BMI and Healthcare Cost Impact of Eliminating Tax Subsidy for Advertising Unhealthy Food to Youth

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Introduction: Food and beverage TV advertising contributes to childhood obesity. The current tax treatment of advertising as an ordinary business expense in the U.S. subsidizes marketing of nutritionally poor foods and beverages to children. This study models the effect of a national intervention that eliminates the tax subsidy of advertising nutritionally poor foods and beverages on TV to children aged 2–19 years.

Methods: We adapted and modified the Assessing Cost Effectiveness framework and methods to create the Childhood Obesity Intervention Cost Effectiveness Study model to simulate the impact of the intervention over the 2015–2025 period for the U.S. population, including short-term effects on BMI and 10-year healthcare expenditures. We simulated uncertainty intervals (UIs) using probabilistic sensitivity analysis and discounted outcomes at 3% annually. Data were analyzed in 2014.

Results: We estimated the intervention would reduce an aggregate 2.13 million (95% UI=0.83 million, 3.52 million) BMI units in the population and would cost $1.16 per BMI unit reduced (95% UI=$0.51, $2.63). From 2015 to 2025, the intervention would result in $352 million (95% UI=$138 million, $581 million) in healthcare cost savings and gain 4,538 (95% UI=1,752, 7,489) quality-adjusted life-years.

Conclusions: Eliminating the tax subsidy of TV advertising costs for nutritionally poor foods and beverages advertised to children and adolescents would likely be a cost-saving strategy to reduce childhood obesity and related healthcare expenditures.

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Introduction

Children and adolescents view thousands of food-related TV ads each year.[1] These ads include extensive promotion of nutritionally poor foods and beverages that are high in calories; contain significant amounts of sodium, saturated fat, and added sugars; and are low in nutrients.[2–4] In 2009, food marketers spent $633 million on youth-directed TV in the U.S.[5] Despite changes in TV viewing platforms and advertising expenditures, TV remains the predominant medium to reach youth, accounting for 35% of total youth-directed expenditures.[5] Children are particularly vulnerable to persuasive messages because of their inability to identify persuasive intent,[6] and exposure to TV food

advertising is associated with increased consumption of nutritionally poor foods among both children and adolescents.[7–10]

There are numerous long-term risks associated with TV viewing and advertising exposure in childhood,[11] and the association between TV viewing and BMI has been extensively studied over the past 30 years.[12] Following a systematic evidence review including 49 studies, the *Guide to Community Preventive Services*[13] recommended behavioral interventions to reduce recreational sedentary screen time among children, finding evidence for significant reductions in BMI and obesity prevalence. Two other recent meta-analyses[14,15] reached the same conclusion, as did a systematic review[16] among very young children. Current evidence indicates that the relationship between TV and BMI is driven by increased energy intake,[7,17–20] and specifically commercial TV viewing.[21] Accordingly, the American Academy of Pediatrics[22] reported that there is sufficient evidence to warrant a ban on junk food or fast food advertising in children's TV programming in order to reduce childhood obesity and improve children's nutrition.

Past attempts to regulate food advertising to children in the U.S. have been unsuccessful.[23,24] The industry promotes its Children's Food and Beverage Advertising Initiative (CFBAI) as an alternative to voluntary federal standards. Although 17 companies participate in CFBAI pledges, the weak nutrition standards used allow companies to continue marketing foods of poor nutritional quality.[25] Further, participation in the CFBAI is voluntary and CFBAI pledges do not limit food marketing to adolescents.[26] Evaluations of CFBAI's effectiveness have demonstrated minimal to moderate improvement.[4,25–33] As currently practiced, the CFBAI is not sufficient to address food marketing to children.[25]

