

Cost Effectiveness of Nutrition Policies on Processed Meat: Implications for Cancer Burden in the U.S.



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Introduction: Processed meats are associated with increased risk of colorectal and stomach cancers, but health and economic impacts of policies to discourage processed meats are not well established. This paper aims to evaluate the cost effectiveness of implementing tax and warning labels on processed meats.

Methods: A probabilistic cohort-state transition model was developed in 2018, including lifetime and short-term horizons, healthcare, and societal perspectives, and 3% discount rates for costs and health outcomes. The model simulated 32 subgroups by age, gender, and race/ethnicity from the U.S. adult population and integrated nationally representative 2011–2014 data on processed meat consumption, with etiologic effects of processed meat consumption on cancer incidence, medical and indirect societal costs, and policy costs.

Results: Over a lifetime, the 10% excise tax would prevent 77,000 cases of colorectal cancer (95% uncertainty interval=56,800, 107,000) and 12,500 cases of stomach cancer (95% uncertainty interval=6,880, 23,900), add 593,000 quality-adjusted life years (95% uncertainty interval=419,000, 827,000), and generate net savings of \$2.7 billion from a societal perspective, including \$1.1 billion healthcare costs saved. The warning label policy would avert 85,400 cases of colorectal cancer (95% uncertainty interval=56,600, 141,000) and 15,000 cases of stomach cancer (95% uncertainty interval=6,860, 34,500), and add 660,000 quality-adjusted life years (95% uncertainty interval=418,000, 1,070,000), with net savings of \$4.5 billion from a societal perspective, including \$1.3 billion healthcare costs saved. In subgroup analyses, greater health and economic benefits accrued to (1) younger subpopulations, (2) subpopulations with greater cancer risk, and (3) those with higher baseline processed meat consumption.

Conclusions: The model shows that implementing tax or warning labels on processed meats would be a cost-saving strategy with substantial health and economic benefits. The findings should encourage policy makers to consider nutrition-related policies to reduce cancer burden.

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INTRODUCTION

Consumption of processed meats—those preserved through salting, other preservatives, or curing (e.g., ham, bacon, and sausages)—is associated with the risk of developing colorectal or stomach cancer.^{1–4} The International Agency for Research on Cancer classified processed meats as carcinogenic to humans based on the strength and consistency of evidence.^{5,6}

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Reducing the consumption of processed meats could improve population health and avoid costs associated with cancer, which accounted for \$80.2 billion in annual healthcare costs.⁷ Existing population-level policies, such as warning labels for smoking or taxes on sugar-sweetened beverages (SSBs), have been shown to be effective in altering risky behaviors.^{8–11} Although similar policies, including taxes or warning labels, have been proposed to discourage processed meat consumption,^{12,13} the potential impact of such policies has not been examined. Using a U.S. population-based cost-effectiveness model, this paper compares the projected cancer and economic outcomes of taxes and warning labels on processed meats with status quo (no policy).

METHODS

The Dietary and Cancer Outcome Model is a probabilistic state-transition cohort model that projects the population effect of nutrition policies on cancer outcomes. The model consists of the following:

1. six health states: healthy without cancer, initial treatment with colorectal cancer, continuous care with colorectal cancer, initial treatment with stomach cancer, continuous care with stomach cancer, and dead (from cancer or other causes);
2. the annual likelihood of changes in health;
3. the lifetime consequences of such changes on health outcomes and economic costs.¹⁴

The model estimated health benefits (life years, quality-adjusted life years [QALYs], cancer incidence, and years living with cancer) and economic impact (e.g., policy implementation costs, healthcare costs, and productivity benefits). [Table 1](#) and [Appendix Figure 1](#) (available online) provide input parameters and the model structure.

Following the updated reporting guidelines,¹⁵ the model assessed the incremental changes through implementing the two policies versus the status quo from healthcare and societal perspectives, along with an Impact Inventory table that listed important outcomes to be considered from both perspectives ([Appendix Table 1](#), available online). Incremental cost-effectiveness ratios were separately calculated for each policy versus the status quo. To account for input parameter uncertainty, probabilistic sensitivity analysis was performed using probability distributions for all input parameters. The results reported the 95% uncertainty intervals (UI) based on the 2.5 and 97.5 percentiles of 1,000 simulations. In the base-case analysis, the model used a lifetime horizon and discounted both costs and health outcomes at 3% per year. All analyses and model development were conducted in Stata, version 14, and R, version 3.3.1.^{16,17} The model validation and the source code are available online in [Appendix Text 1](#).

