**Technical Appendix**

**Table of Contents:**

* **Appendix A1. Sugar-sweetened Beverage (SSB) Excise Tax Intervention Specification and Background**
	+ **Appendix Exhibit A1.1.** Logic Model Linking Sugar-sweetened Beverage Excise Tax to Change in BMI
	+ **Appendix Exhibit A1.2.** Key Model Variables to Evaluate Sugar-sweetened Beverage Excise Tax Effect on BMI
* **Appendix A2. Advertising Tax Intervention Specification and Background**
	+ **Appendix Exhibit A2.1.** Logic model linking TV advertising tax policy change to reduction in BMI
	+ **Appendix Exhibit A2.2.** Key Model Variables to Evaluate Effect of TV Advertising Tax Policy Change Effect on BMI
* **Appendix A3. Microsimulation Model Description**
	+ **Appendix Exhibit A3.1.** Microsimulation model parameters
	+ **Appendix Exhibit A3.2.** Annual Medical Expenditures for Individuals by Age and Obesity Status
* **Appendix A4. Restaurant Menu Calorie Labeling Intervention Specification and Background**
	+ **Appendix Exhibit A4.1.** Logic Model Linking Restaurant Menu Calorie Labeling to Change in BMI
	+ **Appendix Exhibit A4.2.** Key Model Variables to Evaluate Restaurant Menu Calorie Labeling Effect on BMI
* **Appendix A5. Nutrition Standards for School Meals Intervention Specification and Background**
	+ **Appendix Exhibit A5.1.** Logic Model Linking Nutrition Standards for School Meals to Change in BMI
	+ **Appendix Exhibit A5.2.** Key Model Variables to Evaluate School Meals Effect on BMI
* **Appendix A6. Nutrition Standards for All Foods and Beverages Sold in Schools (Smart Snacks) Intervention Specification and Background**
	+ **Appendix Exhibit A6.1.** Logic Model Linking Smart Snacks in School to Change in BMI
	+ **Appendix Exhibit A6.2.** Key Model Variables to Evaluate Smart Snacks in School Effect on BMI
* **Appendix A7. Improving Nutrition, Physical Activity, and Screen Time Policies and Practices in Early Care and Education through the Nutrition and Physical Activity Self- Assessment for Child Care (NAP SACC) Program: Intervention Specification and Background**
	+ **Appendix Exhibit A7.1.** Logic Model Linking the Nutrition and Physical Activity Self-Assessment for Child Care to Change in BMI
	+ **Appendix Exhibit A7.2.** Key Model Variable to Evaluate NAP SACC Effect on BMI
* **Appendix A8. Bariatric Surgery Intervention Specification and Background**
	+ **Appendix Exhibit A8.1.** Logic Model Linking Bariatric Surgery to Change in BMI
	+ **Appendix Exhibit A8.2.** Key Model Variable to Evaluate Bariatric Surgery Effect on BMI

**Appendix A1. Sugar-sweetened Beverage (SSB) Excise Tax Intervention Specification and Background**

**Modeled Intervention**

We modeled the effect of an specific excise tax of $0.01/oz of SSBs administered at the state level and implemented nationally based on recent proposals under consideration by federal, state and local governments.1 SSBs include all beverages with added caloric sweeteners.The modeled excise tax does not apply to 100% juice, milk products, or artificially-sweetened beverages.

**Background**

Despite recent declines, SSB consumption in the United States remains high among children and adults.2 Observational studies and randomized controlled trials have linked SSB consumption to excess weight gain, diabetes, and cardiovascular disease.3-4 The *Dietary Guidelines for Americans, 2010* recommends that individuals reduce SSB intake in order to manage their body weight.5 In 2009, the Institute of Medicine suggested taxing SSBs as a potential local strategy to reduce consumption of calorie-dense, nutrient-poor foods.6

**Assessment of Benefit**

The impact of a $0.01/oz SSB tax on individual body mass index (BMI) was modeled based on the logic model in Appendix Exhibit A1.1. Key model input parameters based on this logic model are described below and are detailed in Appendix Exhibit A1. Means and 95% uncertainty intervals are based on 1,000 simulations drawn from parameter-specific distributions.

**Appendix Exhibit A1.1.Logic Model Linking Sugar-sweetened Beverage Excise Tax to Change in BMI**

∆ State Excise Tax

∆ SSB

Price

∆ SSB

Purchases

∆ BMI

∆ SSB

Consumption

**SOURCE** Authors’ model **NOTES** BMI is body mass index (kg/m2). SSB is sugar-sweetened beverage.

*Impact of Tax on Price to Consumers*

Consistent with economic theory and international evidence, we assumed that the full price of the excise tax would be passed on to consumers.7-12 The expected percent increase in SSB price was estimated based on the average national retail price of $0.059/ounce in 2012 reported by Powell et al.,13 which was inflated to $0.0612 in July 2014 dollars to be consistent with recent modeling of the cost-effectiveness of an SSB excise tax.14 The $0.01/ounce excise tax would then result in a 16.3% price increase (0.0712/0.0612). We assumed that the tax rate would be adjusted annually for inflation to maintain the 16.3% price increase throughout the ten-year modeling time frame.

*Price Elasticity of Demand for SSBs*

We estimated the potential reduction in current SSB purchases due to the tax based on a systematic review of recent estimates of the price elasticity of demand for SSBs by Powell et al.15 The review estimated a mean own-price elasticity of demand for SSBs weighted by SSB category consumption shares of -1.21, ranging from -3.87 to -0.69.

*Change in SSB Intake in Response to Excise Tax*

We modeled current SSB consumption using age and sex-specific mean daily intake (oz) estimated from the first day 24-hour dietary recall from the 2011-2012 National Health and Nutrition Examination Survey. The change in individual intake was estimated by multiplying current intake by the 16.3% price increase and the sampled price elasticity of demand sampled in each model iteration. On average, we estimated that the 16.3% price increase would result in a 20% decrease in consumption from current levels.

*Effect of change in SSB consumption on change in BMI*

Based on a review of studies included in thirteen systematic reviews,16-28 we estimated the impact of reductions in SSB consumption on weight or BMI based on four large longitudinal studies in adults29-32(0.21-0.57 BMI units/12-ounce serving) and a double-blind, placebo controlled randomized trial in youth (1.01 kg/8-ounce serving).33 These studies provide the best available evidence of the impact of a change in SSB consumption on weight and BMI accounting for any compensatory changes in other dietary intake or physical activity.

**Reach**

The intervention reaches all youth and adults aged 2 and older in the US. In the first year, the intervention would reach 307 million people.

**Costs**

We estimated the cost of the intervention based on administrative data provided in 2010 from two states (Washington and West Virginia) that had existing or planned excise taxes on SSBs. The states required between 0.10 and 0.54 full-time equivalent (FTE) government tax agent time per year per million residents to administer the tax and between 0.24 and 0.35 FTE per year per million residents to conduct audits. We applied these per capita costs nationally assuming no economies of scale and estimated salary costs from the 2014 Bureau of Labor statistics for tax examiners, collectors and revenue agents (BLS Occupation: 13-2081). We assumed that industry would require equivalent time to comply with audits and file new tax statements and applied salary costs from the 2014 Bureau of Labor statistics for accountants and auditors (BLS Occupation: 13-2011). We assumed that the time to administer and conduct audits would be twice the annual rate during the first year of implementation. Additional limited costs estimated included field audit direct costs and limited tax certification system operating costs.