In light of the limited effectiveness of self-regulation, the U.S. Constitution's protection of marketing as commercial speech, and the reluctance of the current U.S. government to regulate even minimal restrictions on advertising,[6,34] alternative regulatory approaches have been considered. Tax incentives and disincentives are known to be powerful tools for promoting the health and well-being of the population.[35] Accordingly, eliminating[36] or amending[37] the tax deduction available to food companies for the costs of advertising to children has been proposed. Currently, the Federal Income Tax Code allows advertising costs to be deducted as an ordinary business expense in the immediate year incurred for tax purposes.[37] Assuming an average effective federal tax rate paid by corporations of 12.6%[36,38] the U.S. Government provides the food and beverage industry an annual tax subsidy of nearly $80 million for the $633 million spent on youth-directed TV advertising. By changing the tax treatment of advertising nutritionally poor foods to children and adolescents, the food industry will have less incentive to advertise obesogenic foods and beverages to children and adolescents.[37] In May 2014, Senators Blumenthal and Harkin introduced Senate Bill 2342, which would amend the Internal Revenue Code to remove the deductibility of expenses related to advertising food of poor nutritional quality to children.[39] Similar proposals have been introduced in Congress, including a bill proposed in the 113th Congress by Representative Rosa DeLauro (H.R. 2831).[40]

The purpose of this study is to estimate the impact on BMI and cost effectiveness of an intervention that eliminates the tax deduction available for advertising nutritionally poor foods and beverages to children and adolescents on TV. The policy, political, and ethical implications of the economic evaluation are systematically situated within the broader debate in the U.S. over policy approaches to curb the obesity epidemic.

Methods

The Intervention

The intervention involves the elimination of the tax subsidy of TV advertising costs for nutritionally poor foods and beverages advertised to children and adolescents. The intervention would apply to TV programming watched on traditional TV and to TV advertising aired during children's programming defined as >35% child-audience share.[41] Ads seen on children's programming account for >40% of total exposure to food and beverage TV advertising for children aged 2–11 years.[4] We did not model the effect of changes in advertising exposure to adults or the impact of changes in non-TV forms of digital advertising and marketing.

Current Practice

The comparator for the study was current practice. Currently, food and beverage advertising is considered an ordinary business expense that reduces taxable corporate income. Although the Children's Television Act of 1990 limits advertising during children's programs to 10.5 minutes/hour on weekends and 12 minutes/hour on weekdays, exposure to food and beverage advertising by children and adolescents remains high. Recent estimates indicate that preschoolers aged 2–5 years see 11.9 food-related ads/day, children aged 6–11 years see 13.4 food-related ads per day, and adolescents aged 12–17 years see 16.2 food-related ads per day.[1]

Modeling Framework

Researchers from the Harvard School of Public Health, Columbia Mailman School of Public Health, Deakin University, and University of Queensland in Australia adapted and modified the Australian Assessing Cost Effectiveness (ACE)[42–45] methodologies using U.S. data, and incorporating reporting recommendations from the U.S. Panel on Cost-Effectiveness in Health and Medicine,[46] to create the Childhood Obesity Intervention Cost Effectiveness Study (CHOICES) model. We modified the ACE

approach by focusing on short-term BMI change and 10-year BMI-related outcomes instead of lifetime outcomes, given concerns about assuming lifetime maintenance of childhood intervention effects.[43,47,48] Health gains expected from the intervention, including changes in BMI, reductions in disease burden and healthcare expenditures, and quality-adjusted life-years (QALYs) gained over 10 years, were estimated using a Markov cohort model. The model also estimated differences in healthcare expenditures with and without the intervention based on differences in healthcare costs for children and adults with and without obesity. These healthcare costs were based on analyses of the Medical Expenditure Panel Survey and are reported as net present value discounted at 3% per year.[49] We calculated the impact of the intervention on QALYs among adults aged ≥18 years based on analysis of Medical Expenditure Panel Survey data.[50] Additional details on the modeling framework are described in an accompanying paper in this theme issue.[51] Data were analyzed in 2014.