Study Population

Using the two most recent cycles (2011–2012 and 2013–2014) of the National Health and Nutrition Examination Survey (NHANES), 32 subgroups were created from four age groups (20–44, 45–54, 55–64, and >65 years), both sexes (male and female), and four race/ethnicity groups (white, non-Hispanic; black,

non-Hispanic; Hispanic; and others). All analyses estimated population-level outcomes by combining the 32 subgroup-level groups according to NHANES survey design and sampling weights.

Measures

The baseline intake of processed meats was estimated through linking the NHANES dietary data with corresponding Food Patterns Equivalents Database, which provides disaggregated information of the U.S. Department of Agriculture food code into the 37 specific food groups, including processed meats^{18,19} ([Appendix Text 2](#), available online). To simulate processed meat intake, the model applied a two-step approach:

1. using binomial distributions to select processed meat consumers;
2. then using gamma distributions to capture the skewed distribution of processed meat intake among those who consume processed meat.

A dose-response meta-analysis reported that the daily consumption of each 50 grams of processed meats is associated with an RR of 1.16 (95% CI=1.08, 1.26) for developing colorectal cancer and of 1.18 (95% CI=1.01, 1.38) for developing stomach cancer.^{2–4} The RR denotes ratio measures of effect (e.g., risk ratios, rate ratios, or ORs) and is adjusted for potential confounders, such as age, sex, smoking status, alcohol consumption, energy intake, and BMI. The association between processed meats and cancer risk incorporates the average effects of any substitution for processed meats with either healthier or nonhealthier choices.

Findings from prospective cohort studies suggested that processed meat intake was not associated with colorectal cancer incidence within the first 4 years, but the association became stronger after 4–12 years.²⁰ Thus, the base-case analysis applied a 5-year latency period between onset of reduced processed meat intake and its impact on cancer incidence. The model also assumed that reduced processed meat consumption does not confer survival benefits after developing cancer,²¹ and that the joint chance of developing both cancers simultaneously was negligible, although individuals could develop both cancers.

The U.S. Cancer Statistics, the official federal cancer statistics, provided incidence of colorectal and stomach cancers incidence for 32 subgroups.^{22,23} To account for underlying trends in cancer incidence, average annual percentage changes in age-adjusted incidence rates were estimated from 1999 to 2013, and then applied to the 2013 baseline incidence to project future incidence for each cancer site²⁴ ([Appendix Table 2](#), [Appendix Text 3](#), available online). Using 5-year relative survival data,²³ the model estimated cancer-specific excess annual mortality rates, and combined these with the age-, sex-, and race/ethnicity-stratified general population mortality data.²⁵

The three modeled policy interventions are the following:

1. status quo (no change);
2. a 10% federal excise tax;
3. a warning label informing the public that frequent consumption of processed meat may increase the risk of cancer.

Given limited data, the base-case analysis assumed that the policy effect on processed meat consumption remains constant over