**Appendix Exhibit A1.2.Model Variables to Evaluate Sugar-sweetened Beverage Excise Tax Effect on BMI**

|  |  |  |  |
| --- | --- | --- | --- |
| **Parameters** | **Mean Value** | **95% Uncertainty Interval** | **Sources and Modeling Assumptions** |
| Individual daily SSB intake (oz) | N/A | N/A | Sex and age-specific mean intake from first day 24-hour dietary recall from the 2011-2012 National Health and Nutrition Examination Survey |
| Own-price elasticity of demand for SSB | 1.22 | (0.70, 2.67) | Samples drawn from an exponential function (β=0.5251, shift=0.6892) based on absolute value of weighted frequency of 12 estimates in Powell et al. review15 |
| Change in weight (kg) per change in SSB consumption (8oz/day) among youth | 1.01 | (0.57, 1.45) | Samples drawn from a normal distribution (mean=1.01, s.d.=0.27) based on mean and s.e. from de Ruyter et al.33 |
| Change in BMI per change in SSB consumption (12oz/day) among adults | 0.39 | (0.22, 0.56) | Samples drawn from a uniform distribution based on the range of estimates from four longitudinal studies among adults (min:0.21, max=0.57 BMI units)29-32 |

**SOURCE** Sources for each model input parameter are noted in the table. **NOTES** Mean value and 95% uncertainty interval based on 1,000 simulations drawn from parameter-specific distributions. SSB is sugar-sweetened beverage. kg is kilograms. BMI is body mass index.

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**Appendix A2. Advertising Tax Deduction Intervention Specification and Background**

**Modeled Intervention**

We modeled the effect of eliminating the tax deductibility of TV advertising costs for nutritionally poor foods and beverages advertised to children and adolescents ages 2-19. The intervention applied to TV programming watched on traditional TV and to TV advertising aired during children’s programming defined as >35% child-audience share.1 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. The change in tax code would be administered at the federal level and would result in limited auditing/monitoring activities conducted by the Internal Revenue Service.

**Background**

Children and adolescents view thousands of food-related TV ads each year.2 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.3-5 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

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,6,11 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.12 Accordingly, eliminating13 or amending14 the tax deduction available to food companies for the costs of advertising to children has been proposed by Senators Blumenthal and Harkin15 and in Congress by Representative Rosa DeLauro (H.R. 2831).16

**Assessment of Benefit**

The impact of eliminating the tax subsidy of TV advertising costs for nutritionally poor foods and beverages advertised to children and adolescents was modeled using daily hours of TV viewed as our measure of food advertising exposure based on the logic model in Appendix Exhibit A2.1. Key model input parameters based on this logic model are described below and are detailed in Appendix Exhibit A2.2. Means and 95% uncertainty intervals are based on sampling 1,000 iterations from the defined distributions for each parameter.

**Appendix Exhibit A2.1. Logic model linking TV advertising policy change to reduction in BMI.**

∆ Federal Tax Code

∆ Advertising

Price

∆ Advertising Exposure

∆ BMI

**SOURCE** Authors’ model **NOTES** BMI is body mass index (kg/m2).

*Impact of Change in Federal Tax Code on Advertising Price*

The model assumes an effective corporate income tax rate of 12.6%, which will increase advertisement prices by 14.4%.17 Using estimates from a national analysis of TV advertising and childhood obesity, which found the price elasticity of demand for TV advertising to be 0.74 for ages 2-9 and 0.61 for ages 10-19, we calculated an expected reduction in actual advertising.18

*Impact of Change in Advertising Price on Advertising Exposure*

The model estimates that 89%-96% of all food advertisements will be impacted and combines the tax rate and elasticity estimates from Chou et al. to project a 10.7% reduction among children and an 8.8% reduction among adolescents in advertisement exposure.4,5

*Impact of Change in Advertising Exposure on BMI*

To estimate the impact of change in advertising on change in BMI, we reviewed studies included in recently completed systematic reviews and meta analyses19-23 to identify those meeting the following criteria: RCTs of screen time interventions (screen time includes TV, videotapes, videogames, computer time) that manipulated screen time but not other aspects of children's diet or physical activity; ages included were from 2-18; measured change in weight, BMI z-score or BMI was a reported outcome; significant change in screen time was measured in hours per day; minimum duration of the study was six months. We identified two RCTs that met these criteria, including one study that found significant changes in BMI associated with changes in TV time.24 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/m2 per hour/day of screen time. Although not statistically significant due to the small sample size (n=70), the only other study identified found comparable results in a younger sample: -0.33 kg/m2 per hour/day of screen time.25 Based on the literature, this model has 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.

**Reach**

An elimination of Tax Deductibility among Targeted Advertising has the potential to reach 74 million children, ages 2- 19 years in all 50 states and DC.

**Costs**

Costs related to processing and auditing were included for the new tax, but not for enacting. Overhead costs of the tax system included administrative costs (e.g., tax audits, litigation) and personnel responsible for these undertakings. The model assumed 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.26 The model assumed that each audit would demand 0.25-0.75 full-time equivalent (FTE). The model assumed that the costs and labor associated with tax compliance by the food and beverage industry are equal to the cost of administration reported by the government. The model assumed that, industry-wide, the reduction in sales of poor quality food will be offset by the increase in sales of other foods and that a loss in revenue by commercial broadcasters will likely be offset by new advertising contracts for other products.27

**Appendix Exhibit A2.2. Key Model Variables to Evaluate Effect of TV Advertising Tax Policy C Effect on BMI**

|  |  |  |  |
| --- | --- | --- | --- |
| **Parameters** | **Mean Value** | **95% Uncertainty Interval** | **Sources and Modeling Assumptions** |
| Number of hours of TV watched per day | Age 2-4: 3.483Age 5-9: 3.483Age 10-14: 3.176Age 15-19: 3.176 | N/A | The Nielsen Company. State of the media: The cross-platform report. Quarter 1, 2012.28 |
| Reduction in advertising targeted at children and adolescents expected from intervention | Children: 10.6% Adolescents: 8.8%  | (9.7%; 11.6%)(8.0%; 9.6%) | Estimated by Chou et al. based on the effect of the price of an advertisement on messages seen.13 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%. Uniform distribution +/-10% of mean using (min= -11.7%, max= -9.6%)**Adolescents:** reduction is 14.4%\*--0.61= -8.8%. Uniform distribution +/-10% of mean using (min= -9.7%, max= -7.9%) |
| Share of ads targeted at children and adolescents which are for nutritionally poor foods  | Age 2-4: 95.8%Age 5-9: 97.3%Age 10-14: 97.3%Age 15-19: 89.4% | N/A | Deterministic values based on estimates from Powell LM et al.4 and Powell LM et al.5 |
| Change in BMI per hour of TV  | 0.34 | (0.15;0.53) | Samples from a normal distribution with mean and standard deviation from Robinson et al, rescaled per hour/day of screen time (mean=0.33, s.d.=0.104).24 |
| % of BMI effect due to energy intake | 75% | (61%; 88%) | Assumption of 75%. Beta distribution (lower=50%, most likely: 75%, higher= 80%).29 |
| % 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% | N/A  | Deterministic values from Powell LM, et al.5,30 |

**SOURCE** Sources for each model input parameter are noted in the table. **NOTES** Mean value and 95% uncertainty interval based on 1,000 simulations drawn from parameter-specific distributions. BMI is body mass index.

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**Appendix A3: Microsimulation Model Description**

We developed a stochastic, discrete-time, individual-level microsimulation model of the population in the United States to simulate the experience of the population in the United States from 2015-2025. Key input parameters for the model are detailed in Appendix Exhibit A3.1 and are described below.

**Population Baseline Characteristics**

*Demographics*

We simulated a population of 1,000,000 individuals using a simple random sample from the 2010 U.S. Census at the census tract level and initiated the simulation in 2010. Using non-parametric statistical matching,1-3 we assigned additional demographic variables (Exhibit A3.1) to individuals by sampling observations with replacement from the 2008-2012 American Community Survey (ACS) 5-Year Estimates conditional on census tract, age, sex and race/ethnicity. The matching algorithm employed dynamic strata definitions to achieve a minimum sample size within each strata of the datasets used to assign additional data to the simulated population.