Implementation and Equity Considerations

In addition to estimating quantitative effects of the proposed intervention, key implementation and equity considerations relevant to policymakers and consumers were qualitatively evaluated.[45] A working group of stakeholders (which included attorneys, public health practitioners, epidemiologists, child health policy specialists, business experts, and economists) evaluated the intervention against a series of implementation considerations, including strength of evidence, equity, acceptability to stakeholders, sustainability, feasibility, potential for side effects, and social and policy norms.

Assessment of Benefit

Ideal evidence would consist of RCTs of a change in the tax policy that reduced children's exposure to TV advertising and documented the impact on change in measured BMI. We have not identified any such RCTs. However, the *Guide to Community Preventive Services*[13] conducted a systematic review of 49 studies and found significant evidence for effects of interventions that limit screen time on reductions in children's BMI and prevalence of obesity. Because daily TV viewing is directly related to advertising exposure (the number of ads seen per day),[36] we used daily hours of TV viewed as our measure of food advertising exposure in the analyses. We developed a logic model (Figure 1) showing how the policy change reduced advertising time (measured by TV time) and this change in turn reduced BMI (via changes in energy balance).

In calculating the impact of the intervention, we assumed an effective corporate income tax rate of 12.6%.[38] A national analysis of TV advertising and childhood obesity estimated the price elasticity of demand for TV advertising of 0.74 for ages 2–9 years and 0.61 for ages 10–19 years.[36] We used these estimates to calculate a reduction in advertising expected from our intervention. We estimated that the intervention would apply to 89%–96% of all food ads that are nutritionally poor.[3,4] We did not account for any product reformulation that may occur as a result of the intervention.

Despite substantial shifts in the distribution of time spent watching TV across screens and devices, traditional TV still accounts for the vast majority of time children (24:23 hours/week) and adolescents (22:14 hours/week) spend watching.[52] Because the amount of adult TV programming increases with age, we assumed that the intervention applied to 46% of ads seen by children aged 2–4 years, 44% of ads seen by youth aged 5–14 years, and 25% of ads seen by adolescents aged 15–19 years, and we reduced daily TV time accordingly in the model.[4,5,53]

Although the *Guide to Community Preventive Services* estimates the overall effects of interventions on reductions in BMI and prevalence of obesity, we needed to estimate the relationship of change in daily TV hours to change in BMI in order to estimate the impact of change in advertising on change in BMI. We accordingly reviewed studies included in recently completed systematic reviews and meta-analyses[13–16,54] to identify those meeting the following criteria: RCTs of screen time interventions (screen time includes TV, videotapes, videogames, and computer time) that manipulated screen time but not other aspects of children's diet or physical activity; included youth aged 2–18 years; measured change in weight or BMI *z*-score, or BMI was a reported outcome; significant change in screen time was measured in hours/day; and minimum duration of the study was 6 months. We identified two RCTs that met these criteria, including one study[55] that found significant changes in BMI associated with changes in TV time. This 7-month cluster randomized trial with 192 children led to relative reductions of 1.37 hours of screen time per day and –0.45 BMI units (p=0.002), or a reduction of –0.33 kg/m^2 per hour/day of screen time. Although not statistically significant owing to the small sample size (n=70), the only other identified study found comparable results in a younger sample: –0.33 kg/m^2 per hour/day of screen time.[17]

There is abundant evidence that the direct relationship between TV time and BMI in children is mainly driven by increased energy intake,[7,17–20,56] most of which is thought to be driven by food and beverage advertising.[21,57] Two potential limitations to using daily TV time as an indicator of TV food advertising exposure concern potential other effects of reduced TV viewing independent of TV advertising exposure. First, reduced TV time could lead to increased physical activity and, via this pathway, reduced BMI.

