 to 87)	-16 (-246 to 245)	87 (26 to 175)	218 (48 to 432)	63 (3 to 131)	58 (-54 to 189)
	+industry response	229 (50 to 493)	490 (99 to 1060)	-11 (-124 to 134)	73 (-154 to 363)	122 (56 to 218)	283 (115 to 507)	87 (27 to 163)	98 (-12 to 238)
Non-Hispanic Black	*consumer behavior*	60 (-10 to 158)	18 (-80 to 128)	24 (-1 to 54)	30 (-20 to 87)	32 (9 to 63)	19 (-16 to 62)	5 (-6 to 19)	10 (2 to 19)
	+industry response	98 (21 to 207)	64 (-36 to 184)	34 (9 to 67)	44 (-4 to 102)	39 (17 to 72)	27 (-9 to 70)	9 (-2 to 23)	13 (5 to 23)
Hispanic	*consumer behavior*	68 (5 to 150)	194 (13 to 422)	26 (-4 to 60)	46 (-5 to 105)	4 (-11 to 22)	18 (-3 to 44)	6 (-2 to 14)	2 (-8 to 12)
	+industry response	108 (40 to 201)	273 (92 to 518)	36 (7 to 70)	63 (11 to 124)	10 (-5 to 28)	26 (6 to 53)	8 (0 to 18)	5 (-5 to 15)
Other	*consumer behavior*	-2 (-27 to 30)	18 (-29 to 72)	17 (4 to 33)	0 (-20 to 23)	8 (1 to 16)	10 (3 to 19)	0 (-4 to 3)	2 (-6 to 13)
	+industry response	9 (-17 to 43)	36 (-9 to 94)	19 (7 to 36)	4 (-16 to 28)	10 (3 to 18)	13 (5 to 22)	1 (-3 to 5)	4 (-5 to 14)

Esophageal Adenocarcinoma									
Age	*consumer behavior*	715 (43 to 1480)		92 (-296 to 501)		419 (136 to 719)		128 (-60 to 309)	
	+industry response	1300 (602 to 2100)		293 (-102 to 708)		556 (270 to 858)		206 (20 to 390)	
Race/Ethnicity									
Non-Hispanic White	*consumer behavior*	45 (-25 to 125)	406 (-228 to 1100)	-9 (-55 to 41)	26 (-368 to 419)	30 (7 to 58)	345 (64 to 630)	27 (5 to 50)	92 (-88 to 263)
	+industry response	91 (17 to 179)	815 (174 to 1560)	7 (-40 to 60)	179 (-210 to 578)	43 (20 to 73)	449 (174 to 739)	35 (14 to 59)	155 (-17 to 330)
Non-Hispanic Black	*consumer behavior*	10 (-2 to 22)	10 (-28 to 50)	3 (-1 to 8)	11 (-7 to 32)	5 (2 to 9)	67 (-7 to 22)	1 (-1 to 3)	4 (0 to 7)
	+industry response	16 (4 to 29)	28 (-11 to 69)	5 (1 to 9)	16 (-2 to 37)	6 (3 to 11)	9 (-4 to 25)	1 (0 to 3)	5 (2 to 8)
Hispanic	*consumer behavior*	28 (2 to 57)	196 (-2 to 414)	9 (-1 to 20)	46 (-7 to 112)	2 (-3 to 8)	24 (3 to 47)	2 (-1 to 4)	2 (-7 to 12)
	+industry response	44 (17 to 76)	280 (80 to 504)	13 (2 to 24)	63 (7 to 130)	3 (-1 to 10)	32 (11 to 56)	3 (0 to 5)	4 (-4 to 15)
Other	*consumer behavior*	-1 (-10 to 11)	10 (-16 to 41)	6 (1 to 11)	0 (-12 to 13)	2 (0 to 5)	7 (2 to 12)	0 (-1 to 1)	2 (-4 to 8)
	+industry response	3 (-6 to 15)	21 (-6 to 52)	75 (2 to 12)	2 (-10 to 15)	3 (1 to 6)	8 (4 to 13)	0 (-1 to 1)	2 (-3 to 9)
Colorectal									
Age	*consumer behavior*	584 (183 to 1090)		79 (-90 to 289)		251 (126 to 412)		117 (19 to 224)	
	+industry response	1050 (605 to 1610)		201 (23 to 426)		341 (209 to 514)		175 (81 to 289)	
Race/Ethnicity									
Non-Hispanic White	*consumer behavior*	67 (-51 to 261)	169 (-107 to 569)	-35 (-106 to 64)	-17 (-151 to 163)	52 (11 to 111)	126 (21 to 262)	55 (11 to 115)	44 (-36 to 129)
	+industry response	144 (-2 to 382)	358 (40 to 790)	-12 (-80 to 97)	38 (-99 to 233)	75 (30 to 146)	168 (62 to 313)	73 (28 to 138)	70 (-7 to 162)
Non-Hispanic Black	*consumer behavior*	31 (-9 to 88)	38 (-48 to 144)	11 (-1 to 29)	26 (-13 to 79)	19 (7 to 36)	14 (-17 to 49)	3 (-4 to 12)	8 (1 to 17)
	+industry response	53 (9 to 119)	78 (-8 to 203)	17 (4 to 36)	36 (-2 to 91)	23 (11 to 41)	20 (-9 to 56)	6 (-1 to 15)	11 (3 to 21)
Hispanic	*consumer behavior*	45 (2 to 113)	185 (25 to 409)	20 (1 to 43)	57 (9 to 114)	3 (-7 to 16)	21 (2 to 44)	4 (-1 to 11)	1 (-8 to 11)

	+industry response	73 (18 to 155)	256 (84 to 504)	26 (8 to 51)	70 (23 to 129)	6 (-3 to 20)	28 (10 to 53)	6 (1 to 13)	4 (-5 to 14)
Other	*consumer behavior*	-2 (-21 to 26)	20 (-31 to 89)	7 (-1 to 19)	1 (-20 to 26)	4 (0 to 11)	8 (1 to 16)	-1 (-3 to 2)	3 (-6 to 13)
	+industry response	6 (-13 to 36)	41 (-9 to 115)	9 (1 to 21)	5 (-15 to 31)	6 (1 to 12)	10 (4 to 19)	0 (-2 to 3)	4 (-5 to 14)
Thyroid									
Age	*consumer behavior*	374 (114 to 751)		10 (-69 to 125)		84 (44 to 144)		34 (7 to 68)	
	+industry response	683 (349 to 1130)		67 (-17 to 200)		117 (70 to 187)		52 (22 to 91)	
Race/Ethnicity									
Non-Hispanic White	*consumer behavior*	96 (-59 to 382)	52 (-59 to 273)	-28 (-85 to 56)	-15 (-64 to 58)	21 (1 to 62)	28 (1 to 73)	20 (2 to 47)	8 (-9 to 31)
	+industry response	205 (-15 to 563)	131 (-26 to 395)	-8 (-63 to 92)	3 (-43 to 85)	33 (5 to 80)	40 (12 to 90)	28 (9 to 58)	14 (-3 to 40)
Non-Hispanic Black	*consumer behavior*	29 (-10 to 113)	7 (-10 to 36)	8 (-1 to 24)	3 (-3 to 12)	12 (6 to 22)	2 (-2 to 8)	1 (-2 to 5)	1 (0 to 2)
	+industry response	52 (-1 to 153)	16 (-4 to 50)	12 (2 to 30)	5 (-1 to 15)	14 (8 to 26)	3 (-1 to 10)	2 (0 to 7)	2 (1 to 3)
Hispanic	*consumer behavior*	68 (1 to 201)	59 (6 to 151)	15 (-5 to 39)	13 (2 to 30)	2 (-4 to 12)	4 (0 to 9)	2 (-1 to 6)	0 (-1 to 3)
	+industry response	113 (22 to 276)	84 (26 to 189)	21 (2 to 48)	16 (6 to 35)	4 (-2 to 15)	5 (2 to 12)	3 (0 to 8)	1 (-1 to 3)
Other	*consumer behavior*	-4 (-38 to 59)	13 (-13 to 56)	6 (-4 to 20)	1 (-7 to 12)	5 (2 to 10)	5 (3 to 8)	-1 (-2 to 1)	0 (-2 to 3)
	+industry response	12 (-25 to 82)	23 (-2 to 70)	8 (-1 to 23)	3 (-5 to 14)	6 (3 to 11)	6 (4 to 9)	0 (-2 to 2)	1 (-1 to 4)
Multiple Myeloma									
Age	*consumer behavior*	370 (113 to 743)		78 (-46 to 242)		181 (85 to 308)		63 (7 to 128)	
	+industry response	653 (327 to 1120)		164 (29 to 357)		243 (142 to 385)		97 (41 to 169)	
Race/Ethnicity									
Non-Hispanic White	*consumer behavior*	27 (-34 to 138)	102 (-61 to 375)	-14 (-50 to 50)	-4 (-96 to 139)	24 (3 to 67)	96 (25 to 204)	20 (1 to 52)	23 (-23 to 83)
	+industry response	64 (-22 to 204)	207 (0 to 544)	-1 (-38 to 74)	29 (-60 to 199)	36 (9 to 87)	125 (52 to 246)	28 (8 to 65)	39 (-5 to 111)

Non-Hispanic Black	*consumer behavior*	39 (-9 to 135)	22 (-63 to 178)	14 (-1 to 43)	27 (-15 to 95)	19 (4 to 45)	11 (-22 to 60)	4 (-4 to 17)	10 (2 to 22)
	+industry response	66 (1 to 183)	65 (-30 to 242)	22 (4 to 55)	38 (-3 to 113)	24 (9 to 54)	18 (-13 to 71)	6 (-1 to 20)	13 (5 to 26)
Hispanic	*consumer behavior*	26 (0 to 79)	111 (12 to 277)	7 (-5 to 24)	25 (-3 to 68)	2 (-4 to 11)	15 (3 to 32)	2 (-1 to 7)	0 (-5 to 7)
	+industry response	43 (6 to 110)	154 (50 to 340)	10 (0 to 30)	33 (6 to 82)	4 (-2 to 15)	19 (8 to 39)	3 (0 to 9)	1 (-3 to 9)
Other	*consumer behavior*	0 (-7 to 11)	8 (-11 to 41)	7 (3 to 12)	0 (-10 to 12)	1 (1 to 4)	4 (1 to 9)	-0 (-1 to 1)	1 (-3 to 6)
	+industry response	2 (-4 to 16)	16 (-3 to 53)	8 (4 to 13)	1 (-8 to 15)	2 (0 to 5)	5 (2 to 11)	0 (-1 to 1)	1 (-2 to 6)
Stomach (Gastric Cardia)									
Age	*consumer behavior*	338 (49 to 803)		58 (-99 to 264)		182 (70 to 347)		54 (-19 to 149)	
	+industry response	607 (241 to 1140)		141 (-20 to 378)		240 (129 to 420)		86 (15 to 190)	
Race/Ethnicity									
Non-Hispanic White	*consumer behavior*	18 (-19 to 77)	208 (-55 to 648)	-9 (-31 to 25)	24 (-128 to 233)	15 (4 to 37)	145 (35 to 304)	14 (3 to 28)	34 (-36 to 124)
	+industry response	43 (-6 to 117)	380 (51 to 886)	-1 (-24 to 38)	86 (-67 to 322)	22 (9 to 47)	187 (77 to 364)	18 (8 to 35)	58 (-9 to 160)
Non-Hispanic Black	*consumer behavior*	7 (-2 to 21)	6 (-19 to 44)	2 (0 to 6)	7 (-5 to 24)	3 (1 to 7)	3 (-6 to 15)	0 (0 to 2)	3 (1 to 5)
	+industry response	12 (2 to 28)	19 (-8 to 62)	3 (1 to 7)	10 (-2 to 29)	4 (2 to 8)	5 (-4 to 17)	1 (0 to 2)	3 (2 to 6)
Hispanic	*consumer behavior*	15 (1 to 39)	63 (-7 to 170)	5 (0 to 13)	16 (-4 to 45)	1 (-2 to 5)	7 (0 to 18)	1 (0 to 3)	1 (-3 to 5)
	+industry response	24 (6 to 52)	95 (21 to 214)	7 (2 to 16)	22 (3 to 54)	2 (-1 to 6)	10 (3 to 23)	1 (0 to 3)	2 (-2 to 7)
Other	*consumer behavior*	-1 (-7 to 10)	5 (-14 to 34)	5 (2 to 9)	0 (-8 to 12)	1 (0 to 3)	4 (1 to 9)	0 (-1 to 1)	1 (-3 to 6)
	+industry response	2 (-5 to 14)	12 (-7 to 46)	6 (3 to 10)	2 (-6 to 15)	2 (0 to 4)	5 (2 to 10)	0 (-1 to 1)	2 (-2 to 7)
Gallbladder									
Age	*consumer behavior*	161 (67 to 263)		51 (8 to 100)		76 (47 to 109)		29 (11 to 51)	
	+industry response	282 (181 to 396)		86 (43 to 138)		101 (73 to 137)		44 (25 to 66)	