*Body Mass Index and Dietary Behavior*

The microsimulation was designed to provide valid state-level estimates of population obesity and related mortality and healthcare expenditures. To capture state-level variation in height and weight within demographic subgroups, using the same non-parametric matching techniques, adults sampled from the 2010 U.S. Census with household income data from ACS were matched to individuals from the 2011 Behavioral Risk Factor Surveillance System (BRFSS) to assign self-reported height and weight conditional on demographic variables and state residence. After excluding observations with missing demographic variables and self-reported height and weight (n=99,912) and excluding pregnant women because of possible effects on weight (n=2,758), data were sampled with replacement proportion to sampling weights from 401,738 individuals to assign self-reported height and weight to individuals in the simulation model.

Data on state-specific child and adolescent parent-reported height and weight from the 2003-2004 and 2007-2008 National Survey on Children’s Health (NSCH) were used to incorporate state-level variation in childhood height and weight conditional on demographic variables. The NSCH is a national and state-representative telephone survey covering a range of children’s health data conducted by the Centers for Disease Control and Prevention’s National Center for Health Statistics. Additional detail on the sampling methodology has been reported previously.4, 5 Data from both waves of the surveys were available for 213,900 responses. After excluding observations with missing demographic variables needed for the matching process (n=29,235) and those missing parent-reported height and weight (n=51,452), 133,213 responses were used in this study’s analysis. Sample weights were pooled across survey rounds. Data on height and weight were not available in the 2011-2012 NSCH public use datasets, although derived BMI values are available based on parent self-reported height and weight for participants aged 10-17 years.

Objectively-measured height and weight and selected dietary intake variables were assigned to individuals in the simulated population by matching to individuals sampled with replacement from the 2005-2010 National Health and Nutrition Examination Survey (NHANES) conditional on age, sex, race/ethnicity, household income and self or parent-reported height and weight from BRFSS and NSCH. After excluding observations with missing data for the variables of interest (n=2885) and excluding pregnant women (n=415), the final sample from NHANES included 15,018 respondents aged 18 and older. After excluding individuals with missing demographic data (n=356) and those with missing measured height and weight (n=224), data on height and weight were available from 9,377 individuals aged 2-17. Sample weights for the pooled dataset were calculated following the NHANES analytic guidelines.6 In contrast to estimates based on self-reported BRFSS data, the resulting population closely reproduced the body mass index (BMI) distribution, obesity prevalence and severe obesity prevalence of the U.S. based on objectively-measured data from NHANES.7 State-level estimates of childhood obesity were validated against objectively-measured data from states that conducted a census of childhood obesity among schoolchildren.8

**Lifetime Height and Weight Trajectories**

Building on previous studies,9 we developed a nationally-representative set of lifetime height and weight trajectories by combining objectively-measured height and weight trajectories from the following longitudinal cohort studies: National Longitudinal Survey of Youth (1986-2010; n=9,402), the National Longitudinal Study of Adolescent to Adult Health (Add Health) (1994-2008; n=4,972), the Early Childhood Longitudinal Study-Kindergarten (1998-2007; n=15,180), the Panel Survey on Income Dynamics (n=4,792), and the NHANES I Epidemiologic Follow-up Study (NHEFS, n=7,221). For children and adolescents, we used CDC growth charts to inform age-specific, non-linear interpolation between observed measurements of height and weight. For adults (ages >20), height was assumed to remain constant and weight was linearly interpolated between observations. Because none of the nationally-representative height and weight trajectories includes data across the lifecourse, synthetic trajectories were created by combining trajectories from the original datasets. We matched trajectories conditional on age, sex, race/ethnicity, and overlapping segments of the underlying height and weight trajectories using Bayesian optimization methods to minimize the distance between overlapping segments of matched trajectories.10

While the nationally-representative datasets capture individual heterogeneity in lifetime height and weight trajectories, the resulting BMI distribution from these historical trajectories did not correspond to current population estimates due to secular changes in obesity. To adjust for this difference, we used linear regression to estimate recent time trends in age and sex-specific mean BMI and obesity prevalence using data from the 1999-2012 NHANES. These estimates were used to calibrate the synthesized height and weight trajectories to projected age/sex specific mean BMI and obesity prevalence from 2010-2030 using a simulated annealing directed search. The resulting height and weight trajectory sets thus capture the substantial heterogeneity in individual height and weight changes while representing recent age and sex-specific trends in BMI. We selected 50 good-fitting parameter sets from the calibration and generated 50 unique virtual populations to account for uncertainty in both the statistical matching of cross-sectional population data and the projections of future obesity trends.

**Baseline Smoking Prevalence and Individual Smoking Trajectories**

 Baseline individual self-reported smoking status was assigned using data from the same individuals matched from the 2011 BRFSS when assigning self-reported height and weight to individuals in the simulated population. To model individual smoking trajectories, age and sex-specific smoking initiation and cessation rates were applied using the most recent cohort-specific estimates based on U.S. National Health Interview Surveys conducted from 1965 to 2009.11

**Open Population Characteristics**

Each cycle, the model simulates incoming infants to create an open population based on the number of births per year projected in the U.S. Census 2014 National Population Projections. Race-specific projections were used to account for differences in fertility. Incoming infants were bootstrapped among existing model individuals of the same race in order to maintain the covariance of demographic, anthropometric, and behavioral characteristics.

**Mortality**

*Natural History Mortality*

 In each model cycle (i.e. every month), all-cause mortality was simulated using the 2010 U.S. sex and race/ethnicity-specific period life tables. In the baseline scenario (i.e. no intervention), mortality rates were adjusted simultaneously for smoking and BMI using published age-standardized mortality rates for 313,000 men and 214,000 women aged 50-71 years followed for 10 years in the NIH-AARP Diet and Health Study.12 Sex, age, and race/ethnicity-specific mortality rates were adjusted by BMI category (<18.5, 18.5-20.9, 21.0-23.4,23.5-24.9, 25.0 -26.4,26.5-27.9, 28.0-29.9, 30-34.9, 35.0-39.9, 40+) and smoking status (current smoker, former smoker, never smoker) for adults age 30-100. These baseline mortality rates do not adjust for confounding of the observed relationship between BMI, smoking and mortality. Instead, they represent the expected mortality for each of these subgroups.

*Mortality Shift due to Intervention Impact on BMI*

To estimate the causal effect of reductions in BMI due to modeled interventions, individual-level mortality rates were shifted from baseline using published estimates of the hazard of mortality due to excess BMI from the Prospective Studies Collaborative. The analysis was based on data from 57 prospective studies with 894,576 participants. After controlling for age, sex and baseline smoking status and excluding the first five years of follow-up to account undiagnosed disease that may bias the relationship between BMI and mortality, the authors found that each 5 BMI unit increase within the range of 25-50 BMI units was associated with a 30% higher hazard ratio for death (HR: 1.29; 95% CI: 1.27-1.32).13 The estimated HR by age group was used to shift individual-level mortality risk due to BMI reductions compared to the individual’s risk in the baseline model.

**Modeling the Time Course of Intervention Impact on BMI**

The impact of each of the modeled interventions on individual BMI was estimated based on the best available evidence linking the policy or program to change in BMI, weight, daily energy intake or physical activity using a logic model developed for each intervention. For interventions that included evidence on the impact of the intervention on BMI or weight, the duration of the study follow-up was used to model the time course of weight change for individuals receiving the intervention in the simulated population.

For interventions that resulted in a change in energy balance due either to reduced energy consumption or increased energy expenditure, the full steady-state impact of these interventions on individual weight was modeled after 24 months for youth and 36 months for adults. The modeled time course of energy balance to weight change is based on energy balance models developed by Hall et al.15, 16 If individuals in the simulated population were not exposed to the intervention for the entire time needed to reach full effect, they were assigned a portion of the full effect based on the duration of intervention received. Individuals were assumed to maintain the full effect of the intervention relative to their baseline weight trajectories for the remainder of the ten-year analytic timeframe.