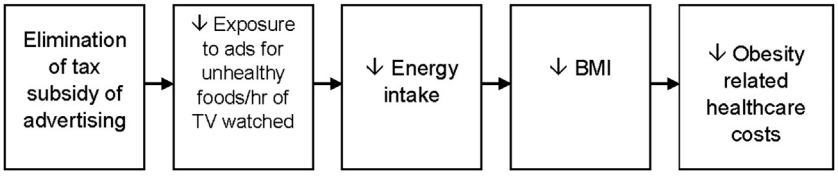

Figure 1. Logic model linking TV advertising policy change to reduction in BMI and healthcare costs.
Note: We assume a logic model where intervention/policy change reduces advertising time (measured by TV time) and this change in turn reduces energy intake, BMI, and over the longer term reduces obesity-related healthcare costs. Almost all the change in BMI occurs via changes in dietary intake.

However, evidence reviews of this relationship[13-15] and two RCTs[17,55] have indicated no significant effect of reduced TV viewing on physical activity levels, although one carefully controlled RCT[56] of change in energy intake and physical activity under conditions of decreased TV viewing did indicate that about 20% of the overall change in energy balance of kilocalories per day could be due to increased physical activity. We thus conservatively reduced estimates of reductions in BMI due to reductions in TV time by 25% to account for any potential effects of increased physical activity. Another alternative argument is that reduced TV time could affect dietary intake because of increased snacking or intake while watching TV, independent of advertising. In experimental studies that manipulated TV time, no significant such effects were observed.[21,54,56] Although we have not identified a plausible alternative to the role of advertising as a driver of the causal relationship between the impact of TV viewing on BMI as measured in RCTs reducing TV exposure, the current approach relies on assumptions linking multiple sources of evidence and can be viewed as the best-possible estimate in the absence of more-direct measures of the effect of the proposed policy.

Costs of Intervention

The analysis of intervention costs was undertaken from a modified societal perspective. The implementation of the intervention entailed minimal costs and included those related to processing and auditing, but not enacting, the new tax. Overhead costs of the tax system included administrative costs and expenses related to tax audits and litigation and were estimated at the cost of five full-time federal employees. These estimates were based on the assumption that 20%–25% of the 44 food companies responsible for the majority of expenditures for food and beverage marketing to children would be audited for compliance.[53] No data were available to inform our estimate of resources required to conduct such audits; thus, we assumed that each audit would demand a 0.25–0.75 full-time equivalent (FTE). The costs and labor associated with tax compliance by the food and beverage industry were assumed to be equal to the cost of administration reported by the government.

A loss in revenue by companies that sell predominantly nutritionally poor foods would be expected, although purchasing of other healthier foods that are not covered by the proposed intervention would likely increase. We assumed that, industry wide, the reduction in sales of nutritionally poor foods would be offset by the increase in sales of other foods and that a loss in revenue by commercial broadcasters would likely be offset by new advertising contracts for other products.[58] Tax payment and revenue represent a transfer payment from taxpayers to the state and therefore cancel out from the societal perspective. As such, tax payments do not offset intervention costs. We assumed the intervention persists for 10 years, and 10-year costs are included in the cost-effectiveness calculations. We also calculated first-year expected additional tax revenues under the policy.

Cost-Effectiveness Analysis

Short-term cost effectiveness was estimated in terms of cost per BMI unit reduced over 2 years.[59] We used 2 years because research has indicated a substantial time course for weight change following interventions in both adults and children, with near-full effects for children seen after 2 years. BMI-related health benefits and healthcare cost reductions were also estimated over 10 years, with no benefits estimated during the first year of implementation. The incremental cost-effectiveness ratios were calculated by dividing the difference in net costs by the difference in net effectiveness, comparing the intervention with the control scenarios using cost per BMI unit reduced. We also evaluated the cost savings per each intervention dollar spent. Additional details on the modeling framework are described in an accompanying paper of this theme issue.[51]

Sensitivity Analyses

We conducted probabilistic sensitivity analyses by simultaneously sampling all parameter values from predetermined distributions (Table 1) using Monte Carlo simulations (@RISK software, version 6, and compiled code in Java). Means and 95% uncertainty intervals (UIs) were reported for BMI effects and costs based on 10,000 iterations. Impact on healthcare cost savings, net costs, and QALYs were estimated based on 1 million iterations.