Du M, *et al. BMJ Open* 2023; 13:e063614. doi: 10.1136/bmjopen-2022-063614

Race/Ethnicity									
Non-Hispanic White	*consumer behavior*	24 (-10 to 71)	19 (-13 to 61)	0 (-25 to 30)	1.97 (-17 to 24)	19 (5 to 38)	23 (6 to 42)	16 (3 to 31)	6 (-5 to 17)
	+industry response	47 (10 to 99)	39 (5 to 88)	9 (-16 to 42)	9 (-10 to 34)	27 (12 to 48)	29 (13 to 50)	21 (8 to 37)	9 (-1 to 21)
Non-Hispanic Black	*consumer behavior*	27 (-6 to 70)	2 (-17 to 26)	11 (0 to 24)	6 (-4 to 18)	14 (4 to 26)	4 (-4 to 12)	2 (-2 to 7)	2 (0 to 4)
	+industry response	45 (11 to 93)	11 (-8 to 38)	15 (4 to 29)	9 (-1 to 21)	17 (8 to 30)	5 (-2 to 14)	4 (-1 to 9)	3 (1 to 5)
Hispanic	*consumer behavior*	32 (2 to 73)	42 (-10 to 106)	10 (-4 to 26)	14 (-2 to 34)	3 (-5 to 11)	7 (1 to 15)	3 (-1 to 7)	0 (-3 to 4)
	+industry response	53 (19 to 96)	65 (11 to 130)	15 (1 to 31)	19 (3 to 39)	5 (-2 to 14)	9 (3 to 18)	4 (1 to 9)	1 (-2 to 5)
Other	*consumer behavior*	0 (-11 to 18)	3 (-6 to 15)	6 (1 to 13)	0 (-4 to 5)	3 (0 to 7)	3 (1 to 5)	0 (-1 to 1)	1 (-1 to 3)
	+industry response	5 (-7 to 24)	7 (-2 to 19)	7 (2 to 14)	1 (-3 to 6)	4 (1 to 8)	3 (1 to 5)	0 (-1 to 2)	1 (-1 to 3)
Advanced Prostate									
Age	*consumer behavior*	163 (9 to 360)		37 (-54 to 146)		106 (33 to 194)		35 (-14 to 91)	
	+industry response	300 (130 to 507)		85 (-6 to 203)		142 (67 to 240)		56 (9 to 119)	
Race/Ethnicity									
Non-Hispanic White	*consumer behavior*	0	86 (-24 to 267)	0	-1 (-80 to 98)	0	75 (9 to 162)	0	24 (-23 to 80)
	+industry response	0	162 (32 to 350)	0	30 (-48 to 144)	0	100 (36 to 199)	0	40 (-5 to 102)
Non-Hispanic Black	*consumer behavior*	0	3 (-61 to 97)	0	21 (-17 to 69)	0	16 (-13 to 51)	0	8 (2 to 17)
	+industry response	0	34 (-33 to 145)	0	31 (-5 to 83)	0	22 (-7 to 57)	0	11 (4 to 20)
Hispanic	*consumer behavior*	0	59 (8 to 133)	0	13 (-3 to 37)	0	9 (2 to 20)	0	1 (-3 to 5)
	+industry response	0	82 (28 to 163)	0	18 (1 to 44)	0	12 (5 to 23)	0	2 (-2 to 7)
Other	*consumer behavior*	0	3 (-10 to 21)	0	0 (-7 to 8)	0	4 (2 to 8)	0	1 (-3 to 5)
	+industry response	0	8 (-5 to 28)	0	1 (-5 to 9)	0	5 (3 to 9)	0	2 (-2 to 6)

Ovarian									
Age	*consumer behavior*	66 (-10 to 180)		16 (-20 to 75)		31 (11 to 69)		28 (11 to 61)	
	+industry response	129 (16 to 277)		33 (-6 to 102)		45 (17 to 87)		37 (19 to 75)	
Race/Ethnicity									
Non-Hispanic White	*consumer behavior*	34 (-25 to 147)	0	-4 (-38 to 54)	0	20 (2 to 55)	0	25 (8 to 57)	0
	+industry response	71 (-23 to 220)	0	7 (-30 to 72)	0	30 (6 to 71)	0	32 (15 to 70)	0
Non-Hispanic Black	*consumer behavior*	11 (-5 to 41)	0	4 (0 to 13)	0	6 (3 to 13)	0	1 (-1 to 5)	0
	+industry response	19 (-3 to 56)	0	6 (0 to 17)	0	8 (4 to 16)	0	2 (0 to 6)	0
Hispanic	*consumer behavior*	21 (-2 to 67)	0	8 (-1 to 21)	0	1 (-3 to 8)	0	1 (-1 to 5)	0
	+industry response	34 (1 to 91)	0	11 (3 to 26)	0	3 (-1 to 10)	0	2 (0 to 6)	0
Other	*consumer behavior*	-8 (-19 to 13)	0	6 (2 to 13)	0	2 (1 to 5)	0	0 (-1 to 1)	0
	+industry response	-3 (-15 to 21)	0	7 (3 to 14)	0	3 (1 to 6)	0	0 (-1 to 2)	0

1. Values are the median estimates (95% uncertainty intervals) of each distribution of 1000 simulations.

Supplementary Table 11. Estimated cancer deaths reduced by the federal menu calorie labeling in the US by age, sex, race/ethnicity, and cancer type, over a lifetime (U.S. population=235,162,844)[1]

Cancer Type	Policy Scenario	20-44 y Female	20-44 y Male	45-54 y Female	45-54 y Male	55-64 y Female	55-64 y Male	65 + y Female	65 + y Male
Breast (Postmenopausal)									
Age	*consumer behavior*	2490 (260 to 4980)		151 (-204 to 521)		285 (129 to 479)		126 (30 to 227)	
	+industry response	4610 (2290 to 7240)		336 (-26 to 725)		396 (237 to 598)		178 (82 to 284)	
Race/Ethnicity									
Non-Hispanic White	*consumer behavior*	1350 (-652 to 3690)	0	-55 (-373 to 278)	0	165 (33 to 327)	0	103 (10 to 204)	0
	+industry response	2620 (480 to 5150)	0	54 (-264 to 419)	0	238 (105 to 401)	0	139 (47 to 244)	0
Non-Hispanic Black	*consumer behavior*	560 (-109 to 1280)	0	85 (-11 to 200)	0	95 (32 to 173)	0	13 (-12 to 40)	0
	+industry response	901 (238 to 1660)	0	126 (26 to 247)	0	117 (53 to 196)	0	21 (-4 to 49)	0
Hispanic	*consumer behavior*	572 (45 to 1180)	0	76 (-7 to 163)	0	9 (-21 to 44)	0	10 (-3 to 24)	0
	+industry response	922 (364 to 1570)	0	104 (21 to 193)	0	21 (-9 to 57)	0	15 (2 to 30)	0
Other	*consumer behavior*	0 (-306 to 378)	0	39 (9 to 76)	0	15 (2 to 31)	0	-1 (-6 to 3)	0
	+industry response	125 (-185 to 532)	0	45 (16 to 84)	0	19 (6 to 35)	0	0 (-5 to 5)	0
Liver									
Age	*consumer behavior*	2840 (897 to 4890)		628 (-181 to 1570)		852 (411 to 1340)		227 (18 to 455)	
	+industry response	4900 (2760 to 7190)		1200 (345 to 2210)		1140 (689 to 1650)		357 (146 to 587)	
Race/Ethnicity									
Non-Hispanic White	*consumer behavior*	139 (-108 to 504)	1040 (-237 to 2780)	15 (-147 to 207)	-70 (-749 to 722)	98 (31 to 196)	440 (93 to 858)	63 (6 to 130)	97 (-88 to 297)
	+industry response	310 (42 to 719)	1900 (449 to 3830)	67 (-93 to 276)	199 (-478 to 1040)	137 (67 to 240)	565 (241 to 1020)	85 (30 to 159)	161 (-18 to 369)

Non-Hispanic Black	*consumer behavior*	134 (-25 to 317)	72 (-601 to 932)	49 (3 to 110)	193 (-133 to 632)	43 (12 to 85)	100 (-95 to 336)	6 (-6 to 22)	29 (-4 to 69)
	+industry response	214 (51 to 425)	382 (-273 to 1280)	68 (23 to 133)	276 (-37 to 729)	54 (24 to 97)	139 (-49 to 377)	10 (-2 to 27)	41 (8 to 83)
Hispanic	*consumer behavior*	199 (17 to 473)	1020 (88 to 2210)	87 (2 to 189)	285 (13 to 630)	12 (-26 to 62)	99 (18 to 201)	15 (-4 to 35)	6 (-28 to 46)
	+industry response	316 (111 to 623)	1430 (482 to 2690)	116 (31 to 223)	365 (94 to 729)	26 (-11 to 78)	131 (48 to 242)	21 (3 to 43)	17 (-15 to 59)
Other	*consumer behavior*	2 (-47 to 68)	90 (-110 to 339)	32 (7 to 65)	-2 (-88 to 108)	12 (0 to 28)	30 (4 to 61)	0 (-6 to 6)	7 (-22 to 42)
	+industry response	22 (-28 to 93)	168 (-26 to 434)	36 (13 to 71)	15 (-70 to 130)	16 (4 to 32)	39 (14 to 74)	1 (-4 to 8)	11 (-18 to 46)
Endometrial									
Age	*consumer behavior*	1190 (309 to 2140)		251 (-248 to 785)		394 (177 to 659)		213 (51 to 378)	
	+industry response	2100 (1200 to 3110)		512 (26 to 1060)		548 (325 to 817)		302 (139 to 472)	
Race/Ethnicity									
Non-Hispanic White	*consumer behavior*	440 (-210 to 1170)	0	-42 (-511 to 440)	0	206 (36 to 399)	0	173 (13 to 319)	0
	+industry response	858 (218 to 1620)	0	114 (-351 to 606)	0	298 (127 to 491)	0	234 (76 to 388)	0
Non-Hispanic Black	*consumer behavior*	412 (-90 to 937)	0	139 (-9 to 293)	0	157 (42 to 295)	0	26 (-24 to 83)	0
	+industry response	666 (177 to 1210)	0	201 (51 to 361)	0	195 (81 to 338)	0	42 (-8 to 97)	0
Hispanic	*consumer behavior*	315 (22 to 645)	0	105 (-22 to 222)	0	16 (-33 to 70)	0	19 (-7 to 44)	0
	+industry response	505 (197 to 854)	0	144 (21 to 261)	0	34 (-14 to 89)	0	28 (3 to 54)	0
Other	*consumer behavior*	8 (-99 to 139)	0	51 (13 to 99)	0	17 (1 to 36)	0	-3 (-10 to 5)	0
	+industry response	50 (-56 to 187)	0	58 (21 to 107)	0	22 (6 to 41)	0	0 (-8 to 7)	0
Kidney (Renal Cell)									
Age	*consumer behavior*	1050 (284 to 1830)		263 (-153 to 695)		506 (225 to 778)		182 (20 to 338)	
	+industry response	1880 (1100 to 2680)		539 (106 to 977)		679 (402 to 954)		276 (112 to 429)	
Race/Ethnicity									