**Cost Evaluation**

**We** developed a cost evaluation protocol consistent with general practice in cost-effectiveness projects and building on the work of the Assessing Cost-Effectiveness (ACE) studies. 17-20 All costs are reported in 2014 dollars with future costs discounted at 3% annually. Non-healthcare cost inputs were adjusted to 2014 dollars using the Consumer Price Index.

*Intervention Costing*

The costing protocol entails three steps to evaluating the incremental cost of each of the modeled intervention: 1) Identification of the types of resources used; 2) Measurement of the quantity of each resource used per person, per state, or nationally for each model time period; and 3) Valuation of resource utilization in monetary terms. The model employs a modified societal perspective that includes all opportunity costs regardless of payer except for costs in time and other resources that program participants incur in order to participate in an intervention program. Capital costs were amortized over their useful life for each intervention. Labor costs were based on the 2014 state-specific annual or hourly wages by occupation from the Bureau of Labor Statistics. A fringe rate of 45.56% was applied to all labor costs based on data from the U.S. Bureau of Labor on the proportion of total compensation due to wages. A description of the cost inputs for each modeled intervention is included in Appendix A2 through Appendix A8.

*Healthcare costs*

We estimated the annual total medical expenditures per person in the simulated population by obesity status based on a published analysis of data from the 2001-2003 Medical Expenditure Panel Surveys.21 The authors estimated the incremental cost of healthcare among children and adults with obesity after controlling for age, gender, race/ethnicity, insurance status and census region. The incremental cost for children 6-19 was estimated to be $220. Incremental costs for adults increased with age from $240 at age 20 to $2,147 for ages 74 and older. Costs were inflated to 2014 dollars using the Medical Care Consumer Price Index. Healthcare cost savings were estimated based on the lower annual age and sex-specific obesity prevalence due to each intervention. The actual inputs are described in Table A.3.2.

**Model Outcomes**

Over the 10 year period 2015-2015, the model calculates a range of outcomes for each intervention scaled to the U.S. 2010 Census population of 309 million individuals, including:

* Total and annualized intervention costs
* First year and total intervention reach
* Intervention cost per benefiting individual
* Mean BMI reduction among individuals in the benefiting population
* Intervention cost per BMI unit reduced per benefiting person
* Obesity-related healthcare cost savings
* Net costs including intervention costs and healthcare cost savings
* Life years gained
* Years with obesity prevented
* Reduction in childhood obesity prevalence in the 2025 simulated population
* Cases of childhood obesity prevented in the 2025 simulated population
* Net cost per year with obesity prevented
* Net cost per case of childhood obesity prevented
* Healthcare cost savings per 1$ invested

**Uncertainty Analysis**

The model incorporates uncertainty by running 1,000 iterations of probabilistic sensitivity analysis around a range of overall and intervention-specific parameters. In each iteration, a population was sampled from the 50 generated unique populations to account for baseline uncertainty. Incremental reductions in population obesity prevalence and related reductions in mortality, morbidity and healthcare costs can then be calculated compared to the selected population’s baseline indicators.

Intervention-specific model parameters were sampled from distributions in 1,000 model iterations, with correlation induced between related recruitment, effectiveness, and cost parameters. Intervention outcomes are reported with 95% Uncertainty Intervals based on these 1,000 model iterations. Key model input parameters for each intervention are included in Appendix Exhibits A1.2-A2.2 and A3.2 through A8.2.

**The Microsimulation Model compared to Markov Cohort Simulation Models**

As noted in the main paper, in prior publications we used a Markov cohort simulation model to estimate the impact of two of the interventions modeled here: The SSB Excise Tax and the Ad Tax Deduction.(22-24) The cohort model is more limited than a population-based microsimulation in a number of ways:(25) in its ability to model heterogeneity of individual differences, exposure to the intervention, the accuracy of modeling trajectories of BMI over the lifecourse, and the inability to calculate population estimates for specific years. With the microsimulation model we are able to estimate the number of cases of obesity prevented. For these interventions, the cost per BMI unit reduction estimates were similar under both modeling approaches, and were cost-saving. The microsimulation also allows much more potential for future modeling, including combining interventions.

**Exhibit A3.1 Microsimulation model parameters**

| **Parameter** | **Modeling Assumptions** | **Sources** |
| --- | --- | --- |
| **Population Demographics*** Sex
* Race/Ethnicity
* Census Tract
* Age
 | Individuals were sampled randomly within census tracts to create a simulated population of 1,000,000 children and adults at model initiation  | U.S. 2010 Census |
| **Population Demographics*** Household income
* Poverty ratio
* Public school attendance
* SNAP
 | Individual demographic variables not included in 2010 Census were assigned using non-parametric statistical matching techniques conditional on age, sex, race/ethnicity and census tract | 2008-2012 American Community Survey (ACS) 5-Year Microdata |
| **Adult Self-reported height and weight** | Individual self-reported height and weight were sampled with replacement proportional to sampling weights and assigned to individuals conditional on age, sex, race/ethnicity, household income and state | 2011 Behavioral Risk Factor Surveillance System |
| **Child and adolescent parent-reported height and weight** | Individual parent-reported height and weight were sampled with replacement proportional to sampling weights and assigned to individuals conditional on age, sex, race/ethnicity, household income and state | 2003-2004 and 2007-2008 National Survey on Children’s Health |
| **Measured height and weight, and Dietary Intake** | Individual objectively-measured height and weight were sampled with replacement proportional to sampling weights and assigned to individuals conditional on age, sex, race/ethnicity, household income and self- or parent-reported height and weight percentile. Food frequencies and dietary intake were also simulated from sampled individuals. | 2005-2010 National Health and Nutrition Examination Survey |
| **Lifetime height and weight trajectories** | Lifetime height and weight trajectories synthesized from a number of longitudinal cohort studies. Trajectories calibrated to match projected mean BMI by age and sex from 2010-2030 | * National Longitudinal Survey of Youth
* National Longitudinal Study of Adolescent to Adult Health
* Early Childhood Longitudinal Study-Kindergarten
* Panel Survey on Income Dynamics
* NHANES I Epidemiologic Follow-up Study
* NHANES 1999-2012
 |
| **Baseline Smoking Prevalence and Smoking Trajectories** | Individual smoking prevalence among adults from 2011 BRFSS with initiation and cessation rates from published estimates | * 2011 Behavioral Risk Factor Surveillance System
* 1965-2009 U.S. National Health Interview Surveys11
 |
| **Open population characteristics** | Race-specific projections of births were used, and incoming infants bootstrapped from among existing model individuals to maintain the covariance between demographic, anthropometric, and behavioral characteristics | * U.S. Census 2014 National Population Projections
 |
| **Baseline Mortality Rates** | 2010 age, sex, and race-ethnicity life tables adjusted for smoking and BMI based on data from 527,000 members of the NIH-AARP Diet and Health Study  | * U.S. 2010 Period Life Tables
* NIH-AARP Diet and Health Study12
 |
| **BMI-related mortality reduction due to intervention**  | Based on data from 900,000 participants, each 5 BMI unit increase within the range of 25-50 BMI units was associated with a 30% higher risk of death (HR: 1.29; 95% CI: 1.27-1.32). The estimated HR was used to shift individual-level mortality risk due to BMI reductions compared to the individual’s risk in the natural history model. | * Prospective Studies Collaborative13
 |
| **Healthcare costs** | Annual total medical expenditures per person in the simulated population by BMI category based on a published analysis of data | * 2001-2003 Medical Expenditure Panel Surveys21
 |