Model uncertainty was assessed by comparing the primary scenario to the secondary scenario. In a secondary scenario, we used results from a study of naturally occurring variations in fast food advertising in different metropolitan areas in the U.S. to levels of BMI and obesity among children and youth.[36] This analysis estimated differences in BMI associated with the number of fast food advertising messages seen, controlling for a wide variety of confounding variables in fixed effects regressions, and thus provided a conservative estimate of the association between all food advertising to children and BMI. Inputs for each step in the logic pathways linking intervention to BMI in the primary and secondary scenarios are listed in Table 1.

Results

The intervention would reach approximately 74 million youth aged 2–19 years. At full effect, we estimated that eliminating the tax subsidy of TV advertising of nutritionally poor foods and beverages to children and adolescents would reduce mean BMI by 0.028 (95% UI=0.011, 0.046) units among children aged 2–19 years (Table 2). This is a small percentage change in mean BMI, about 0.14%, and we estimate that this would result in a reduction in obesity prevalence in this cohort of about 0.30%. Over the first 2 years, the intervention would reduce an aggregate 2.13 million (95% UI=0.83 million, 3.52 million) BMI units in the population and would cost $1.16 per BMI unit reduced (95% UI=$0.51, $2.63). Over the 2015–2025 period, these BMI reductions would result in $352 million (95% UI=$138 million, $581 million) in healthcare cost savings and a $343 million (95% UI=$129 million, $572 million) reduction in net societal costs. The policy change would lead to increases in QALYs: 4,540 (95% UI=1,750, 7,490). The intervention was "cost saving," as it would result in an increase in QALYs and reduction in total costs compared with current practice. The intervention would save an estimated $38.0 (95% UI=$14.3, $74.3) for every dollar spent on the intervention.

Table 1. Key Model Variables

Parameters	M (95% uncertainty interval)		Sources and modeling parameters
Change in BMI and energy intake modeling component			
Number of hours of TV watched per day (Primary Scenario)	Age 2–4: 3.483 Age 5–9: 3.483 Age 10–14: 3.176 Age 15–19: 3.176	N/A	The Nielsen Company. State of the media: The cross-platform report. Quarter 1, 2012[51]
Reduction in advertising targeted at children and adolescents expected from intervention (Primary and Secondary Scenario)	Children: 10.7% (9.9%, 11.4%) Adolescents: 8.8% (8.2%, 9.4%)		Estimated by Chou et al.[36] based on the effect of the price of an advertisement on messages seen; price elasticity of demand for advertising is −0.74 for children and −0.61 for adolescents From a 12.6% effective tax rate, prices would increase by 14.4% **Children:** reduction is 14.4%× − 0.74= −10.7%; beta distribution using ±10% (minimum: −11.7%, most likely: −10.7%, maximum: −9.6%) **Adolescents:** reduction is 14.4%× − 0.61= −8.8%; beta distribution using ±10% (minimum: −9.7%, most likely: −8.8%, maximum: −7.9%)
Share of ads targeted at children and adolescents which are for nutritionally poor foods (Primary and Secondary Scenario)	Age 2–4: 95.8% Age 5–9: 97.3% Age 10–14: 97.3% Age 15–19: 89.4%		Samples from two Powell et al. studies[3,4]
Change in BMI per hour of TV (Primary Scenario)	0.33 (0.13, 0.54)		Sample from a normal distribution with M and SD from Robinson et al., rescaled per hour/day of screen time[54]
% of BMI effect due to energy intake	72% (60%, 79%)		Assumption of 75%; beta distribution (min: 50%, most likely: 75%, max: 80%)[21]
% of TV viewed which is children's programming	Age 2–4: 46.2% Age 5–9: 43.5% Age 10–14: 43.5% Age 15–19: 25%		Sample drawn from Powell et al.[4,5]
Number of food ads seen per day (Secondary Scenario)	Age 2–4: 11.9 Age 5–9: 13.4 Age 10–15: 13.4 Age 15–19: 16.2		Estimates from Rudd Report[26]
Estimated change in BMI for the natural log of food ads seen (Secondary Scenario)	Males Age 2–9: 0.271 (0.028, 0.511) Age 10–19: 0.546 (0.293, 0.800) Females Age 2–9: 0.295 (0.060, 0.532) Age 10–19: 0.367 (0.154, 0.581)		Analysis of data from the 1997 National Longitudinal Survey of Youth, which links variations in fast-food advertising in different metropolitan areas in the U.S. to levels of BMI and obesity among children and youth in the samples[36]; normal distribution with M and SD from published estimates
Cost of intervention modeling component			
Department of Revenue Officer salary ($) (+56% non-salary benefits)	89,500		Mean annual salaries from the U.S. Bureau of Labor Statistics 2013 salary for Occupation 13-2081: tax examiners, collectors, and revenue agents plus 56% non-salary benefits
Industry auditor salary ($) (+43% non-salary benefits)	106,000		Mean annual salaries from the U.S. Bureau of Labor Statistics 2013 salary for Occupation 13-2011: accountants and auditors plus 43% non-salary benefits