Non-Hispanic White	*consumer behavior*	57 (-23 to 159)	332 (-183 to 922)	-16 (-128 to 106)	26 (-351 to 396)	72 (14 to 138)	287 (42 to 525)	66 (9 to 124)	81 (-68 to 219)
	+industry response	111 (27 to 224)	663 (123 to 1280)	22 (-90 to 146)	168 (-199 to 552)	105 (46 to 171)	378 (138 to 623)	89 (33 to 148)	133 (-12 to 272)
Non-Hispanic Black	*consumer behavior*	67 (-16 to 162)	48 (-225 to 326)	24 (-2 to 53)	59 (-40 to 171)	30 (10 to 56)	35 (-32 to 106)	5 (-5 to 16)	16 (3 to 28)
	+industry response	113 (25 to 218)	174 (-96 to 461)	34 (9 to 64)	87 (-14 to 199)	37 (17 to 63)	49 (-17 to 121)	8 (-2 to 20)	20 (7 to 33)
Hispanic	*consumer behavior*	111 (9 to 229)	367 (0 to 792)	30 (-3 to 62)	118 (-15 to 261)	6 (-13 to 29)	47 (5 to 98)	7 (-2 to 17)	4 (-12 to 23)
	+industry response	177 (67 to 305)	522 (168 to 968)	40 (8 to 74)	157 (23 to 303)	13 (-5 to 36)	64 (22 to 116)	11 (1 to 21)	9 (-7 to 28)
Other	*consumer behavior*	3 (-23 to 34)	33 (-40 to 122)	15 (5 to 28)	0 (-28 to 33)	5 (1 to 11)	16 (5 to 29)	-1 (-3 to 2)	4 (-8 to 17)
	+industry response	13 (-12 to 45)	63 (-10 to 156)	17 (7 to 30)	6 (-22 to 39)	6 (2 to 12)	20 (9 to 33)	0 (-2 to 3)	5 (-6 to 18)
Pancreatic									
Age	*consumer behavior*	656 (220 to 1160)		74 (-166 to 350)		362 (175 to 581)		131 (20 to 250)	
	+industry response	1160 (707 to 1730)		243 (1 to 535)		483 (293 to 708)		199 (87 to 321)	
Race/Ethnicity									
Non-Hispanic White	*consumer behavior*	101 (-40 to 310)	213 (-100 to 659)	-44 (-143 to 78)	-13 (-216 to 221)	79 (24 to 158)	193 (44 to 384)	56 (3 to 117)	50 (-45 to 162)
	+industry response	196 (42 to 425)	420 (85 to 911)	-10 (-111 to 120)	67 (-140 to 326)	111 (51 to 198)	250 (102 to 448)	78 (25 to 146)	84 (-10 to 203)
Non-Hispanic Black	*consumer behavior*	48 (-7 to 125)	16 (-72 to 117)	22 (-1 to 49)	27 (-18 to 78)	29 (8 to 57)	18 (-15 to 56)	5 (-5 to 17)	9 (1 to 17)
	+industry response	78 (18 to 162)	57 (-33 to 164)	31 (9 to 62)	39 (-3 to 91)	36 (15 to 65)	24 (-8 to 63)	8 (-1 to 20)	12 (4 to 19)
Hispanic	*consumer behavior*	55 (5 to 118)	175 (13 to 374)	24 (-4 to 53)	42 (-5 to 97)	4 (-10 to 20)	16 (-2 to 40)	5 (-2 to 13)	1 (-7 to 10)
	+industry response	88 (33 to 158)	245 (83 to 462)	32 (6 to 63)	57 (10 to 113)	9 (-5 to 25)	23 (5 to 48)	8 (1 to 16)	4 (-4 to 13)
Other	*consumer behavior*	-2 (-23 to 25)	16 (-23 to 63)	14 (3 to 27)	0 (-18 to 20)	7 (1 to 14)	9 (3 to 17)	0 (-3 to 3)	2 (-5 to 11)
	+industry response	7 (-14 to 36)	32 (-7 to 82)	16 (6 to 30)	3 (-14 to 24)	9 (2 to 16)	11 (5 to 19)	1 (-2 to 4)	3 (-4 to 12)

Du M, *et al. BMJ Open* 2023; 13:e063614. doi: 10.1136/bmjopen-2022-063614

Esophageal Adenocarcinoma									
Age	*consumer behavior*	631 (33 to 1320)		78 (-255 to 423)		348 (113 to 584)		101 (-42 to 239)	
	+industry response	1150 (520 to 1870)		246 (-96 to 601)		457 (225 to 699)		161 (19 to 302)	
Race/Ethnicity									
Non-Hispanic White	*consumer behavior*	40 (-23 to 112)	366 (-206 to 1000)	-8 (-47 to 36)	24 (-314 to 359)	24 (6 to 47)	283 (55 to 516)	22 (4 to 41)	71 (-65 to 202)
	+industry response	81 (15 to 160)	732 (157 to 1400)	5 (-34 to 51)	152 (-176 to 495)	35 (16 to 59)	366 (142 to 602)	28 (11 to 48)	119 (-13 to 253)
Non-Hispanic Black	*consumer behavior*	9 (-1 to 20)	9 (-25 to 45)	3 (0 to 7)	10 (-6 to 28)	4 (1 to 8)	6 (-6 to 18)	1 (-1 to 2)	3 (0 to 5)
	+industry response	14 (3 to 26)	25 (-10 to 62)	4 (1 to 8)	14 (-2 to 33)	5 (2 to 9)	8 (-3 to 21)	1 (0 to 3)	4 (1 to 6)
Hispanic	*consumer behavior*	25 (2 to 52)	164 (2 to 354)	3 (-1 to 13)	40 (-7 to 99)	1 (-3 to 7)	21 (3 to 42)	1 (-1 to 4)	1 (-6 to 10)
	+industry response	40 (15 to 68)	235 (70 to 425)	5 (0 to 16)	55 (6 to 114)	3 (-1 to 8)	28 (10 to 50)	2 (0 to 4)	4 (-4 to 12)
Other	*consumer behavior*	-1 (-9 to 10)	9 (-14 to 35)	5 (1 to 9)	-1 (-10 to 10)	2 (0 to 4)	6 (2 to 10)	0 (-1 to 1)	1 (-3 to 7)
	+industry response	3 (-6 to 14)	18 (-5 to 46)	6 (2 to 10)	1 (-8 to 12)	2 (1 to 5)	7 (3 to 11)	0 (-1 to 1)	2 (-3 to 7)
Colorectal									
Age	*consumer behavior*	430 (139 to 779)		56 (-48 to 184)		150 (77 to 241)		63 (13 to 119)	
	+industry response	764 (450 to 1160)		133 (23 to 268)		203 (126 to 304)		95 (46 to 153)	
Race/Ethnicity									
Non-Hispanic White	*consumer behavior*	49 (-36 to 181)	119 (-75 to 391)	-21 (-65 to 40)	-10 (-89 to 97)	32 (7 to 67)	72 (11 to 150)	31 (6 to 63)	22 (-17 to 64)
	+industry response	106 (4 to 261)	248 (28 to 545)	-6 (-49 to 59)	24 (-60 to 140)	46 (20 to 85)	96 (36 to 176)	41 (16 to 76)	35 (-3 to 81)
Non-Hispanic Black	*consumer behavior*	26 (-7 to 70)	27 (-36 to 104)	8 (0 to 21)	18 (-9 to 53)	13 (4 to 24)	9 (-10 to 31)	2 (-2 to 7)	5 (0 to 10)
	+industry response	44 (9 to 94)	58 (-7 to 145)	12 (4 to 26)	25.1 (-1 to 61)	15 (7 to 27)	13 (-6 to 36)	3 (-1 to 9)	6 (2 to 12)
Hispanic	*consumer behavior*	36 (2 to 88)	136 (21 to 300)	13 (0 to 27)	37 (5 to 74)	2 (-4 to 10)	13 (2 to 28)	2 (-1 to 7)	1 (-5 to 6)

	+industry response	58 (17 to 120)	188 (65 to 366)	16 (5 to 32)	45 (14 to 84)	4 (-2 to 13)	18 (6 to 33)	4 (0 to 8)	2 (-3 to 8)
Other	*consumer behavior*	-1 (-15 to 20)	16 (-21 to 65)	5 (-1 to 11)	0 (-12 to 15)	2 (0 to 6)	5 (1 to 9)	0 (-2 to 1)	1 (-3 to 6)
	+industry response	5 (-9 to 27)	30 (-5 to 83)	6 (1 to 13)	2 (-9 to 17)	3 (1 to 7)	6 (2 to 11)	0 (-1 to 2)	2 (-2 to 7)
Stomach (Gastric Cardia)									
Age	*consumer behavior*	286 (45 to 672)		50 (-84 to 224)		149 (58 to 282)		42 (-14 to 113)	
	+industry response	513 (196 to 965)		120 (-14 to 321)		196 (105 to 342)		67 (13 to 145)	
Race/Ethnicity									
Non-Hispanic White	*consumer behavior*	14 (-16 to 63)	178 (-46 to 545)	-7 (-26 to 20)	21 (-109 to 194)	13 (4 to 30)	118 (29 to 248)	11 (3 to 22)	27 (-26 to 95)
	+industry response	34 (-5 to 95)	322 (43 to 766)	-1 (-19 to 30)	74 (-58 to 270)	18 (7 to 38)	152 (63 to 296)	14 (6 to 27)	45 (-6 to 121)
Non-Hispanic Black	*consumer behavior*	5 (-1 to 17)	2 (-11 to 29)	2 (0 to 5)	6 (-5 to 22)	2 (1 to 5)	3 (-5 to 13)	0 (0 to 1)	2 (1 to 4)
	+industry response	9 (2 to 22)	7 (-5 to 43)	2 (1 to 6)	9 (-2 to 26)	3 (2 to 6)	4 (-3 to 15)	1 (0 to 2)	3 (1 to 5)
Hispanic	*consumer behavior*	13 (1 to 35)	57 (-6 to 154)	5 (0 to 12)	14 (-3 to 38)	1 (-1 to 4)	6 (0 to 15)	1 (0 to 2)	0 (-2 to 4)
	+industry response	22 (5 to 47)	86 (20 to 194)	6 (2 to 14)	19 (3 to 46)	1 (-1 to 5)	8 (2 to 19)	1 (0 to 3)	1 (-1 to 6)
Other	*consumer behavior*	-1 (-5 to 7)	4 (-9 to 25)	4 (2 to 8)	0 (-7 to 10)	1 (0 to 3)	3 (1 to 7)	0 (-1 to 1)	1 (-2 to 5)
	+industry response	1 (-3 to 9)	9 (-4 to 34)	4 (2 to 8)	2 (-5 to 12)	1 (0 to 3)	4 (2 to 8)	0 (0 to 1)	1 (-2 to 5)
Multiple Myeloma									
Age	*consumer behavior*	220 (65 to 441)		51 (-29 to 150)		112 (54 to 186)		42 (6 to 84)	
	+industry response	380 (202 to 657)		105 (20 to 215)		151 (89 to 232)		63 (27 to 111)	
Race/Ethnicity									
Non-Hispanic White	*consumer behavior*	11 (-13 to 52)	59 (-34 to 221)	-8 (-32 to 31)	-3 (-59 to 83)	15 (2 to 41)	58 (15 to 123)	14 (1 to 35)	15 (-14 to 54)