Table 1. Key Input Parameters in the Dietary and Cancer Outcome Model^a

Variable	Base-case value	Uncertainty range	Distribution	Source
Baseline intake characteristics				
Proportion of meat eaters (%)	Appendix Table 6 (available online)		Binomial	NHANES
Average processed meat intake among meat eaters (g/day)	Appendix Table 6 (available online)		Gamma	NHANES
Policy intervention characteristics				
Effect size (% reduction in processed meat intake)				
10% federal excise tax	9	5–15	Beta	Dong et al., 2015 ²⁷ ; Lusk et al., 2016 ²⁸ ; Appendix Text 4 (available online)
Mandatory warning label	13	0.2–25.7	Beta	Shangguan et al., 2018 ³⁶ Appendix Text 5 (available online)
Intervention costs (\$ per year)				
10% federal excise tax	62.9 million	—	—	Appendix Text 6 (available online)
Mandatory warning label	2.44 million	—	—	Appendix Text 7 (available online)
Cancer statistics				
Incidence, colorectal and stomach cancers	Appendix Table 2 and Appendix Text 3 (available online)		Beta	USCS
Annual probability of dying from cancer ^b				
Colorectal cancer	0.091	0.069–0.115	Beta	NPCR
Stomach cancer	0.199	0.160–0.242	Beta	NPCR
Relative risk of processed meat and cancer (per 50 g/day increase in processed meat)				
Colorectal cancer	1.16	1.08–1.26	Log normal	CUP, 2017 ³
Stomach cancer	1.18	1.01–1.38	Log normal	CUP, 2016 ⁴
Health-related quality of life (HRQOL)				
Colorectal cancer				
Initial phase	0.761	0.703–0.814	Beta	Farkkila et al., 2013 ⁴⁵
Continuous phase	0.834	0.784–0.878	Beta	Farkkila et al., 2013 ⁴⁵
End-of-life phase	0.644	0.544–0.733	Beta	Farkkila et al., 2013 ⁴⁵
Stomach cancer				
Initial phase	0.839	0.762–0.901	Beta	Zhou et al., 2012 ⁴⁶
Continuous phase	0.862	0.788–0.922	Beta	Zhou et al., 2012 ⁴⁶
End-of-life phase	0.680	0.480–0.834	Beta	Zhou et al., 2012 ⁴⁶
Annual HCE, \$ ^c				
Colorectal cancer				
Initial phase, male	63,300	3,300–307,000	Gamma	Mariotto et al., 2011 ²⁴
Initial phase, female	65,800	3,800–302,000	Gamma	Mariotto et al., 2011 ²⁴
Continuous phase, male	4,800	280–21,700	Gamma	Mariotto et al., 2011 ²⁴

(continued on next page)

Table 1. Key Input Parameters in the Dietary and Cancer Outcome Model^a (continued)

Variable	Base-case value	Uncertainty range	Distribution	Source
Continuous phase, female	3,200	180–14,500	Gamma	Mariotto et al., 2011 ²⁴
End-of-life phase, male	94,800	4,600–456,000	Gamma	Mariotto et al., 2011 ²⁴
End-of-life phase, female	87,800	5,700–358,000	Gamma	Mariotto et al., 2011 ²⁴
Stomach cancer				
Initial phase, male	84,400	4,300–403,000	Gamma	Mariotto et al., 2011 ²⁴
Initial phase, female	75,400	3,900–352,000	Gamma	Mariotto et al., 2011 ²⁴
Continuous phase, male	4,600	300–20,700	Gamma	Mariotto et al., 2011 ²⁴
Continuous phase, female	4,300	210–21,400	Gamma	Mariotto et al., 2011 ²⁴
End-of-life phase, male	114,000	5,500–524,000	Gamma	Mariotto et al., 2011 ²⁴
End-of-life phase, female	109,000	6,500–485,000	Gamma	Mariotto et al., 2011 ²⁴
Background HCE, general population	Appendix Table 4 (available online)		Gamma	MEPS
End-of-life HCE, general population	40,956	26,700–59,300	Gamma	Hogan et al., 2001 ⁶⁷
Productivity loss among cancer survivors (\$ per year)				
Colorectal cancer survivors ^d	5,930	2,730	12,400	Zheng et al., 2016 ⁴²
Annual time spent on medical care (hours)				
Age <65 years				
Without cancer	13.6	8.32–19.1	Normal	Yabroff et al., 2014 ⁴³
With cancer	30.1	18.4–43.4	Normal	Yabroff et al., 2014 ⁴³
Age >65 years				
Without cancer	36.9	23.1–50.5	Normal	Yabroff et al., 2014 ⁴³
With cancer	55.0	33.0–76.1	Normal	Yabroff et al., 2014 ⁴³
Mean hourly wage (\$)	24.5			BLS

^aAll costs were expressed in 2014 U.S. Dollars.

^bAnnual probabilities of dying from specific cancer were derived from the 5-year relative survival data available from the CDC's National Program of Cancer Registries.

^cBecause the original source did not provide uncertainty estimates, the model assumed the SEs were 20% of the mean estimate to generate gamma distribution.

^dBecause no data was available for stomach cancer survivors, the model applied the productivity loss among colorectal cancer survivors to stomach cancer survivors.