Table 2. Cost-Effectiveness Results

Variable	M (95% uncertainty interval)	
Total population reached (millions)	74	
First-year cost ($ millions)	1.05 (0.69, 1.42)	
Ten-year intervention cost ($ millions)	9.26 (6.03, 12.51)	
Short-term outcomes	Primary scenario	Secondary scenario
Mean per capita BMI unit reduction for youth 2–19 years of age	0.028 (0.011, 0.046)	0.013 (0.008, 0.017)
Total BMI units reduced for youth 2–19 years of age (millions)	2.13 (0.83, 3.52)	0.99 (0.65, 1.32)
Cost per BMI unit reduced for youth 2–19 years of age ($)[a]	1.16 (0.51, 2.63)	2.24 (1.28, 3.65)
Ten-year outcomes		
Total QALYs[b] increased	4,540 (1,750, 7,490)	2,820 (1,790, 3,840)
Healthcare costs[c] ($ millions)	−352 (−581, −138)	−157 (−215, −101)
Net costs ($ millions)[d]	−343 (−572, −129)	−149 (−206, −92.3)
Net cost per QALY increased ($)[e]	Cost-saving[f]	Cost-saving[f]
Net cost savings per dollar spent ($)	38.0 (14.3, 74.3)	17.1 (9.94, 29.14)

[a]Cost per BMI unit reduced based on 2 years of cost of implementation and total BMI reduction for all ages in the 2015 cohort or for youth only.
[b]QALYs increased due to the proposed intervention are calculated as the difference in the simulated quality-adjusted years of life lived over 10 years in the intervention cohort compared to the baseline cohort of the U.S. population (>1 year of age) in 2015.
[c]The reduction in healthcare costs refers to the simulated difference in 10-year healthcare costs due to the intervention for a baseline cohort of the U.S. population in 2015. Healthcare costs and health effects are estimated annually and are reported as present value in July 2014 dollars discounted at 3% annually.
[d]Net costs include total implementation costs and healthcare cost savings over 10 years.
[e]Values are calculated as the ratio of mean incremental costs over QALYs increased in the intervention scenario compared to the no-intervention scenario, with the mean and 95% uncertainty intervals reported from 10,000 iterations of the @Risk BMI simulation model and one million iterations of the BMI-to-QALY simulation.
[f]Interventions are considered "cost-saving," and summary statistics are not calculated when they result in both cost savings and an increase in QALYs.[60]
$, 2014 U.S. dollars; LY, life-years; QALYs, Quality-adjusted life-years.