	+industry response	26 (-7 to 81)	122 (1 to 321)	-1 (-23 to 45)	19 (-37 to 123)	22 (6 to 53)	75 (32 to 147)	19 (6 to 44)	26 (-3 to 71)
Non-Hispanic Black	*consumer behavior*	17 (-4 to 63)	14 (-40 to 115)	10 (0 to 29)	17 (-10 to 59)	12 (3 to 28)	7 (-14 to 38)	2 (-3 to 11)	6 (1 to 12)
	+industry response	29 (1 to 83)	44 (-20 to 159)	15 (3 to 37)	24 (-1 to 70)	15 (6 to 34)	11 (-8 to 45)	4 (-1 to 13)	7 (3 to 15)
Hispanic	*consumer behavior*	16 (0 to 51)	72 (9 to 193)	5 (-3 to 17)	15 (-2 to 42)	1 (-3 to 8)	10 (2 to 22)	2 (-1 to 5)	0 (-3 to 5)
	+industry response	28 (5 to 71)	100 (31 to 244)	7 (0 to 21)	21 (4 to 51)	3 (-1 to 10)	13 (5 to 26)	3 (0 to 6)	1 (-2 to 6)
Other	*consumer behavior*	0 (-3 to 6)	5 (-7 to 27)	4 (2 to 7)	0 (-6 to 7)	1 (0 to 2)	3 (1 to 6)	0 (-1 to 1)	1 (-2 to 4)
	+industry response	1 (-2 to 8)	10 (-2 to 36)	4 (2 to 8)	1 (-5 to 9)	1 (0 to 3)	4 (2 to 7)	0 (-1 to 1)	1 (-1 to 4)
Gallbladder									
Age	*consumer behavior*	136 (58 to 229)		44 (7 to 86)		65 (40 to 93)		24 (9 to 41)	
	+industry response	239 (153 to 341)		74 (36 to 119)		86 (61 to 117)		36 (20 to 53)	
Race/Ethnicity									
Non-Hispanic White	*consumer behavior*	22 (-10 to 64)	15 (-10 to 52)	0 (-23 to 27)	2 (-14 to 19)	16 (4 to 32)	19 (6 to 36)	13 (2 to 25)	5 (-4 to 14)
	+industry response	43 (9 to 90)	32 (4 to 72)	8 (-15 to 37)	8 (-8 to 27)	23 (10 to 40)	24 (11 to 42)	17 (6 to 30)	8 (-1 to 18)
Non-Hispanic Black	*consumer behavior*	24 (-5 to 61)	2 (-14 to 21)	10 (0 to 21)	4 (-3 to 14)	12 (4 to 23)	3 (-3 to 10)	2 (-2 to 6)	2 (0 to 3)
	+industry response	40 (10 to 80)	9 (-7 to 31)	14 (4 to 27)	6 (-1 to 17)	15 (7 to 26)	4 (-2 to 12)	3 (0 to 7)	2 (1 to 4)
Hispanic	*consumer behavior*	28 (2 to 63)	33 (-8 to 85)	9 (-4 to 23)	12 (-2 to 30)	2 (-4 to 10)	6 (1 to 13)	2 (-1 to 6)	0 (-2 to 3)
	+industry response	45 (16 to 83)	51 (9 to 106)	13 (1 to 28)	16 (3 to 35)	4 (-2 to 13)	8 (3 to 16)	4 (0 to 8)	1 (-1 to 4)
Other	*consumer behavior*	0 (-10 to 16)	2 (-5 to 12)	5 (1 to 11)	0 (-2 to 2)	3 (0 to 6)	2 (1 to 4)	0 (-1 to 1)	0 (-1 to 2)
	+industry response	4 (-6 to 21)	5 (-2 to 15)	6 (2 to 12)	0 (-1 to 3)	4 (1 to 7)	3 (1 to 5)	0 (-1 to 2)	1 (-1 to 2)
Advanced Prostate									
Age	*consumer behavior*	101 (13 to 214)		18 (-17 to 58)		33 (11 to 58)		15 (-4 to 38)	

	+industry response	174 (80 to 304)		37 (1 to 83)		43 (22 to 71)		24 (6 to 48)	
Race/Ethnicity									
Non-Hispanic White	*consumer behavior*	0	43 (-13 to 140)	0	0 (-29 to 35)	0	20 (3 to 42)	0	10 (-9 to 32)
	+industry response	0	82 (16 to 192)	0	11 (-17 to 50)	0	27 (10 to 51)	0	16 (-2 to 40)
Non-Hispanic Black	*consumer behavior*	0	2 (-31 to 51)	0	9 (-7 to 30)	0	7 (-5 to 20)	0	4 (1 to 9)
	+industry response	0	17 (-16 to 75)	0	13 (-2 to 36)	0	9 (-3 to 23)	0	6 (2 to 11)
Hispanic	*consumer behavior*	0	47 (7 to 103)	0	7 (-2 to 20)	0	4 (1 to 9)	0	0 (-1 to 3)
	+industry response	0	64 (23 to 127)	0	10 (1 to 25)	0	6 (2 to 11)	0	1 (-1 to 3)
Other	*consumer behavior*	0	1 (-4 to 12)	0	0 (-2 to 3)	0	1 (0 to 2)	0	0 (-1 to 2)
	+industry response	0	2 (-1 to 16)	0	0 (-2 to 3)	0	1 (1 to 2)	0	1 (-1 to 2)
Ovarian									
Age	*consumer behavior*	45 (-3 to 114)		13 (-14 to 54)		24 (9 to 51)		21 (8 to 46)	
	+industry response	87 (19 to 175)		25 (-4 to 75)		34 (14 to 64)		28 (15 to 56)	
Race/Ethnicity									
Non-Hispanic White	*consumer behavior*	21 (-15 to 89)	0	-3 (-29 to 38)	0	15 (2 to 41)	0	19 (6 to 43)	0
	+industry response	45 (-10 to 131)	0	5 (-21 to 52)	0	22 (5 to 51)	0	25 (11 to 52)	0
Non-Hispanic Black	*consumer behavior*	7 (-3 to 27)	0	3 (0 to 11)	0	5 (2 to 11)	0	1 (-1 to 4)	0
	+industry response	13 (-1 to 38)	0	5 (1 to 13)	0	7 (3 to 13)	0	1 (0 to 5)	0
Hispanic	*consumer behavior*	15 (0 to 48)	0	6 (-1 to 16)	0	1 (-2 to 6)	0	1 (-1 to 4)	0
	+industry response	25 (2 to 64)	0	8 (2 to 20)	0	2 (-1 to 8)	0	2 (0 to 5)	0
Other	*consumer behavior*	-5 (-13 to 9)	0	5 (1 to 10)	0	2 (0 to 4)	0	0 (-1 to 1)	0
	+industry response	-1 (-9 to 15)	0	5 (2 to 11)	0	2 (1 to 4)	0	0 (0 to 1)	0

Thyroid									
Age	*consumer behavior*	9 (2 to 22)		3 (-4 to 11)		6 (3 to 12)		4 (1 to 7)	
	+industry response	16 (7 to 33)		6 (0 to 16)		9 (5 to 15)		5 (3 to 9)	
Race/Ethnicity									
Non-Hispanic White	*consumer behavior*	0 (0 to 2)	0 (-1 to 5)	0 (-1 to 1)	-2 (-7 to 5)	0 (0 to 1)	3 (0 to 8)	1 (0 to 4)	1 (-1 to 3)
	+industry response	0 (0 to 3)	1 (0 to 9)	0 (-1 to 2)	0 (-5 to 9)	1 (0 to 2)	4 (1 to 10)	2 (1 to 4)	1 (0 to 4)
Non-Hispanic Black	*consumer behavior*	1 (0 to 5)	1 (-2 to 7)	0 (0 to 1)	0 (0 to 2)	1 (0 to 2)	0 (0 to 1)	0 (0 to 1)	0 (0 to 1)
	+industry response	2 (0 to 7)	2 (-1 to 10)	0 (0 to 2)	0 (0 to 2)	1 (0 to 2)	0 (0 to 1)	0 (0 to 1)	0 (0 to 1)
Hispanic	*consumer behavior*	3 (0 to 10)	1 (0 to 9)	1 (0 to 3)	2 (0 to 5)	0 (0 to 1)	1 (0 to 2)	0 (0 to 1)	0 (0 to 1)
	+industry response	5 (1 to 14)	2 (0 to 12)	1 (0 to 4)	2 (1 to 7)	0 (0 to 1)	1 (0 to 3)	1 (0 to 2)	0 (0 to 1)
Other	*consumer behavior*	0	0 (-1 to 3)	0 (0 to 1)	0 (-1 to 1)	0 (0 to 1)	0 (0 to 1)	0	0 (0 to 1)
	+industry response	0	0 (0 to 4)	0 (0 to 1)	0 (-1 to 2)	0 (0 to 1)	0 (0 to 1)	0	0 (0 to 1)

1. Values are the median estimates (95% uncertainty intervals) of each distribution of 1000 simulations.

Supplementary Table 12. Estimated health gains and costs associated with the federal menu calorie labeling on reducing cancer burdens in the US over a lifetime, one-way sensitivity analyses at 25% and 75% calorie compensation outside restaurant settings (US population=235,162,844)[1]

	Menu Calorie Labeling Policy			
	75% Compensation		25% Compensation	
	Consumer Behavior Median (2.5% to 97.5%)	**Consumer Behavior + Industry Response** Median (2.5% to 97.5%)	**Consumer Behavior** Median (2.5% to 97.5%)	**Consumer Behavior + Industry Response** Median (2.5% to 97.5%)
New Cancer Cases Averted, N (95% UI)				
Liver cancer	2550 (265 to 5030)	4280 (2000 to 6770)	7760 (5160 to 10500)	12800 (9790 to 16000)
Endometrial cancer	2490 (-633 to 5890)	4640 (1570 to 8070)	8890 (5500 to 12700)	15100 (11800 to 19100)
Kidney cancer	2360 (65 to 4510)	4160 (1900 to 6410)	7810 (5230 to 10000)	13000 (10400 to 15300)
Breast cancer (postmenopausal)	2060 (-616 to 5280)	3930 (1260 to 7200)	7640 (4560 to 11400)	13000 (9700 to 17200)
Pancreatic cancer	638 (51 to 1280)	1140 (536 to 1800)	2140 (1490 to 2890)	3590 (2840 to 4460)
Esophageal adenocarcinoma	598 (-239 to 1400)	1100 (262 to 1930)	2130 (1200 to 3000)	3560 (2600 to 4520)
Colorectal cancer	480 (56 to 940)	851 (423 to 1330)	1600 (1060 to 2140)	2660 (2030 to 3310)
Multiple myeloma	343 (61 to 674)	576 (281 to 950)	1050 (677 to 1480)	1730 (1240 to 2340)
Stomach cancer (cardia)	312 (-42 to 736)	533 (192 to 998)	994 (555 to 1530)	1640 (1060 to 2300)
Thyroid cancer	185 (-70 to 498)	406 (128 to 749)	851 (473 to 1310)	1470 (963 to 2100)
Gallbladder cancer	165 (70 to 274)	266 (167 to 378)	468 (348 to 602)	758 (626 to 912)
Advanced prostate cancer	162 (-28 to 360)	282 (87 to 493)	519 (304 to 768)	868 (603 to 1160)
Ovarian cancer	65 (-17 to 179)	119 (26 to 245)	228 (96 to 398)	384 (196 to 617)
Total	12700 (2430 to 24200)	22600 (12400 to 34100)	42800 (30400 to 53900)	71500 (59100 to 82800)
Cancer Deaths Prevented, N (95% UI)				
Liver cancer	2200 (199 to 4450)	3750 (1720 to 5970)	6790 (4490 to 9270)	11200 (8570 to 14100)
Breast cancer (postmenopausal)	1140 (-958 to 3640)	2420 (281 to 4990)	4980 (2540 to 7860)	8670 (6030 to 12000)
Endometrial cancer	980 (-69 to 2030)	1710 (675 to 2770)	3160 (2020 to 4450)	5270 (4120 to 6630)
Kidney cancer	939 (94 to 1820)	1630 (795 to 2520)	3020 (2080 to 3930)	4990 (4020 to 6020)
Pancreatic cancer	561 (54 to 1120)	996 (473 to 1590)	1870 (1300 to 2510)	3130 (2480 to 3890)
Esophageal adenocarcinoma	503 (-224 to 1190)	932 (203 to 1640)	1820 (1010 to 2580)	3050 (2220 to 3890)
Colorectal cancer	323 (41 to 640)	571 (280 to 910)	1080 (724 to 1440)	1800 (1390 to 2240)
Stomach cancer (cardia)	264 (-32 to 623)	446 (159 to 838)	824 (454 to 1280)	1360 (887 to 1910)
Multiple myeloma	213 (45 to 411)	350 (178 to 576)	635 (419 to 897)	1040 (757 to 1370)
Gallbladder cancer	141 (60 to 234)	226 (142 to 320)	398 (300 to 512)	644 (531 to 777)
Advanced prostate cancer	80 (-12 to 179)	135 (44 to 239)	246 (144 to 373)	410 (278 to 563)
Ovarian cancer	49 (-7 to 123)	87 (26 to 170)	162 (76 to 270)	272 (155 to 415)
Thyroid cancer	11 (1 to 24)	19 (8 to 33)	34 (21 to 53)	56 (39.9 to 81.8)
Total	7760 (1280 to 13900)	13600 (7160 to 20100)	25600 (17900 to 32300)	42500 (34600 to 49600)
Life Years Gained	34700 (5070 to 66300)	62200 (32500 to 93500)	118000 (82400 to 151000)	197000 (161000 to 232000)