BLS, Bureau of Labor Statistic; CUP, Continuous Update Project; HCE, healthcare expenditure; MEPS, Medical Expenditures Panel Survey; NHANES, National Health and Nutrition Examination Survey; USCS, United States Cancer Statistics.

time, and that it is identical across population subgroups. The reduction in the intake was converted into the relative reduction for cancer risk. [Appendix Texts 4 and 5](#) (available online) discuss the policy effect size in detail.

Federal excise taxes are applied to a variety of products in the U.S. and, in contrast to sales taxes, increase the consumers' pre-purchase price for specific items.²⁶ From the U.S.-based price elasticity estimates (changes in purchases because of cost) for deli meat products,^{27,28} a 10% excise tax would reduce processed meat intake by 9% (UI=5%, 15%), assuming 100% price pass-through to the consumer,²⁹ with a 50% pass-through examined in sensitivity analysis.³⁰

The cost of implementing the processed meat tax was estimated to be 2% of the tax revenue, assuming equal burdens on government administration and industry compliance.^{31–33} Tax revenues were calculated from post-intervention national expenditure data on processed meat consumption, including at-home and away-from-home food purchase data^{34,35} ([Appendix Text 6](#), available online).

The warning label policy was modeled as a government warning label on the consumer-facing packaging of all retail processed meat products. A recent meta-analysis showed that food labeling on unhealthy foods (e.g., SSBs and foods higher in saturated fat) would lead to a 13.0% (UI=0.2%, 25.7%) relative reduction,³⁶ similar to the effect sizes of warning labels on cigarettes.^{37,38}

The warning label intervention costs included the costs of industry labeling production and government oversight. Using the Food and Drug Administration Labeling model, which is designed to estimate the cost of label changes for various Food and Drug Administration–regulated products, the industry costs were derived by multiplying a unit cost per universal product code with the number of universal product codes for meat-frozen and meat/poultry-canned.³⁹ Government costs were added as an additional 25% of industry labeling costs based on prior literature⁴⁰ ([Appendix Text 7](#), available online).

Healthcare expenditures were based on the following:

1. annual costs of cancer care for initial (with treatment), continuous, and end-of-life phases²⁴;
2. background medical spending among individuals without cancer.

This was based on nationally representative 2013–2014 Medical Expenditure Panel Survey data ([Appendix Table 4](#), available online).⁴¹ Non-healthcare costs among cancer survivors included productivity loss⁴² and time costs for treatment.⁴³ All costs were expressed in 2014 U.S. dollars and the Personal Health Care index was used to adjust total medical expenditures for inflation.⁴⁴ Health-related quality of life weights for patients with colorectal or stomach cancer reflected three different phases of cancer care^{45,46} and, for methodologic consistency, had all been assessed with the three-level EQ-5D, a preference-based, multi-attribute utility instrument.⁴⁷

Secondary Analysis

Scenario analyses were conducted to examine the potential impact of a set of different modeling choices and assumptions. The plausible alternative values were chosen, as they are likely to occur as a set of parameters in each scenario. Under a conservative scenario, the model applied a 10-year (rather than 5-year) latency period

while simultaneously lowering the impact of the 10% tax on processed meat intake to a 3% (95% UI=1%, 5%) reduction, from 9% (95% UI=5%, 15%), based on the price elasticity of fast-food intake.⁴⁸ Similarly, the effect of the warning label policy was reduced to 4% (95% UI=2%, 8%), from 13% (95% UI=0.2%, 25.7%).⁴⁹ Under an optimistic scenario, the model assumed that background colorectal and stomach cancer incidence in 2013 remained constant over time and applied a larger effect size of both policies, such as 13% (95% UI=10%, 15%) for the tax and 20% (95% UI=15%, 25%) for the warning label, applying evidence from different studies.^{28,37,50}

The population impact of the two nutrition policies was analyzed for each of the 32 subgroups using subpopulation size estimates from NHANES. Additional sensitivity analyses were conducted to examine the effect of the following:

1. shorter analytic time horizons of 10, 15, and 25 years for policy makers interested in near-term return on investment durations;
2. different discounting rates of 0% and 5% (instead of 3%);
3. 50% pass-through of the tax burden (instead of 100% pass-through).