**Exhibit A.3.2. Annual Medical Expenditures for Individuals by Age and Obesity Status**

|  |  |  |  |
| --- | --- | --- | --- |
| Age | Annual Medical Expenditures for Individuals with Normal Weight (BMI <30) | Annual Medical Expenditures for Individuals with Obesity (BMI≥30) | Excess Annual Medical Expenditures for Individuals with Obesity (BMI≥30) |

|  |  |  |  |
| --- | --- | --- | --- |
| 0 | 1318 | 1318 | 0 |
| 1 | 1318 | 1318 | 0 |
| 2 | 1318 | 1318 | 0 |
| 3 | 1318 | 1318 | 0 |
| 4 | 1318 | 1318 | 0 |
| 5 | 1318 | 1318 | 0 |
| 6 | 1279 | 1561 | 282 |
| 7 | 1279 | 1561 | 282 |
| 8 | 1279 | 1561 | 282 |
| 9 | 1279 | 1561 | 282 |
| 10 | 1279 | 1561 | 282 |
| 11 | 1279 | 1561 | 282 |
| 12 | 1279 | 1561 | 282 |
| 13 | 1279 | 1561 | 282 |
| 14 | 1279 | 1561 | 282 |
| 15 | 1279 | 1561 | 282 |
| 16 | 1279 | 1561 | 282 |
| 17 | 1279 | 1561 | 282 |
| 18 | 1279 | 1561 | 282 |
| 19 | 1279 | 1561 | 282 |
| 20 | 1457 | 1766 | 309 |
| 21 | 1478 | 1810 | 333 |
| 22 | 1511 | 1863 | 353 |
| 23 | 1545 | 1899 | 354 |
| 24 | 1584 | 1959 | 375 |
| 25 | 1626 | 2023 | 397 |
| 26 | 1671 | 2083 | 412 |
| 27 | 1710 | 2144 | 434 |
| 28 | 1768 | 2230 | 462 |
| 29 | 1824 | 2302 | 478 |
| 30 | 1878 | 2357 | 480 |
| 31 | 1945 | 2462 | 518 |
| 32 | 2014 | 2584 | 570 |
| 33 | 2083 | 2665 | 581 |
| 34 | 2163 | 2753 | 590 |
| 35 | 2246 | 2907 | 661 |
| 36 | 2333 | 3025 | 691 |
| 37 | 2432 | 3105 | 673 |
| 38 | 2521 | 3238 | 717 |
| 39 | 2626 | 3414 | 788 |
| 40 | 2747 | 3642 | 895 |
| 41 | 2866 | 3695 | 829 |
| 42 | 2992 | 3874 | 881 |
| 43 | 3118 | 4060 | 942 |
| 44 | 3239 | 4258 | 1019 |
| 45 | 3365 | 4424 | 1059 |
| 46 | 3518 | 4549 | 1031 |
| 47 | 3660 | 4847 | 1187 |
| 48 | 3817 | 5085 | 1268 |
| 49 | 3983 | 5259 | 1276 |
| 50 | 4142 | 5456 | 1313 |
| 51 | 4320 | 5614 | 1294 |
| 52 | 4522 | 5947 | 1424 |
| 53 | 4694 | 6223 | 1530 |
| 54 | 4862 | 6456 | 1594 |
| 55 | 5048 | 6709 | 1662 |
| 56 | 5256 | 6941 | 1685 |
| 57 | 5441 | 7103 | 1663 |
| 58 | 5636 | 7426 | 1789 |
| 59 | 5832 | 7786 | 1954 |
| 60 | 6049 | 8062 | 2013 |
| 61 | 6260 | 8324 | 2064 |
| 62 | 6431 | 8626 | 2195 |
| 63 | 6655 | 8837 | 2182 |
| 64 | 6862 | 8996 | 2135 |
| 65 | 7055 | 9229 | 2174 |
| 66 | 7238 | 9568 | 2330 |
| 67 | 7419 | 9858 | 2439 |
| 68 | 7580 | 10113 | 2533 |
| 69 | 7743 | 10254 | 2511 |
| 70 | 7901 | 10390 | 2489 |
| 71 | 8059 | 10665 | 2606 |
| 72 | 8171 | 10889 | 2718 |
| 73 | 8325 | 11097 | 2772 |
| 74 | 8417 | 11169 | 2752 |
| 75 | 8417 | 11169 | 2752 |
| 76 | 8417 | 11169 | 2752 |
| 77 | 8417 | 11169 | 2752 |
| 78 | 8417 | 11169 | 2752 |
| 79 | 8417 | 11169 | 2752 |
| 80 | 8417 | 11169 | 2752 |
| 81 | 8417 | 11169 | 2752 |
| 82 | 8417 | 11169 | 2752 |
| 83 | 8417 | 11169 | 2752 |
| 84 | 8417 | 11169 | 2752 |
| 85 | 8417 | 11169 | 2752 |
| 86 | 8417 | 11169 | 2752 |
| 87 | 8417 | 11169 | 2752 |
| 88 | 8417 | 11169 | 2752 |
| 89 | 8417 | 11169 | 2752 |
| 90 | 8417 | 11169 | 2752 |
| 91 | 8417 | 11169 | 2752 |
| 92 | 8417 | 11169 | 2752 |
| 93 | 8417 | 11169 | 2752 |
| 94 | 8417 | 11169 | 2752 |
| 95 | 8417 | 11169 | 2752 |
| 96 | 8417 | 11169 | 2752 |
| 97 | 8417 | 11169 | 2752 |
| 98 | 8417 | 11169 | 2752 |
| 99 | 8417 | 11169 | 2752 |
| 100 | 8417 | 11169 | 2752 |

**Source:** Author calculations based on estimates from Finkelstein and Trogdon inflated to 2014 dollars using the Medical Care Consumer Price Index.21

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**Appendix A4. Restaurant Menu Calorie Labeling**

Intervention Specification and Background

**Modeled Intervention**

We modeled the effect on body mass index (BMI) of the final federal menu labeling regulations implemented under section 4205 of the Patient Protection and Affordable Care Act of 2010.1 The final rule issued by the U.S. Food and Drug Administration (FDA) in November 2014 requires that chain restaurants and similar retail food establishments with 20 or more locations provide calories for standard menu items on menus and menu boards along with a succinct statement concerning suggested daily caloric intake effective December 1, 2016.2

**Background**

In 2007-2008, fast food and full-service restaurants accounted for 14% of total energy among children and 24% of total energy intake among adolescents and adults.3 The consumption of fast food and food away from home has been associated with lower diet quality and higher body weight.4 The *Dietary Guidelines for Americans, 2010* recommends reviewing posted calorie content at restaurants before eating as a strategy to reduce excess caloric intake when consuming foods prepared away from home.5

**Assessment of Benefit**

The impact of federal restaurant menu calorie labeling on BMI was modeled based on the logic model in Appendix Exhibit A4.1. Key model input parameters based on this logic model are described below and are detailed in Appendix Exhibit A4.2. Means and 95% uncertainty intervals are based on 1,000 simulations drawn from parameter-specific distributions.

**Appendix Exhibit A4.1. Logic Model Linking Restaurant Menu Calorie Labeling to Change in BMI**

∆ Menu Labeling Regulations

∆ Calories Purchased

∆

Calories Consumed

∆ BMI

∆ Daily Energy Intake

**SOURCE** Authors’ model **NOTES** BMI is body mass index (kg/m2).

*Meals per Week Impacted by Restaurant Menu Calorie Labeling*

We modeled the individual frequency of meals consumed away from home based on data from the 2007-2010 National Health and Nutrition Examination Survey (NHANES) Diet Behavior and Nutrition Questionnaires. See the Microsimulation Model appendix for additional detail on how dietary variables from NHANES were matched to individuals in the model. In line with the FDA’s preliminary and final regulatory impact analyses, we assumed that 95% of meals away from home were in restaurants and that 73% of all restaurant meals would be in chain restaurants subject to the regulations.6-7 Therefore, we assumed that 69% of all meals away from home based on the NHANES questionnaire were would be impacted by restaurant menu calorie labeling. We did not estimate any reduction in calories from meals away from home purchased in grocery stores, convenience stores or other settings.