QALYs Gained	51400 (9690 to 95700)	90500 (49300 to 135000)	171000 (119000 to 218000)	284000 (234000 to 334000)
Changes in Health-Related Costs, Cancer Only ($, millions)[2,3]				
Healthcare (medical) cost	-693 (-1250 to -138)	-1210 (-1770 to -660)	-2270 (-2850 to -1640)	-3760 (-4360 to -3140)
Patient time cost	-47.9 (-90.0 to -11.9)	-83.6 (-126 to -47.3)	-155 (-198 to -113)	-258 (-302 to -215)
Productivity loss	-279 (-527 to -56.6)	-490 (-743 to -271)	-929 (-1170 to -673)	-1550 (-1800 to -1290)
Policy Implementation Costs ($, millions)[2,3]				
Government cost	18.5 (14.5 to 25.1)	18.5 (14.4 to 25.5)	18.5 (14.5 to 25.1)	18.5 (14.4 to 25.5)
Administration	9.07 (8.61 to 9.56)	9.09 (8.62 to 9.55)	9.07 (8.61 to 9.56)	9.09 (8.62 to 9.55)
Monitoring	9.40 (5.45 to 16.1)	9.38 (5.30 to 16.3)	9.40 (5.45 to 16.1)	9.38 (5.30 to 16.3)
Industry cost	820 (762 to 889)	1120 (1040 to 1210)	820 (762 to 889)	1120 (1040 to 1210)
Compliance	820 (762 to 889)	823 (757 to 889)	820 (762 to 889)	823 (757 to 889)
Reformulation	-------	296 (249 to 353)	-------	296 (249 to 353)
Net Costs, Cancer Only ($, millions) [2,3,4]				
Societal perspective	-174 (-1032 to 639)	-653 (-1510 to 164)	-2520 (-3390 to -1590)	-4430 (-5310 to -3510)
Healthcare perspective	-674 (-1229 to -120)	-1190 (-1750 to -639)	-2250 (-2830 to -1620)	-3740 (-4350 to -3120)
ICER (dollars/QALY)[5]				
Societal perspective	Dominant	Dominant	Dominant	Dominant
Healthcare perspective	Dominant	Dominant	Dominant	Dominant

Abbreviations: ICER, Incremental Cost-Effectiveness Ratio; QALY, quality-adjusted life years.
1. Values are the median estimates (95% uncertainty intervals) of each distribution of 1000 simulations.
2. Health-related costs were inflated to 2015 US dollars using the Personal Health Care (PHC) index. Policy intervention costs were inflated to 2015 US dollars using the Consumer Price Index. Negative costs represent savings.
3. Costs are medians from 1000 simulations so may not add up to totals.
4. Net costs were calculated as policy costs minus health-related costs from reduced cancer burden. Societal perspective includes healthcare cost, patient time costs, productivity costs, and policy implementation costs; government perspective included policy costs relevant to policy implementation and program monitoring and evaluation and medical costs.
5. ICER threshold was evaluated at $150,000/QALY. Dominant represents less costly and more effective than the “no-policy intervention” scenario.

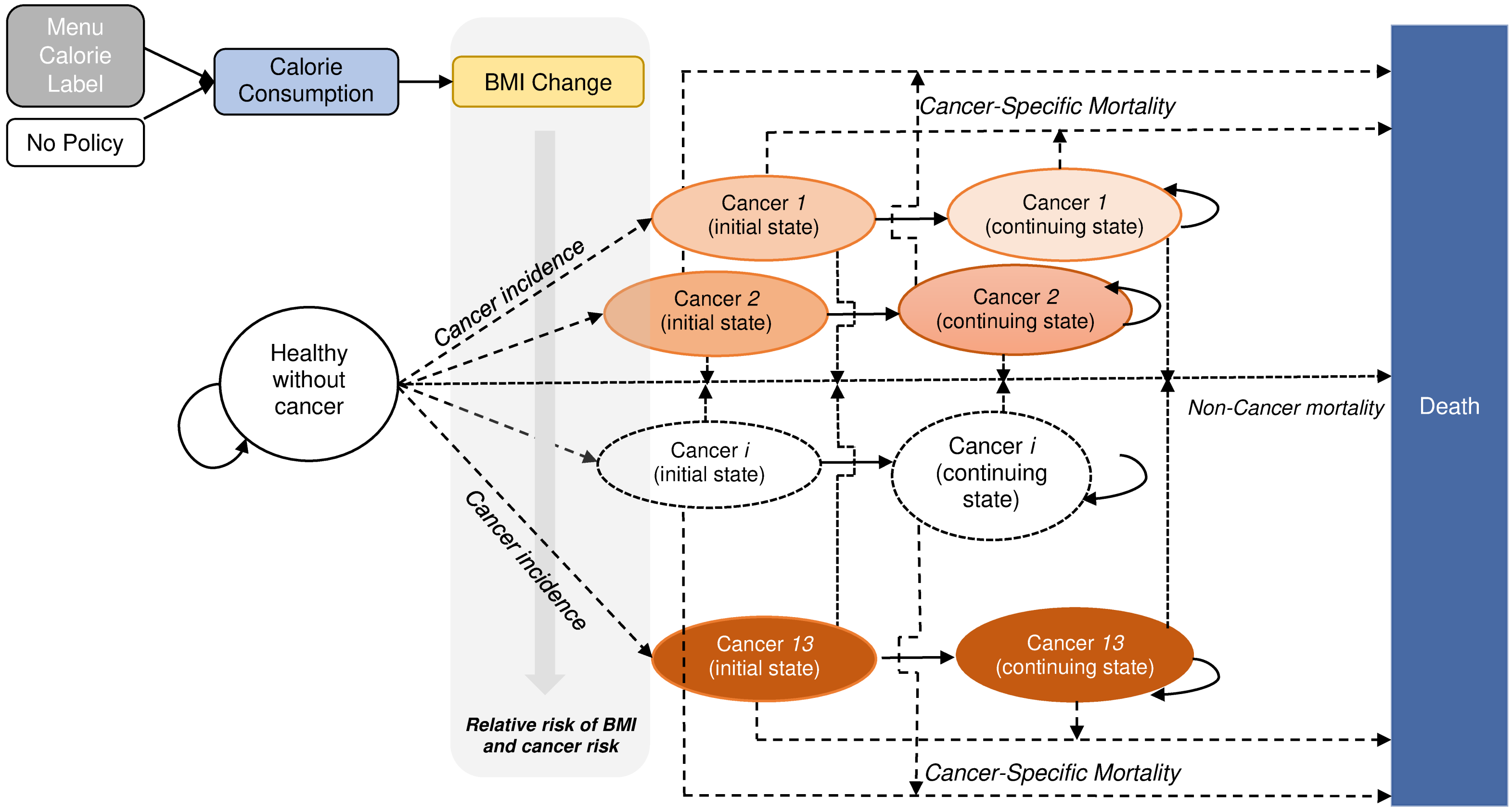
Supplementary Table 13. Estimated health gains and costs associated with the federal menu calorie labeling on reducing cancer burdens in the US over a lifetime, one-way sensitivity analysis, assuming all full-service and fast-food restaurants were covered by the policy (US population=235,162,844)[1]

	Menu Calorie Labeling Policy	
	Consumer Behavior	**Consumer Behavior + Industry Response**
	Median (2.5% to 97.5%)	Median (2.5% to 97.5%)
New Cancer Cases Averted, N (95% UI)		
Liver cancer	7280 (4690 to 10100)	11400 (8480 to 14400)
Kidney cancer	6820 (4180 to 9460)	11100 (8470 to 13700)
Endometrial cancer	5340 (1540 to 9220)	10400 (6690 to 14300)
Breast cancer (postmenopausal)	4920 (1580 to 8420)	9380 (5960 to 13100)
Esophageal adenocarcinoma	2060 (1170 to 3060)	3260 (2310 to 4330)
Pancreatic cancer	1810 (1150 to 2600)	3000 (2290 to 3870)
Colorectal cancer	1320 (772 to 1910)	2200 (1600 to 2880)
Stomach cancer (cardia)	938 (531 to 1510)	1480 (985 to 2140)
Thyroid cancer	746 (430 to 1180)	1270 (850 to 1820)
Multiple myeloma	710 (377 to 1150)	1270 (879 to 1820)
Advanced prostate cancer	430 (208 to 681)	715 (461 to 1010)
Gallbladder cancer	329 (201 to 457)	568 (435 to 708)
Ovarian cancer	133 (20.9 to 292)	263 (109 to 468)
Total	32900 (20300 to 46000)	56400 (43700 to 69300)
Cancer Deaths Prevented, N (95% UI)		
Liver cancer	6460 (4170 to 8980)	10000 (7480 to 12800)
Breast cancer (postmenopausal)	3410 (701 to 6280)	6440 (3560 to 9750)
Kidney cancer	2620 (1610 to 3620)	4250 (3210 to 5300)
Endometrial cancer	1890 (654 to 3140)	3610 (2390 to 4900)
Esophageal adenocarcinoma	1800 (1030 to 2670)	2840 (2010 to 3750)
Pancreatic cancer	1580 (976 to 2250)	2620 (1990 to 3380)
Colorectal cancer	923 (560 to 1310)	1520 (1110 to 1970)
Stomach cancer (cardia)	785 (437 to 1270)	1240 (812 to 1790)
Multiple myeloma	431 (234 to 709)	762 (524 to 1100)
Gallbladder cancer	275 (170 to 385)	479 (366 to 601)
Advanced prostate cancer	219 (117 to 351)	353 (233 to 506)
Ovarian cancer	94 (18 to 197)	185 (91 to 317)
Thyroid cancer	27 (13 to 45)	45 (28 to 68)
Total	7760 (1280 to 13900)	34400 (26800 to 42400)
Life Years Gained	97300 (62300 to 135000)	162000 (126000 to 201000)
QALYs Gained	20500 (13100 to 28500)	230000 (178000 to 287000)
Changes in Health-Related Costs, Cancer Only ($, millions)[2,3]		