The secondary scenario indicated similar but lower levels of cost effectiveness (Table 2), as expected because the advertising effect was restricted to local fast food advertising. Eliminating the tax subsidy of TV advertising of nutritionally poor foods and beverages to children and adolescents was estimated to reduce mean BMI by 0.013 (95% UI=0.008, 0.017) units among children aged 2–19 years, and the intervention would cost $2.24 per BMI unit reduced (95% UI=$1.28, $3.65).

Results of the implementation and equity considerations review are shown in Table 3. Overall, we concluded that the cost-saving intervention would likely have a significant societal impact. The tax policy change would also generate additional tax revenue of an estimated $80 million during the first year, with continuing additional revenue in later years. Eliminating the tax subsidy of advertising expenses would likely be met with great opposition from the food industry and great support from the public. Although awareness of food marketing and its negative impact on children is low among parents, increasing public understanding of these effects along with an understanding of the special vulnerability of children to persuasive advertising[6] would increase support for restrictions on food marketing.[63] There is already evidence of strong public support (75%) for restricting the amount of ads for fast food and other unhealthy foods during children's TV programming.[64] Increasing public awareness, coupled with framing the intervention as removing the federal subsidy of advertising unhealthy foods and beverages to children, could counter opposition by the food industry[65] given its emphases on individual "personal responsibility" and physical activity.[66]

Discussion

Eliminating the federal subsidy of food and beverage advertising to children and adolescents would likely be a cost-saving strategy to reduce childhood obesity and related healthcare expenditures. Given the population-level importance of small changes in BMI at the individual level, the proposed intervention would have significant population effects. This is the first time that the effect of eliminating the tax subsidy of advertising

Table 3. Implementation and Equity Considerations

Level of evidence	Equity	Acceptability	Feasibility	Sustainability	Side-effects	Social and policy norms
Evidence for change in BMI/weight from one high-quality RCT with a sole focus on reducing TV and other screen time[55] Parallel and indirect evidence to support effectiveness Numerous other prospective and change studies link TV time/advertising exposure to BMI/obesity	Benefit could be greater among minority children who watch more TV[27,61,62]	Likely food, beverage, advertising industry opposition Parental support likely with increased understanding of the harmful effects of food marketing[63]	Plausible legal feasibility; needs to be implemented and challenged in court Poor compliance without audits possible	Likely if implemented Product reformulation may reduce effect size	Positive: Reformulation may improve quality of snack foods/sweets/drinks Benefit to adults who watch mixed programming or those who are parents of children and adolescents as a result of reduced pester power Tax revenue Negative: Other media advertising may increase Increased advertising costs may be offset by increased food prices	Publicity concerning law could lead to increased support Federal subsidy of food and beverage advertising costs is not aligned with societal need to uphold rights of children and protect children from exploitation Federal subsidy of food and beverage advertising costs is not aligned with the current administration's commitment to addressing the childhood obesity epidemic
Decision point						
Likely to be effective	Potential benefit	Issues need to be addressed given likely opposition by food industry	There are plausible arguments to be made for the legal feasibility of the intervention, but the constitutionality can only be confirmed if the intervention is implemented and industry challenges it in court	Neutral	Potential for both negative and positive side effects; issues related to shuttling of advertising expenditure may be substantial	Strong potential benefit

Note: Policy considerations: Intervention is cost saving if effect is maintained and would likely have a large societal impact. Eliminating the tax subsidy of advertising expenses would likely be met with great opposition from the food industry and great support from the public.

expenses, as proposed in S. 2342 and H.R. 2831, on BMI and healthcare costs has been estimated. Our findings are consistent with existing modeling studies from Australia and Europe, which have found policies that limit food and beverage advertising to be both effective and cost effective.[67,68] Our study is also supported by many other studies that have demonstrated an association between food and beverage advertising on TV and BMI.[8,21,36,69]