*Impact of Restaurant Menu Calorie Labeling on Calories Purchased per Meal*

We modeled the impact of restaurant menu calorie labeling on the calories purchased per restaurant meal based on the summary effect in a recently published systematic review and meta-analysis of the impact of restaurant calorie menu labeling.8 The review found that customers reduced calories ordered or purchased per meal by 7.63 calories (95% CI: -21.02, 5.76) based on six studies conducted in restaurant settings with control conditions. Lacking information on heterogeneity of this effect size by age or demographic variables, we applied the same per meal calorie reduction to all individuals in the simulation model.

*Impact of per Meal Calorie Reductions on BMI*

We assumed that changes in calories ordered and purchased would result in equivalent reductions in consumption and that there would be no compensation for the small reduction in calories during meal at other times of the day, which is consistent with the findings of an experiment involving menu labeling with a daily anchor statement.9 We translated the resulting reduction in daily caloric intake into changes in body weight and BMI using methods described in the Microsimulation Model appendix.

**Reach**

We evaluated the impact of the regulations on all children and adults aged 2 and older. The intervention would reach 307 millionpeople during the first year of implementation.

**Cost**

We based our evaluation of the cost of implementation on the FDA’s final regulatory impact analysis.7 We revised the FDA’s assumptions as following:

* We included 10 FTE labor costs at the FDA to manager roll-out of the regulations
* We assumed that restaurants would choose the least expensive nutritional analysis consistent with the regulations such that each menu item analyzed would require a nutrition database fee ($56) and four hours of dietitian time (BLS Occupation Code: 29-1031). This is consistent with the lower bound costing used by the FDA, but one quarter of the cost of the laboratory analysis that the FDA used to assess the upper bound of the uncertainty around nutritional analysis costs in their analysis.
* We assumed that all restaurants and other outlets nationally would incur costs of implementation regardless of previous state or local regulations in order to align our cost estimates with benefits estimated nationally
* We included the cost of local public health department monitoring to ensure compliance, which we estimated would require 229 FTEs of Public Health Inspectors (BLS Occupation Code: 13-1041) nationally on an annual basis based on the time cost of public health inspection per resident required to implement menu labeling requirements in New York City

**Appendix Exhibit A4.2. Key Model Variables to Evaluate Restaurant Menu Calorie Labeling Effect on BMI**

|  |  |  |  |
| --- | --- | --- | --- |
| **Parameters** | **Mean Value** | **95% Uncertainty Interval** | **Sources and Modeling Assumptions** |
| Individual frequency of meals away from home | N/A | N/A | 2007-2010 National Health and Nutrition Examination Survey Diet Behavior and Nutrition Questionnaires matched to individuals in the simulated population. See Microsimulation Model appendix for additional detail on matching process |
| Proportion of meals away from home impacted | 69% | N/A | Food and Drug Administration regulatory impact analyses6-7 |
| Change in kilocalories ordered per meal in restaurants in which menu labeling implemented | -7.88 | (-23.48, 7.38) | Samples drawn from a normal distribution based on published meta-analysis of six studies in restaurant settings with control8 (mean=-7.63, s.d.=7.70) |

**SOURCE** Sources for each model input parameter are noted in the table. **NOTES** Mean value and 95% uncertainty interval based on 1,000 simulations drawn from parameter-specific distributions. kg is kilograms. BMI is body mass index.

**Appendix A4 References**

1. Food labeling: Nutrition labeling of standard menu items in restaurants and similar retail food establishments, final rule, 79 Federal Register 71155 (2014).
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**Appendix A5. Nutrition Standards for School Meals Intervention Specification and Background**

**Modeled Intervention**

We modeled the effect of implementation of the federal nutrition standards for school meals for all grade levels. As required by the Healthy, Hunger-Free Kids Act of 2010, in January 2012 the USDA released a final rule updating nutrition standards for school meals for the first time in 15 years,1 based largely on recommendations made by the Institute of Medicine.2 The new standards went into effect in the 2012-2013 school year and required schools to increase the availability of fruits, vegetables, whole grains, and fat-free and low-fat milk; reduce levels of sodium, saturated and trans fats; and for the first time set minimum and maximum calorie levels. All changes except for sodium standards were implemented by the 2014-15 school year.

**Background**

The USDA National School Lunch Program (NSLP) and School Breakfast Program (SBP) play a major role in children’s diets, providing up to half of the daily calories for over 30 million children at lunch and 13 million children at breakfast each school day.3 Nearly all public schools participate in the NSLP and most (79%) participate in the SBP.4 The programs aim to provide nutritious meals to children and youth, in accordance with national nutrition guidance.

**Assessment of Benefit**

The impact of the school meal nutrition standards on BMI was modeled based on the logic model in Appendix Exhibit A5.1. We used evidence from one natural experimental cross-sectional study5 evaluating the difference in weight status by school meal eligibility among 4,870 8th grade students residing in states with nutrition standards exceeding the 1995 USDA standards (the last revision of the standards before 2012) compared to those whose laws did not exceed USDA standards. The study found that the adjusted difference in mean BMI percentile between students who obtained free/reduced price lunches at school was lower than those who did not obtain lunch at school in states that exceeded USDA standards compared with those who did not (B -11.0; 95% CI -17.7, -4.3), and for students who obtained full price lunches at school the difference was smaller and not significant (B -6.0; 95% CI -12.7, 0.6).5 Corresponding differences in BMI units (kg/m2, not published in the manuscript) by gender were obtained from the lead author (D. Taber, personal communication, June 8, 2015). Key model input parameters are detailed in Appendix Exhibit A5.2.

**Appendix Exhibit A5.1. Logic Model Linking Nutrition Standards for School Meals to Change in BMI**

∆ Nutrition Standards for School Meals

∆ BMI

**SOURCE** Authors’ model **NOTES** BMI is body mass index (kg/m2).

**Reach**

The intervention reaches children and youth in grades kindergarten through 12 who attend public schools participating in the NSLP and obtain meals reimbursable through the NSLP. Students are categorized according to meal eligibility status, with on average 48% eligible for free or reduced price meals (range 26-71% by state) and 52% eligible for full price meals.7 We estimate that 89% of free or reduced price meal eligible students and 35% of full price meal eligible students participate in school meals, based on meal participation rates3 and the proportion of all students in each meal eligibility category.

**Costs**

We estimated the cost of the intervention based on cost analyses done by the federal government in conjunction with the passage of the regulation. We estimate that implementation of the intervention requires additional state agency administrative labor for providing ongoing training and technical assistance, as well as coordinated review effort and compliance monitoring, at a cost of $9.4 million per year.1 School districts would pay an additional $414.8 million in food costs and $400 million in food service labor costs per year.1,8 The federal government would spend an additional $396 million per year in reimbursements for meal costs at the 6 cents higher rate for compliant programs8 and $25 million per year to provide grants to school districts for purchasing kitchen equipment.9

**Appendix Exhibit A5.2. Key Model Variables to Evaluate School Meals Effect on BMI**

|  |  |  |  |
| --- | --- | --- | --- |
| **Parameters** | **Mean Value** | **95% Uncertainty Interval** | **Sources and Modeling Assumptions** |
| Change in BMI (kg/m2) due to change in school meal nutrition standards, among students obtaining free or reduced price meals | -1.76 | (-3.59, 0.08) | Samples drawn from normal distributions by sex (males: mean=-1.95, 95% CI=-3.79, -0.11; females: mean=-1.55, 95% CI=-3.25, 0.15) based on one study by Taber et al.5 (D. Taber, personal communication, June 8, 2015) |
| Change in BMI (kg/m2) due to change in school meal nutrition standards, among students obtaining full price meals | -0.83 | (-2.59, 0.98) | Samples drawn from normal distributions by sex (males: mean=-0.79, 95% CI=-2.59, 1.02; females: mean=-0.85, 95% CI=-2.59, 0.88) based on one study by Taber et al.5 (D. Taber, personal communication, June 8, 2015) |

SOURCE Sources for each model input parameter are noted in the table. NOTES Mean value and 95% uncertainty interval based on 1,000 simulations drawn from parameter-specific distributions. kg is kilograms. m is meters. BMI is body mass index. CI is confidence interval.