Healthcare (medical) cost	-1820 (-2500 to -1180)	-3060 (-3740 to -2400)
Patient time cost	-112 (-160 to -62.7)	-197 (-245 to -148)
Productivity loss	-692 (-976 to -401)	-1210 (-1490 to -916)
Policy Implementation Costs ($, millions)[2,3]		
Government cost	18.4 (14.7 to 25.7)	18.4 (14.7 to 25.7)
Administration	9.06 (8.56 to 9.52)	9.07 (8.60 to 9.56)
Monitoring	9.32 (5.61 to 16.5)	9.37 (5.64 to 16.6)
Industry cost	821 (764 to 888)	1120 (1040 to 1200)
Compliance	821 (764 to 888)	821 (763 to 886)
Reformulation	-------	297 (248 to 350)
Net Costs, Cancer Only ($, millions) [2,3,4]		
Societal perspective	-1780 (-2790 to -831)	-1030 (-1590 to -549)
Healthcare perspective	-1800 (-2470 to -1160)	-1670 (-2120 to -1270)
ICER (dollars/QALY)[5]		
Societal perspective	Dominant	Dominant
Healthcare perspective	Dominant	Dominant

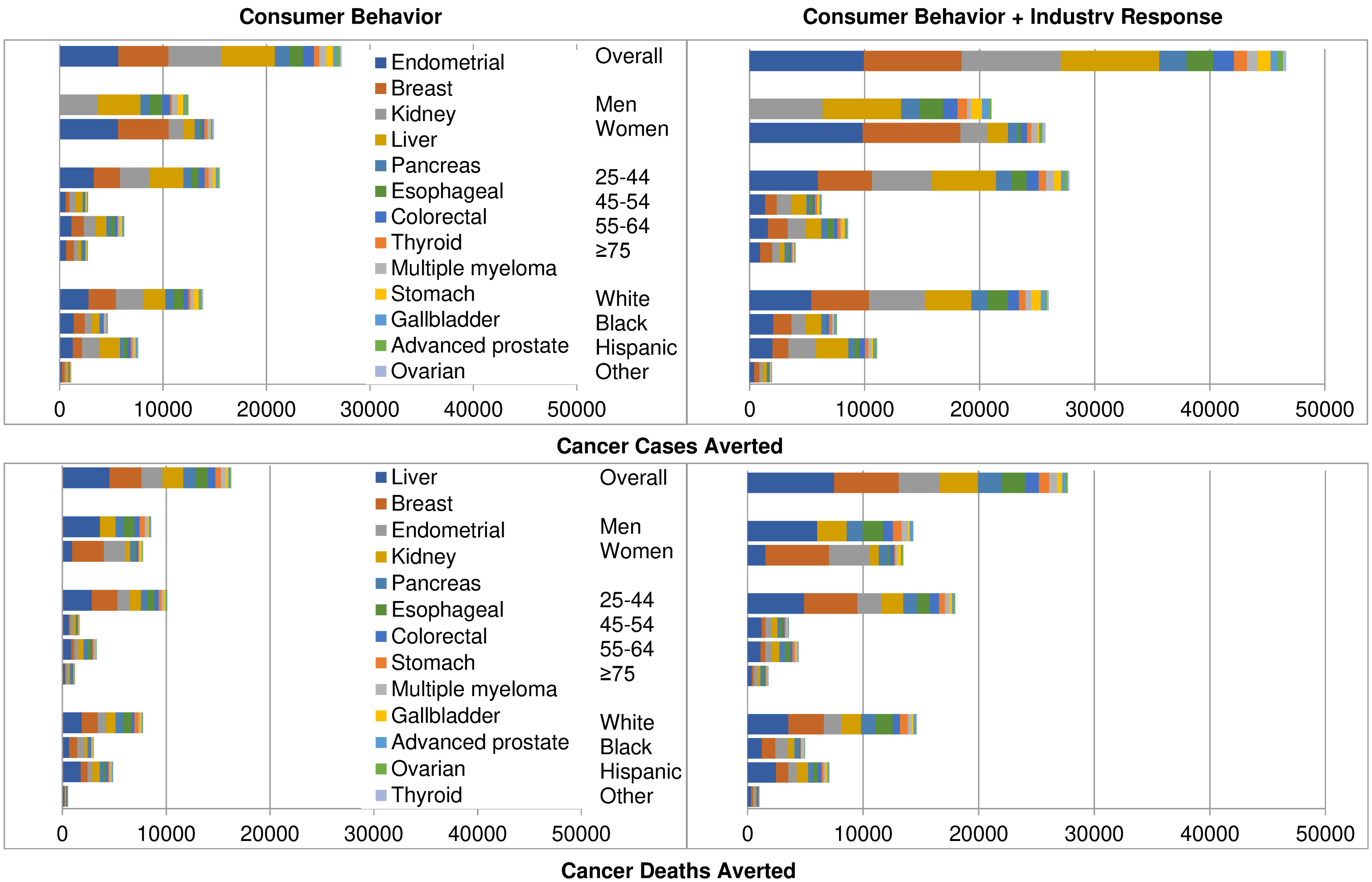
Abbreviations: ICER, Incremental Cost-Effectiveness Ratio; QALY, quality-adjusted life years.

1. Values are the median estimates (95% uncertainty intervals) of each distribution of 1000 simulations.
2. Health-related costs were inflated to 2015 US dollars using the Personal Health Care (PHC) index. Policy intervention costs were inflated to 2015 US dollars using the Consumer Price Index. Negative costs represent savings.
3. Costs are medians from 1000 simulations so may not add up to totals.
4. Net costs were calculated as policy costs minus health-related costs from reduced cancer burden. Societal perspective includes healthcare cost, patient time costs, productivity costs, and policy implementation costs; government perspective included policy costs relevant to policy implementation and program monitoring and evaluation and medical costs.
5. ICER threshold was evaluated at $150,000/QALY. Dominant represents less costly and more effective than the “no-policy intervention” scenario.

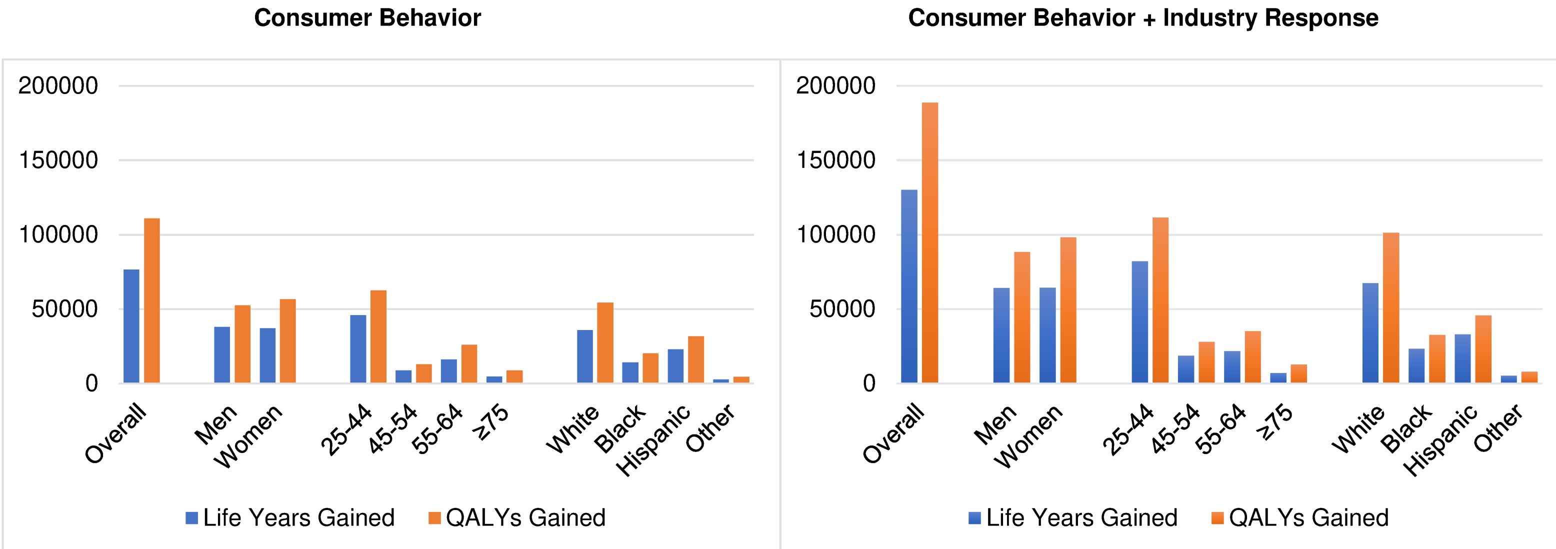


Supplementary Figure 1. Diet and Cancer Outcome Model (DiCOM)

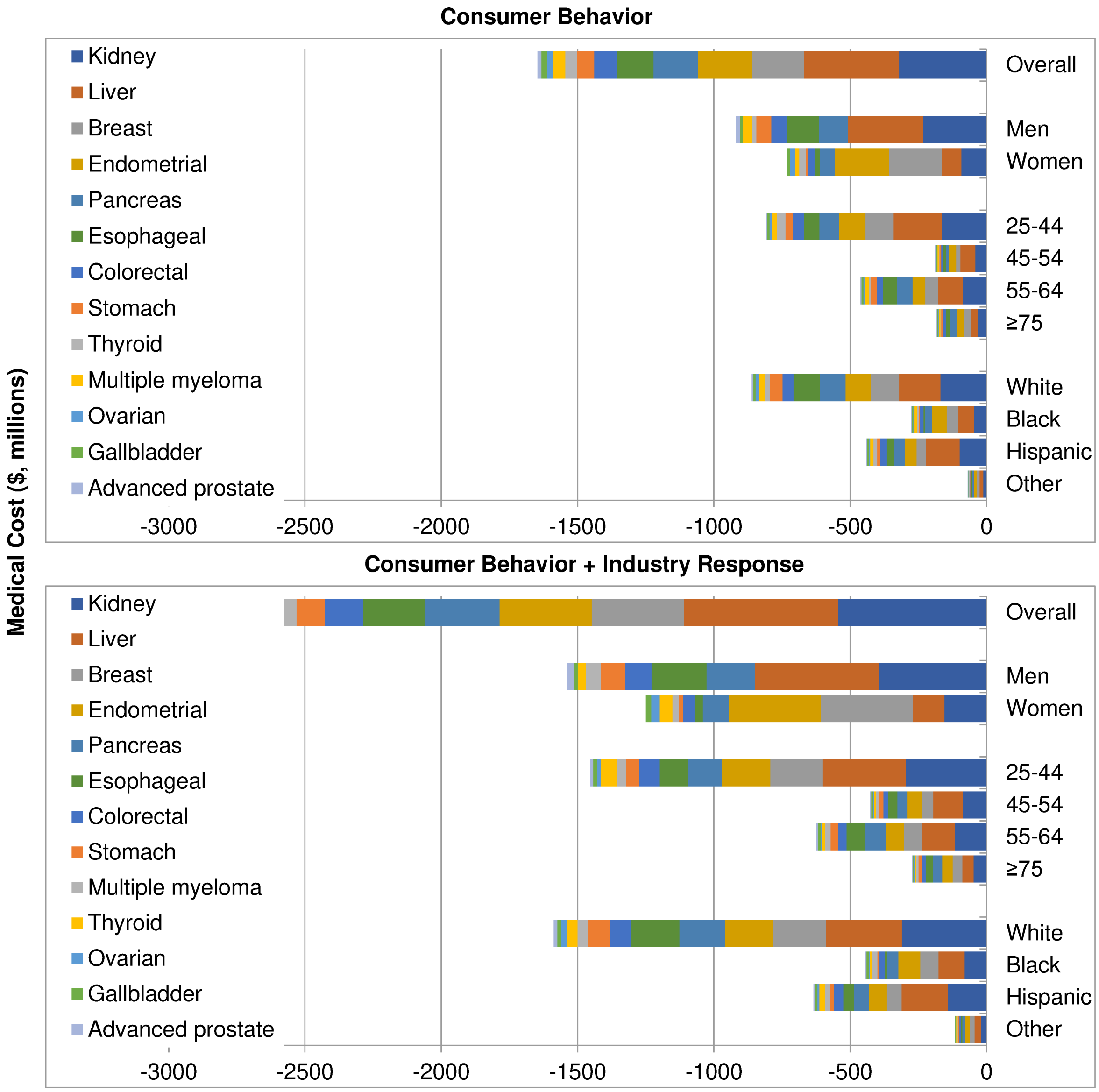
The model consists of four general health states: (a) healthy without cancer (healthy state); (b) initial cancer diagnosis (initial state) for each cancer type *i*; (c) continuing care (continuing state) for each cancer type *i*; and (d) death state. Transitions between states are based on national cancer incidence and cancer-specific mortality rates from SEER (for individual with cancer) and lifetable-based mortality rates (for individuals without cancer). The model simulates the policy impact on the number of new cases and deaths of 13 obesity-associated cancers, health-related quality of life (HRQOL), and health-related costs among U.S. adults over a lifetime by comparing a policy scenario (menu calorie label) to a non-policy scenario (status quo).