RESULTS

From 2011 to 2014, the overall U.S. adult population (249.4 million) consumed an average of 42.0 grams of processed meat daily. Male Americans consistently consumed more than their female counterparts across all age groups, and Hispanic male Americans aged 45–54 years had the highest mean consumption (86.4 grams, SE=7.86) among the 32 subgroups. About one-third of U.S. adults (34.6%) reported no processed meat intake. The prevalence of no consumption was lowest in black, non-Hispanic male Americans (22.6%) and white, non-Hispanic male Americans (25.1%). Among the 163 million adult processed meat consumers (65.4% of 250 million U.S. adults), mean daily consumption was 64.2 grams. Among the 163 million American adults who consume processed meats, the 10% excise tax and warning label policy would decrease the mean daily processed meat intake by 6.1 grams (SE=0.5) and 8.5 grams (SE=0.5) per person, respectively ([Appendix Tables 5 and 6](#), available online).

Over the population's lifetime, the model estimated that a 10% excise tax would prevent 77,000 (95% UI=56,800, 107,000) cases of colorectal cancer and 12,500 (95% UI=6,880, 23,900) cases of stomach cancer, leading to 778,000 (95% UI=533,000, 1,100,000) fewer person-years with colorectal cancer and 593,000 (95% UI=419,000, 827,000) additional QALYs gained. Similarly, the warning label policy was estimated to avert 85,400 (95% UI=56,600, 141,000) incident cases of colorectal cancer and 15,000 (95% UI=6,860, 34,500) of stomach cancer, while adding 660,000 (95% UI=418,000, 1,070,000) QALYs ([Table 2](#)).

From the average annual processed meat expenditure of \$125.96 per person with a 10% tax, the

expected tax revenue was \$12.60 per person, yielding an annual tax administration cost (2% of tax revenue) of 25.2 cents per person. Applying 25.2 cents to the size of the U.S. adult population in 2016,⁵¹ the tax policy intervention costs were \$62.9 million per year. A mandated warning label would cost \$1.95 million annually to the industry for a major label change to all processed meat products and \$0.49 million per year (25% of the industry labeling costs) to the government for regulatory oversight. Assuming 30 years as the effective period for both policies, the net present value of the policy intervention costs with a 3% annual discount rate was \$1.3 billion for the tax and \$50.3 million for the warning label.

A 10% excise tax on processed meats would save \$1.14 billion (95% UI= -1.90, 7.10) in healthcare costs and generate an additional \$2.89 billion savings (95% UI=1.08, 6.26) from non-healthcare costs (i.e., time costs and productivity effects). After accounting for \$1.3 billion of policy intervention costs over the next 30 years, the excise tax was cost saving (i.e., reducing costs and extending QALYs), with lifetime net savings of \$2.70 billion from a societal perspective, including \$1.1 billion healthcare costs saved. From a healthcare sector perspective, the 10% excise tax was still considered extremely cost-effective with an incremental cost-effectiveness ratio of \$270 per QALY gained.

Similarly, the warning label policy would save \$1.31 billion (95% UI= -2.28, 8.21) in healthcare costs and \$3.26 billion (95% UI=1.04, 7.55) in non-healthcare costs. Considering \$50.3 million in warning label costs over the next 30 years, this policy could generate net savings of \$1.26 billion and \$4.52 billion from healthcare and societal perspectives.

Under conservative scenarios, both the excise tax and warning label policies remained cost saving or highly cost-effective from both perspectives. For example, the excise tax still prevented 61,900 (95% UI=56,800, 70,000) incident cases of colorectal cancer and 8,380 (95% UI=6,880, 11,600) incident cases of stomach cancer, added 472,000 (95% UI=419,000, 531,000) QALYs, and saved \$1.85 billion from a societal perspective.

Not surprisingly, under optimistic scenarios, health benefits and cost savings for both policies increased. For example, the warning label policy would avert 108,000 (95% UI=56,600, 171,000) colorectal cancer and 20,700 (95% UI=6,860, 44,900) stomach cancer cases and add 899,000 (95% UI=418,000, 1,440,000) QALYs, with healthcare savings of \$1.49 billion and societal savings of \$5.74 billion (Figure 1, Appendix Table 7, available online).