**Appendix A5 References**

1. U.S. Department of Agriculture. Nutrition Standards in the National School Lunch and School Breakfast Programs, final rule, 7 CFR Parts 210 and 220. Vol 77. Washington, D.C.: Federal Register; 2012:4088-4167.

2. Institute of Medicine. *School Meals: Building Blocks for Healthy Children.* Washington, D.C.: Institute of Medicine; 2010.

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9. USDA Office of Communications. USDA Awards Grants to Support Schools Serving Healthier Meals and Snacks, Release No. 0058.15. March 6, 2015; http://www.usda.gov/wps/portal/usda/usdahome?contentidonly=true&contentid=2015/03/0058.xml. Accessed May 22, 2015.

**Appendix A6. Nutrition Standards for All Foods and Beverages Sold in Schools (Smart Snacks) Intervention Specification and Background**

**Modeled Intervention**

We modeled the effect of implementation of the national policy requiring nutrition standards for all foods and beverages sold in schools, according to the USDA interim final rule issued in June 2013.1 As required by the Healthy, Hunger-Free Kids Act of 2010, the USDA established nutrition standards for all foods sold in schools, which were implemented beginning in the 2014-15 school year.1 These standards, which set allowable food and beverage types and nutrient levels, replace the previous federal regulations restricting the sale of foods of minimal nutritional value (FMNV; i.e., soft drinks, water ices, chewing gum, and certain candies). The food standards focus on providing whole grains, fruits and vegetables, and key dietary nutrients while limiting calories, sodium, fats, and sugar. Beverage standards restrict sugar-sweetened beverages and allow water, low-fat milk, and 100% juice.1

**Background**

The National School Lunch Program (NSLP) provides students with low-cost or free meals in participating schools, via federal reimbursements for qualifying meals. Foods and beverages other than federally reimbursable school meals (aka “competitive foods”) are also sold in vending machines, a la carte, and/or other venues in the majority of schools – 65% of elementary,2 91% of middle,3 and 99% of high school students3 have access. Each year, schools nationally earn $6.5 billion in revenue from these snacks, which is 16% of all school food service revenue.1 Because snacks in school have been widely available and of typically poor nutritional quality,4 the Institute of Medicine recommends strong nutrition standards for all foods and beverages sold or provided in schools.5

**Assessment of Benefit**

The impact of Smart Snacks in School on BMI was modeled based on the logic model in Appendix Exhibit A6.1. We used evidence from one retrospective cohort study6 that examined changes in state laws addressing snacks in school between 2003 and 2006 from the elementary to middle school level and changes in objectively measured BMI between spring 2004 (5th grade) and spring 2007 (8th grade) among the Early Childhood Longitudinal Study Kindergarten Class (ECLS-K) cohort. Compared to students in 15 states with consistently no laws, over 3 years, students in 6 states with new laws that restricted snack sales beyond FMNV gained 0.10 fewer BMI units (95% CI: -0.33, 0.12), and students in 7 states with new weaker laws that recommended but did not require some standards gained 0.39 fewer BMI units (95% CI: -0.56, -0.22). In our model, we assume the BMI reduction for middle school (MS) and high school (HS) students ranges from 0.10–0.39 (mean BMI reduction for MS/HS: 0.245), and for elementary school (ES) students, that it is 53% of this effect (mean BMI reduction for ES: 0.13), corresponding to the percentage of daily kilocalories from competitive foods they consume compared to middle school students.4 Key model input parameters are detailed in Appendix Exhibit A6.2.

**Appendix Exhibit A6.1. Logic Model Linking Smart Snacks in School to Change in BMI**

∆ Smart Snacks Standards

∆ BMI

**SOURCE** Authors’ model **NOTES** BMI is body mass index (kg/m2).

**Reach**

The intervention reaches all children and youth in grades kindergarten through 12 attending schools that participate in the National School Lunch Program (NSLP).

**Costs**

We estimated the cost of the intervention based on cost analyses done by the federal government in conjunction with the passage of the regulation and expert stakeholder opinion. In order to implement the intervention, additional labor will be required for food service staff to keep records of compliance with the nutrition standards (e.g., receipts, nutrition labels, product specifications). According to the USDA,1 the recordkeeping cost is estimated at $23.4 million per year. Additionally, we included the cost of one-time trainings for district-level food service directors and for cafeteria managers in schools with a la carte venues.

**Appendix Exhibit A6.2. Key Model Variables to Evaluate Smart Snacks in School Effect on BMI**

|  |  |  |  |
| --- | --- | --- | --- |
| **Parameters** | **Mean Value** | **95% Uncertainty Interval** | **Sources and Modeling Assumptions** |
| Change in BMI (kg/m2) due to change in nutrition standards for all foods and beverages sold in schools | -0.24 | (-0.38, -0.11) | Samples drawn from a uniform distribution (lower bound=-0.39, upper bound=-0.10) based on one study by Taber et al.6 |
| Average daily intake (kcal/day) of competitive foods and beverages among elementary school students | 63 | (51, 75) | Samples drawn from a normal distribution for the proportion of students consuming any competitive foods or beverages (mean=0.291, s.e.=0.03) multiplied by the mean daily intake (216 kcal/day) of competitive foods and beverages among students who consume any, based on a nationally representative survey (SNDA-IV)4 |
| Average daily intake (kcal/day) of competitive foods and beverages among middle school students | 120 | (103, 136) | Samples drawn from a normal distribution for the proportion of students consuming any competitive foods or beverages (mean=0.437, s.e.=0.03) multiplied by the mean daily intake (273 kcal/day) of competitive foods and beverages among students who consume any, based on a nationally representative survey (SNDA-IV)4 |

**SOURCE** Sources for each model input parameter are noted in the table. **NOTES** Mean value and 95% uncertainty interval based on 1,000 simulations drawn from parameter-specific distributions. kg is kilograms. m is meters. BMI is body mass index. kcal is kilocalories.

**Appendix A6 References**

1. U.S. Department of Agriculture. National School Lunch Program and School Breakfast Program: nutrition standards for all foods sold in school as required by the Healthy, Hunger-Free Kids Act of 2010, interim final rule, 7 CFR Parts 210 and 220. Vol 78: Federal Register; 2013:39068-39120.

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**Appendix A7. Improving Nutrition, Physical Activity, and Screen Time Policies and Practices in Early Care and Education through the Nutrition and Physical Activity Self-Assessment for Child Care (NAP SACC) Program: Intervention Specification and Background**

**Modeled Intervention**

We modeled the effect of the nationwide, state-by-state incorporation of the Nutrition and Physical Activity Self- Assessment for Child Care (NAP SACC) program into state Quality Rating and Improvement Systems (QRIS) for early care and education (ECE) programs, assuming completion of NAP SACC would be required for voluntarily attaining QRIS certification. NAP SACC involves child care health consultants helping ECE program directors to complete self-assessments of current nutrition, physical activity (PA), and screen time practices and policies and then implement improvements.

**Background**

Early care and education programs reach 64.3% of 3-5 year olds in the U.S.,1 and can have a profound influence on young children’s eating and PA habits.2-6 However, ECE programs tend not to meet recommendations for healthy nutrition, PA, and screen time practices.4-15 The NAP SACC program, which has been frequently evaluated16-18 and has been utilized by several different state and local organizations,19 is designed to help ECE programs improve practices. Most states are developing Quality Rating and Improvement Systems (QRIS) for ECE programs, which provide opportunities for programs to voluntarily earn levels of certification in return for completing certain trainings and demonstrating other quality indicators.20 Although NAP SACC Is not currently incorporated into QRIS, we model this implementation scenario given that QRIS could a promising mechanism for disseminating NAP SACC widely.