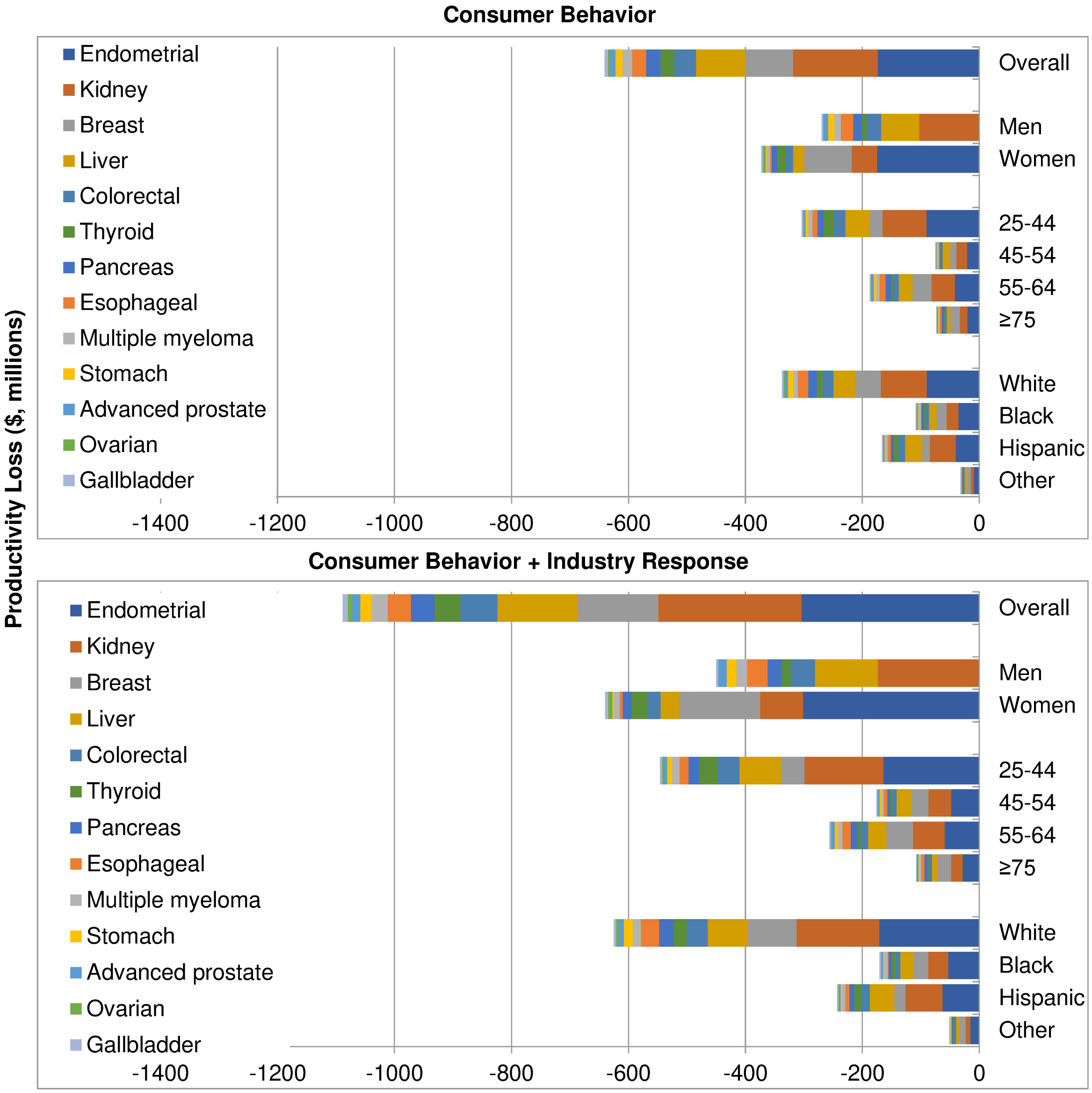
Supplementary Figure 2. Estimated reduced new cancer cases and deaths associated with the federal menu calorie labeling in the US by age, sex, race/ethnicity, and cancer type, over lifetime



Supplementary Figure 3. Estimated life years and QALYs gained associated with the federal menu calorie labeling in the US by age, sex, and race/ethnicity, over a lifetime


Consumer Behavior
Kidney
Liver
Breast
Endometrial
Pancreas
Esophageal
Colorectal
Stomach
Thyroid
Multiple myeloma
Ovarian
Gallbladder
Advanced prostate
Overall
Men
Women
25-44
45-54
55-64
≥75
White
Black
Hispanic
Other
-3000
-2500
-2000
-1500
-1000
-500
0
Medical Cost ($, millions)
Consumer Behavior + Industry Response
Kidney
Liver
Breast
Endometrial
Pancreas
Esophageal
Colorectal
Stomach
Multiple myeloma
Thyroid
Ovarian
Gallbladder
Advanced prostate
Overall
Men
Women
25-44
45-54
55-64
≥75
White
Black
Hispanic
Other
-3000
-2500
-2000
-1500
-1000
-500
0

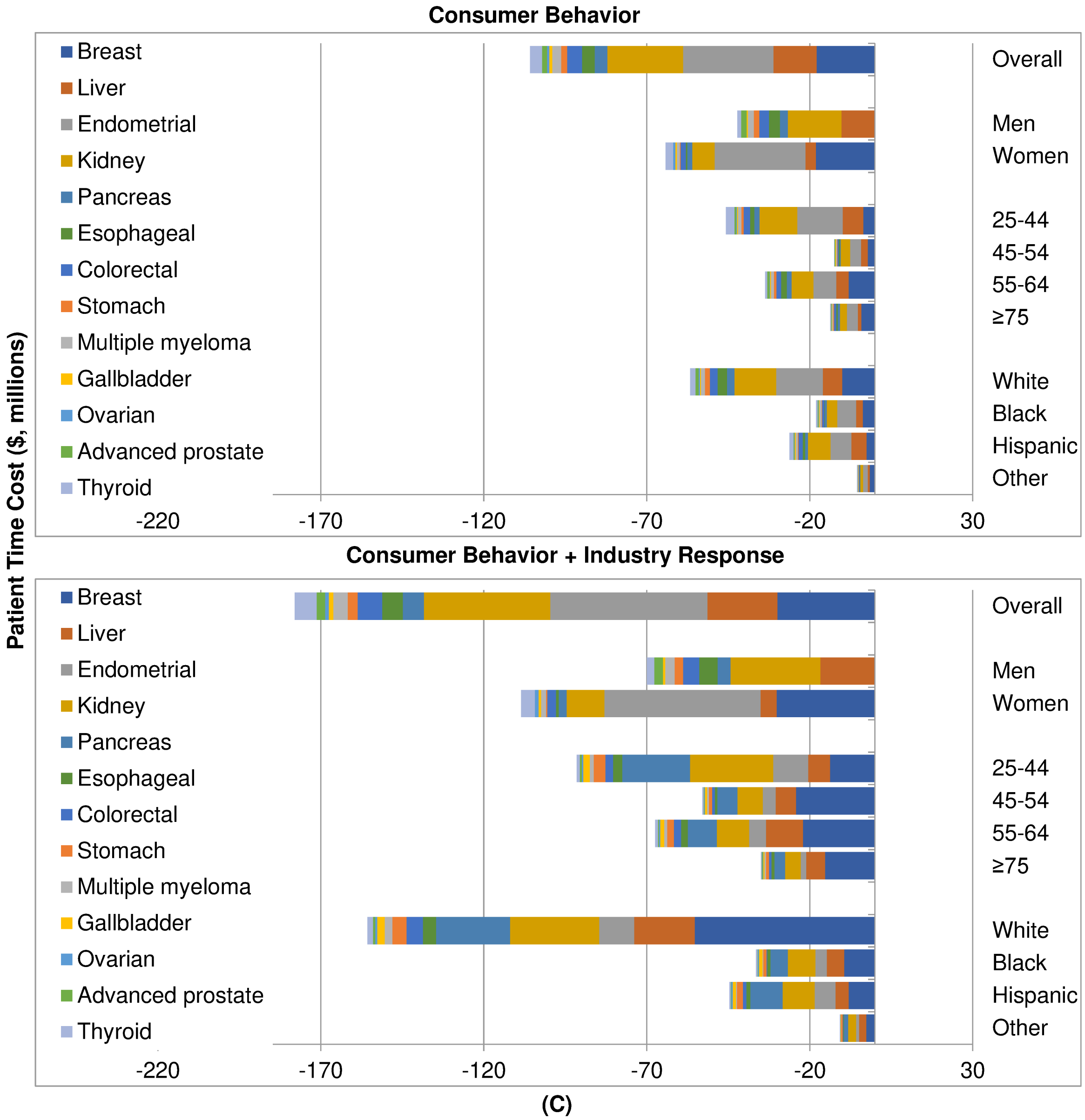
(A)