Both policies remained cost saving across all 32 population subgroups. Larger health and economic benefits were seen among the following:

1. younger subpopulations, because of a longer exposure time for accruing the benefits of nutrition policy changes;
2. subpopulations with greater cancer burdens (e.g., black, non-Hispanic men);
3. those with higher baseline processed meat consumption (e.g., Hispanic men aged 45–54 years; Appendix Table 8A and B, available online).

When examining alternative analytic time horizons, even for a 10-year time horizon (rather than lifetime), both policies remained cost saving from both perspectives, compared with the status quo (Figure 2). For example, over 10 years, the tax policy would produce 44,900 (95% UI=36,800, 54,400) QALYs gained while saving \$1.22 billion and \$1.86 billion from healthcare and societal perspectives, respectively (Appendix Table 9, available online). A 5% discount rate (instead of 3%) reduced the magnitude of health benefits and economic savings but did not change the conclusions (Appendix Table 10, available online). Under the assumption of 50% pass-through of the tax burden to consumers, the impact of reduced intake is halved. Although the lifetime impact of reduced cancer burden and cost effectiveness was attenuated, the tax policy remained a cost-saving strategy from a societal perspective (Appendix Text 8, available online).

DISCUSSION

Considering policy costs, health gains, and healthcare and indirect savings, the model suggests that either a 10% excise tax or a warning label on processed meats would prevent substantial numbers of cancer cases and be cost saving, with robust results in scenario and sensitivity analyses. Among the two proposed policies, the model estimated that the warning label could provide similar health and economic benefits with lower intervention costs than the tax policy, although the impact of the warning label policy was less confident because of greater uncertainty in the effect size. Nonetheless, both policies would lead to substantial health gains and cost savings. The tax policy would also generate substantial government revenue (not accounted for in the analyses) that could be used for other health promotion programs.

Valuing a year of life in perfect health as \$100,000 (\$100,000/QALY) and using a societal perspective,^{52–54} the lifetime net monetary benefits (i.e., differences between the monetized value of QALYs and the associated costs) of implementing the excise tax would be \$597 billion, and that of implementing the warning label, \$664 billion. Our findings are consistent with recent findings that

Table 2. Base-Case Results^a: Lifetime Consequences for Nutrition Policies to Reduce Processed Meat Intake (All U.S. Adult Population, 250 Million)

Policy intervention	Overall health outcomes					Cancer-specific outcomes					Costs, 2014 U.S. \$, in millions			ICER, \$ per QALY	
	Life years	QALYs	CRC cases	CRC deaths	CRC PYs	SC cases	SC deaths	SC PYs	Intervention costs ^b	Healthcare costs	Time costs	Productivity effects	Healthcare sector perspective	Societal perspective ^c	
Policy scenario 1: 1.10% excise tax															
Incremental effects vs status quo	497,000	593,000	-77,000	-55,000	-778,000	-12,500	-11,100	-57,900	1,300	-1,140	-192	-2,700	270	Cost-saving	
Policy scenario 2: warning label															
Incremental effects vs status quo	(348,000, 694,000)	(419,000, 827,000)	(-107,000, -56,800)	(-77,100, -39,500)	(-1,100,000, -533,000)	(-23,900, -6,880)	(-21,000, -5,980)	(-116,000, -26,500)	N/A	(-7,100, 1,900)	(-490, 0)	(-5,770, -1,080)			
Incremental effects vs status quo	553,000	660,000	-85,400	-61,300	-865,000	-15,000	-13,200	-69,400	50.3	-1,310	-213	-3,040	Cost-saving	Cost-saving	
(2.5 percentile, 97.5 percentile)	(346,000, 898,000)	(418,000, 1,070,000)	(-141,000, -56,600)	(-100,000, -39,300)	(-1,440,000, -531,000)	(-34,500, -6,860)	(-30,300, -5,930)	(-167,000, -26,200)	N/A	(-8,210, 2,280)	(-613, 38.9)	(-6,930, -1,080)			

^aThe base-case analysis assumed a lifetime horizon and discounted future costs, life years and QALYs at 3% per year. The results reported the mean estimates with 95% uncertainty interval. ^bPolicy intervention costs represented the net present value over 30 years of the effective period with a 3% discount rate. The impact of nutrition policies was assumed one-time effect that would last at the reduced processed meat intake.

^cA societal perspective included healthcare costs, time costs associated with receiving medical care, and productivity effects.