Although beyond the scope of this modeling exercise, there are several outcomes of the proposed intervention worth noting. First, we estimated that the policy change would generate approximately $80 million per year in tax revenue, which could be directed to health-promotion efforts. The modeled intervention may also confer a larger benefit to lower-income and racial- and ethnic-minority children, who have higher levels of TV viewing than their wealthier and white non-Hispanic peers.[27,61,62] Because the proposed policy may reduce the profitability of marketing and selling unhealthy food to children, the food industry would likely improve the healthfulness of the products marketed to children to maintain current profitability.[70] Although product reformulation would reduce the effect size of the intervention over time, it would improve the quality of snack foods, drinks, and restaurant foods available in the food supply. Further, although TV programming that is directed at children and adolescents likely represents a minority of the programming seen by adults, the proposed intervention could have some benefit on adults given the known prospective association between TV and long-term weight gain among adults.[71] Adults who are parents of children or adolescents, in particular, may benefit from changes in the home food environment, resulting in a reduction in "pester power."

This analysis is limited by the uncertainty of estimates used at each step in the logic pathway linking the tax policy intervention to BMI and eventual health outcomes and, as such, the UIs may not capture all uncertainty in the model. Owing to a lack of available estimates, we do not model the effect of the substantial interactive online marketing strategies used by major food and beverage companies.[72] No empirical evidence was available to inform our estimates of TV industry or food and beverage companies' response to the proposed tax; thus, we are unable to account for possible responses of the TV and food industries. We did not account for the impact of food reformulation noted above in our model. Food and beverage companies could also transfer advertising efforts and funds to non-TV advertising such as online advertising, although the two bills introduced in Congress[39,40] would apply to all forms of marketing and offer an alternative strategy. Although traditional TV is currently the predominant form of TV exposure among youth,[52] we are unable to model possible changes in the TV viewing landscape in the 10-year period. It is also possible that the TV industry would respond by cancelling children's programming in favor of more adult programing or reducing costs of advertising during children's programming.

Our 10-year results are based on the assumption that the intervention effect is maintained for this period. This assumption appears reasonable, as the intervention is assumed to continue and is costed out during the 10 years—a likely scenario if a public policy is enacted, with strong evidence for sustainability from regulations to tax cigarettes and restrict public cigarette smoking. Despite these limitations, our estimate of the potential gains to population health may be conservative. The model relies on BMI-mediated health effects and does not incorporate additional expected reductions in metabolic and other diseases due to a reduction in intake of heavily advertised products high in sodium, saturated fat, and added sugar.[73,74]

Although there are legal and ethical issues related to regulating commercial speech, the increased promotion of healthy food is not a feasible or sufficient response to heavy junk food marketing. The Federal Trade Commission can constitutionally and statutorily regulate marketing practices directed at youth under its deception authority[75]; however, the constitutional feasibility of any intervention that would limit commercial speech is uncertain, especially in light of a 2011 U.S. Supreme Court decision striking down a regulation on First Amendment grounds because it unfairly discriminated against certain marketing messages.[76] Therefore, a tax policy is less intrusive and perhaps a more legally justifiable intervention than other strategies. The proposed intervention will not eliminate the influence of food and beverage marketing on children and adolescents because youth are exposed to a great deal of marketing that is directed to a general or adult audience[53] and marketing through other channels will still occur and proliferate. However, this intervention is likely to offer a substantial improvement over existing industry self-regulatory initiatives.

Conclusions

The proposed intervention, which eliminates the tax subsidy of TV advertising costs for nutritionally poor foods and beverages advertised to children and adolescents, is likely to reduce BMI in children. Although the effects of the intervention may be small at the individual level, the policy could have substantial impact on downstream healthcare expenditures at the population level. Eliminating the tax subsidy of advertising expenses

would also generate tax revenue and is likely to receive strong public support, although the policy would likely be met with great opposition from the food industry. This paper provides important new information to policymakers regarding a feasible approach to reducing children's advertising exposure, thereby achieving substantial related gains in terms of the health of the population.

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