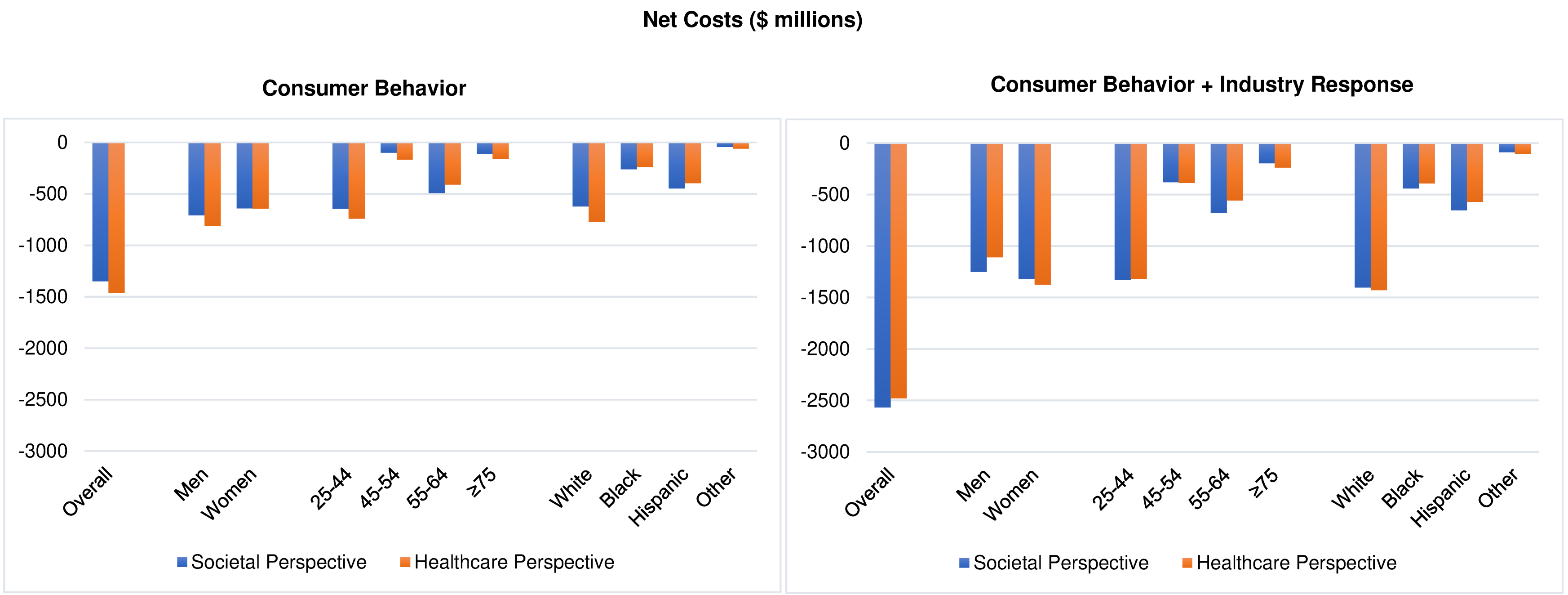
Consumer Behavior
Endometrial
Kidney
Breast
Liver
Colorectal
Thyroid
Pancreas
Esophageal
Multiple myeloma
Stomach
Advanced prostate
Ovarian
Gallbladder
Overall
Men
Women
25-44
45-54
55-64
≥75
White
Black
Hispanic
Other
-1400
-1200
-1000
-800
-600
-400
-200
0
Productivity Loss ($, millions)
Consumer Behavior + Industry Response

(B)

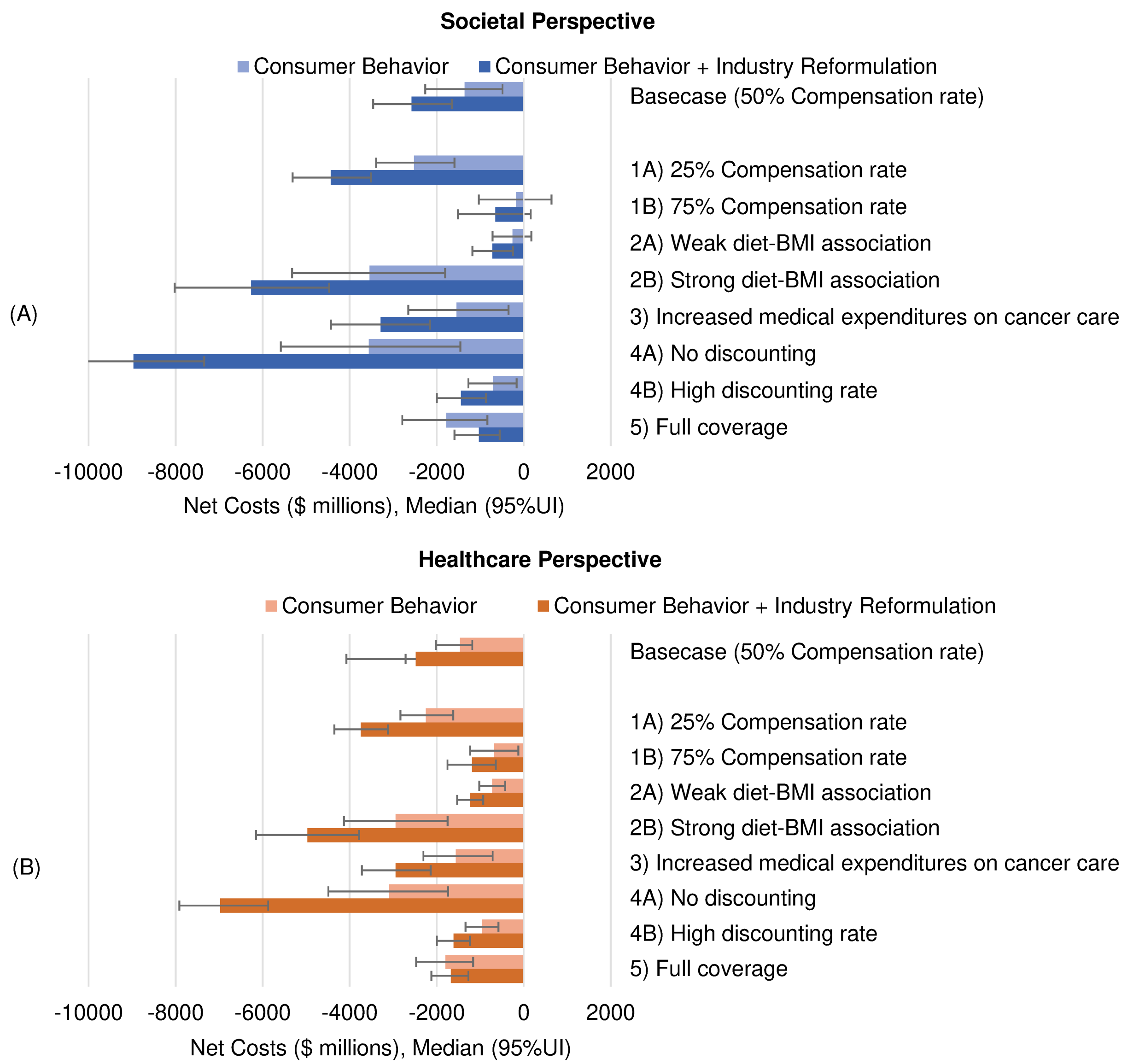
38



Supplementary Figure 4. Estimated changes of health-related costs associated with the federal menu calorie labeling in the US by age, sex, race/ethnicity, and cancer type, over lifetime



Supplementary Figure 5. Estimated net costs from societal and government perspectives associated with the federal menu calorie labeling policy in the US by age, sex, and race/ethnicity, over a lifetime



Supplementary Figure 6. One-Way Sensitivity Analysis of Net Costs of Menu Calorie Labeling and Obesity-Associated Cancer Rates by Varying Assumptions of Key Input Parameters From (A) Societal Perspective and (B) Healthcare Perspective

1a) assumed that only 25% of calorie reduction as a result of industry response would translate into long-term reductions in daily calories; 1b) assumed that only 75% of calorie reduction as a result of industry response would translate into long-term reductions in daily calories; 2a) weaker diet-BMI association assumed half of the base-case diet-BMI association; 2b) stronger diet-BMI association assumed two times of the base-case diet-BMI association; 3) 2% annual increase in medical expenditure on cancer care; 4a) lower discounting rate assumed 0% discounting rate; 4b) higher discounting rate assumed 5% discounting rate; and 5) assumed the coverage of the FDA's final rule increasing from 56.5% to 100% of the calories from full-service restaurants. Under base-case scenario (policy effect assumed consumer behavior: -7.3%, and industry reformulation: -5.0%; assumed that only 50% of calorie reduction as a result of industry response would translate into long-term reductions in daily calories; diet-BMI association assumed healthy-weight: 0.0015 kg/m^2 per kcal, and overweight/obese: 0.003 kg/m^2 per kcal; medical expenditure on cancer care assumed 0% annual increase; discounting rate assumed 3%; policy coverage would affect 56.5% of calories consumed at full-service restaurants and 100% of calories consumed at fast-food restaurants), the policy was cost-saving from both societal and healthcare perspectives. The policy remained cost-saving for all sensitivity analyses from the healthcare perspective and from societal perspective with additional industry reformulation. With consumer behavior alone, the policy was cost-saving under all scenarios.

Du M, *et al. BMJ Open* 2023; 13:e063614. doi: 10.1136/bmjopen-2022-063614

BMJ OPEN

Externally peer reviewed? Yes
Evidence type: Modelling study
Subjects: People

Menu calorie counts likely linked to lower obesity-related cancer rates and healthcare costs

Thousands of cancers and deaths potentially averted and billions of dollars saved in US
Additional food industry product reformulation could substantially boost policy impact

Specifying the number of calories for each item on restaurant menus is likely linked to lower rates of cancers associated with obesity and attendant healthcare costs in the US, suggests a modelling study, published in the open access journal ***BMJ Open.***

Thousands of cancer cases and deaths could potentially be averted and billions of dollars saved as a result of the policy, the figures indicate, prompting the researchers to suggest that additional food industry product reformulation could substantially boost its impact.

One in three Americans is obese, and obesity is an established risk factor for 13 types of cancer, note the researchers. Obesity-related cancers make up 40% of all newly diagnosed cases of the disease and 43.5% of cancer care costs.

Restaurant meals account for 1 in 5 calories consumed by US adults, and to help diners curb their calorie intake, the Affordable Care Act 2010 mandated that all chain restaurants with 20 plus outlets post calorie counts on menus and menu boards for all standard items.

Previously published research suggests that the policy would prevent a large number of cardiovascular disease and type 2 diabetes cases among US adults. But the health and economic impacts on obesity related cancers have not been evaluated.

The researchers therefore used The Diet and Cancer Outcome model (DiCOM) to estimate the impact of the policy on reducing obesity-related cancer rates and associated costs among 235 million US adults aged at least 20, over a simulated lifetime starting from 2015.

The model consists of 4 health states from healthy to death, taking account of the annual likelihood of changes in health plus the lifetime consequences of these changes on health outcomes and healthcare/societal costs, and drawing on several established national demographic, health, economic, dietary intake, and industry data sources.

US adults in 2015–16 had an average age of 48; almost two thirds were of non-Hispanic White ethnicity and 71% were overweight or obese.

Daily calorie intake from full-service or fast food restaurants averaged 332. But younger people (20–44) consumed an average of 425 calories/day, men 388, people of non-Hispanic black ethnicity 361, and those of Hispanic ethnicity 367.

Menu calorie counts were estimated to cut daily calories from restaurant food by an average of 24, and total daily calories by 12. Potential industry reformulation would reduce average intake by an additional 16 calories/day, and total calories by 8/day.

On the basis of consumer behaviour alone, the policy was associated with the prevention of 28,000 new cancer cases and 16,700 cancer deaths; 111,000 extra years of life lived in good health (QALYs); and US$1.48 billion saved in related medical costs over an average monitoring period of 34 years.

The estimates indicated the greatest numbers of new cases averted were cancers of the endometrium (womb lining) (5700), liver (5180), kidney (5090), postmenopausal breast (4840), and pancreas (1400).

The greatest numbers of cancer deaths averted were for those of the liver (4530), postmenopausal breast (3080), endometrium (2060), kidney (1980), and pancreas (1230).

The policy was associated with net savings of, respectively, US$1.46 billion and US$1.35 billion in healthcare and societal costs.

Health gains and cost savings would likely be greater for young adults and people of Hispanic and Black ethnic backgrounds, the figures suggest.

Additional food industry product reformulation could substantially increase policy impact, say the researchers, with the total estimated health gains more or less doubling, preventing 47,300 new cancer cases and 28,200 cancer deaths, and gaining 189,000 QALYs.

“Given the nature of modelling research, this study does not provide a real-world evaluation of the impact of policy implementation on health and economic outcomes,” caution the researchers.

And they acknowledge that menu calorie counts might have a greater impact on people with higher incomes and higher educational attainment.

“We modelled only the impact of menu calorie labelling on calories, although the policy may also result in potential changes in the nutritional quality of the restaurant meals,” they add.

But they conclude: “Using the best available estimates, our study further suggested that the federal menu calorie labelling policy is cost-effective in the short term and cost saving in the long term in reducing obesity-associated cancer burdens.”