CRC, colorectal cancer; ICER, incremental cost-effectiveness ratio; LY, life year; PY, person-year; QALY, quality-adjusted life year; SC, stomach cancer.

population-based strategies to target dietary consumption are cost saving.^{55–57}

Despite population-based approaches, particular subgroups with greater cancer burdens or higher baseline intake of processed meat (e.g., black, non-Hispanic men and Hispanic men aged 45–54 years) can benefit more from these policies. With relatively higher cancer burden in these populations, the proposed policies could reduce health disparities. However, the health and economic consequences of an excise tax or warning label for processed meat products may also affect socioeconomic subgroups differently. For instance, a tax may produce more substantial reductions in consumption among lower-income individuals, whereas a warning label may produce greater reductions among more educated individuals.^{28,58,59} Although such effects would be unlikely to alter the overall findings or inference for these national policies, further study on its impact on disparities would be important.

Both excise taxes and warning labels on unhealthy food products are legally feasible.^{26,60} Although the study did not aim to evaluate political feasibility, policy efforts to discourage the consumption of harmful foods have been accelerating in the U.S. (SSB taxes in multiple cities⁶¹ and sodium warnings on New York City restaurant menus⁶²) and globally (SSB and junk food taxes,^{63,64} and Chile’s Black Box warning labels on packaged foods⁶⁵). Recently, policymakers have begun to focus on processed meats; for example, members of the New York City Council recently proposed banning processed meats in all public schools, which would influence up to one million meals served to children each day.⁶⁶ The study findings add further insights to inform such ongoing policy discussions.

Limitations

Potential limitations include the following: simulation modeling forecasts the likely health benefits and cost effects from the existing data, and findings depend on the underlying validity of key estimates. For example, the effect of a policy on changing processed meat consumption and the etiologic effects of processed meat consumption on cancer are each estimated based on best available data with uncertainty. Thus, the findings should be considered the best available estimates of potential effects, as well as uncertainty in these effects, for policymakers to consider and help inform nutrition-related health policies and their evaluation to reduce cancer.

Aside from general population mortality, additional competing mortality risks were not explicitly modeled. Because processed meat consumption may be associated with other chronic disease risk factors that affect mortality and that are changing over time (e.g., increasing obesity or decreasing smoking), not accounting for these competing

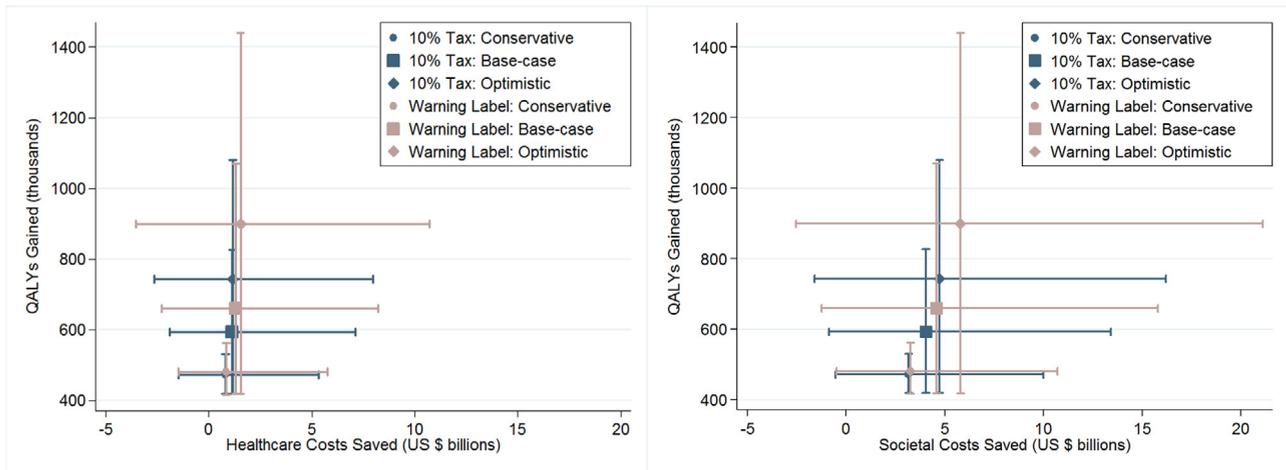


Figure 1. Impact of Nutrition Policies Under Different Scenarios.

Note: Under the scenario analyses, three modeling choices were varied: (1) the latency period, (2) approaches to project secular trends in cancer incidence, and (3) the policy effect size. For the 10% tax policy, (1) the conservative scenario: 3% effect size (uncertain range: 1%–5%), a 10-year latency period, and a historical trend from 1999 to 2013; (2) the base-case scenario: 9% effect size (5%–15%), a 5-year latency period, and a historical trend from 1999 to 2013; and (3) the optimistic scenario: 13% effect size (10%–15%), no latency period, and a constant trend as of 2013. For the warning label policy, (1) the conservative scenario: 4% effect size (2%–8%), a 10-year latency period, and a historical trend from 1999 to 2013; (2) the base-case scenario: 12.5% effect size (2%–23%), a 5-year latency period, and a historical trend from 1999 to 2013; and (3) the optimistic scenario: 20% effect size (15%–25%), no latency period, and a constant trend as of 2013. From a societal perspective, societal costs included savings from both healthcare costs and nonhealthcare costs, including time costs associated with receiving medical care and productivity. Appendix Table 7 (available online) provides full results of the scenario analyses.

QALY, quality-adjusted life year.

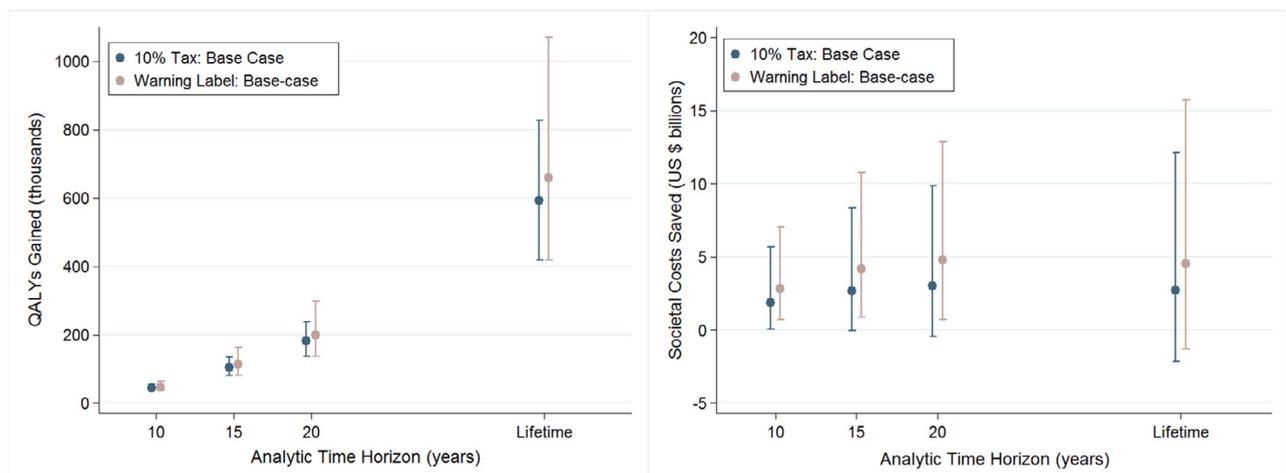


Figure 2. Impact of Analytic Time Horizons on Cost Effectiveness of Nutrition Policies.

Note: Even for a 10-year time horizon (rather than lifetime), both policies were net cost-saving from healthcare and societal perspectives, compared with the status quo. Appendix Table 9 (available online) provides full results from the sensitivity analysis of the analytic time horizon.

QALY, quality-adjusted life year.

risks may under- or over-estimate the number of cancer cases avoided, but quantifying and incorporating these effects into the model would be difficult. Also, the policy effect sizes were not derived from actual implementations for processed meats but derived from existing effects from taxes on SSBs and warning labels for smoking.

CONCLUSIONS

The model shows that implementing a population-wide excise tax or warning label on processed meats could meaningfully reduce the incidence of colorectal and stomach cancers, with net cost savings from a societal perspective. With the growing interest in and demand

for policy interventions on unhealthy foods, it is important to understand the potential health and fiscal impact of population-based nutrition policies.

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SUPPLEMENTAL MATERIAL

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