**Assessment of Benefit**

The impact on child BMI of nationwide implementation of NAP SACC through QRIS certifications was modeled based on the logic model in Appendix Exhibit A7.1. We used evidence from a group-randomized, controlled trial of NAP SACC implementation across three states that examined the impact of NAP SACC on the BMI z-score of 3-5 year old children;18 this study found the intervention was associated with a reduction in BMI z-score of -0.14 units (SE: 0.06, p=0.02) in intervention compared to control children 9 months after the intervention began. In our model, we convert BMI z-score to BMI by multiplying the z-score change by the average standard deviation for BMI for girls (SD=1.54) and boys (SD=1.39) aged 4.0 – 4.49 years in the CDC 2000 Growth Charts reference population;21 this results in an estimated BMI effect of -0.21 kg/m2 per child (SE: 0.09). Key model input parameters based on this logic model are described below and are detailed in Appendix Exhibit A7.2.

**Appendix Exhibit A7.1 Logic Model Linking the Nutrition and Physical Activity Self-Assessment for Child Care to Change in BMI**

∆ BMI

∆ Addition of NAP SACC program to QRIS certification requirement for ECE programs

SOURCE Authors’ model NOTES BMI is body mass index (kg/m2). NAP SACC is the Nutrition and Physical Activity Assessment for Child Care. QRIS is Quality Rating and Improvement Systems. ECE is Early Care and Education.

**Reach**

The intervention reaches all 3-5 year old children attending licensed ECE programs (both child care centers and family daycare homes) that opt to participate in their state’s QRIS. Comparing estimates of licensed ECE program capacity from a survey of state child care licensing agencies22 with Census estimates of the total 3-5 year old population in each state, we calculated the state-specific probability of a 3-5 year old attending a licensed child care center or family daycare home (national average: 41.2%). We then internally surveyed each state’s licensing agency to ascertain whether a QRIS was in place and, if so, how many centers and/or family daycares participated; we then estimated the state-specific probability of QRIS participation for ECE programs (average: 28.8% of licensed programs). We assumed that all programs in QRIS would be eligible for the NAP SACC intervention, but that 73% would complete the intervention;16 all children attending these 73% of eligible programs were then assumed to benefit from the intervention.

**Costs**

We estimated the cost of the intervention based on data provided by both the authors of the study used to estimate the BMI effect (A. Alkon, personal communication, March 18, 2015) and by staff at Go NAP SACC, which is disseminating the NAP SACC intervention (E. Morris, personal communication, 9/19/14). NAP SACC requires training of a cadre of child care health consultants (CCHCs) to work with ECE programs, which we assume is overseen by each state. CCHCs then spend time consulting with each ECE program, which we also assume is paid for by each state; we also estimate travel costs for CCHCs to consult with programs. ECE program directors spend time implementing NAP SACC, while ECE program teachers are assumed to spend 5 hours in training for the program. Participating ECE programs also purchase updated physical activity equipment upgrades and a binder of NAP SACC materials. Lastly, we estimate the likely additional costs incurred by improving nutrition practices by estimating the most likely changes to meal patterns, comparing to baseline meal service, and estimating the cost difference per child per day using the USDA Center for Nutrition Policy and Promotion Food Cost Database.23 Additionally, we assume labor costs at the state level for QRIS administrators to monitor compliance with the intervention.

**Appendix Exhibit A7.2.** Key Model Variable to Evaluate NAP SACC Effect on BMI

|  |  |  |  |
| --- | --- | --- | --- |
| Parameters | Mean Value | 95% Uncertainty Interval | Sources and Modeling Assumptions |
| Change in BMI resulting from attending ECE program participating in NAP SACC | -0.21 | (-0.39, -0.03) | Samples drawn by normal distributions based on one study by Alkon et al.18 BMI z-score change converted to BMI change by multiplying the z-score change by the average of the standard deviation of BMI for girls (1.54) and boys (1.39) at age 4.0 – 4.49 (the mean age of children in the Alkon et al. trial) in the CDC 2000 Growth Charts reference population.21 |

SOURCE Sources for each model input parameter are noted in the table. NOTES Mean value and 95% uncertainty interval based on 1,000 simulations drawn from parameter-specific distributions. NAP SACC is Nutrition and Physical Activity Self Assessment for Child Care. BMI is body mass index.

**Appendix A7 References**

1. Snyder TD, Dillow SA. T.D., and Dillow, S.A. (2013). Digest of Education Statistics 2012 (NCES 2014-015), Table 202.10. National Center for Education Statistics, Institute of Education Sciences, U.S. Department of Education. Washington, DC: 2013. Accessed 2/26/15 at: http://nces.ed.gov/programs/digest/d13/tables/dt13\_202.10.asp
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**Appendix A8. Bariatric Surgery Intervention Specification and Background**

**Modeled Intervention.**

We modeled the effect of a nationwide four-fold increase in the use of bariatric surgery by eligible adolescents, ages 13 to 19 years old, including Roux-en-Y gastric bypass, laparoscopic adjustable gastric banding, and sleeve gastrectomy as currently performed. Intervention components include pre-surgical evaluation, testing, and multidisciplinary medical visits additional to the surgery itself. The proposed intervention would increase the rate of bariatric surgery four-fold over current levels, and will receive the three different surgeries at the higher rate but the same relative proportion seen at baseline.

**Background**

Severe obesity, defined by a BMI ≥120% of the 95th percentile or ≥35 kg/m2 (considered Class 2 obesity in adults), is the fastest growing subcategory of childhood obesity.1 A BMI ≥140% of the 95th percentile or ≥ 40 kg/m2 can be further defined as Class 3 obesity. The prevalence of Class 3 obesity among those 12-19 is approximately 2.1% (so approximately 640,000 adolescents ages 13-19).2 Compared to the overweight and/ or obese, the severely obese have a distinctly adverse cardiometabolic profile and are much less likely to respond to lifestyle modification.1,3 Bariatric surgery may be the only effective treatment option for a select group of severely obese adolescents. The most commonly performed procedures in adolescents are laparoscopic Roux-en-Y gastric bypass [RYGB], adjustable gastric banding [LAGB], and sleeve gastrectomy [SG].4 The American Society for Metabolic and Bariatric Surgery pediatric committee best practice guidelines5 recommend that surgery be considered with a BMI of ≥35 kg/m2 with major co-morbidities or a BMI of ≥40 kg/m2 with minor co-morbidities; however, other clinical organizations (such as the American Academy of Pediatrics6) recommend a much more conservative approach and many physicians are reluctant to refer adolescents for weight loss surgery, citing the invasiveness and potential complications of the procedure.7 Recent evidence suggests that approximately 1,000 adolescents undergo inpatient surgical weight loss procedures each year, which is far fewer than the total number of adolescents with Class 3 obesity;8,9 more current estimates by the authors indicate 1150 cases per year. Since there are approximately 640,000 fitting the criteria, less than 2 in 1,000 receive the procedure.

**Assessment of Benefit**

A systematic review of the literature was performed to identify all available studies. Of the yielded references, fifty-nine studies were reviewed to examine the effectiveness and cost-effectiveness of surgical weight loss in adolescents. Ultimately, an existing systematic review and meta-analysis of adolescent bariatric surgery performed by Black and colleagues10 was chosen to be applied to the model.

Effectiveness Estimates:

* Black et al.,10 reviewed 21 studies with a total of 637 patients; this included 1 randomized controlled trial, 12 retrospective studies, and 8 prospective observational studies.
* Across surgery types (RYGB, LAGB, and SG) the average weighted mean change in BMI units was -13.5 kg/ m2 (95% CI -15.1, -11.9).
* Divided by surgical procedure, RYGB produced the largest change in BMI (-17.2 kg m2; 95% CI -20.1, -14.3) and LAGB produced the smallest BMI reduction (-10.5 kg m2; 95% CI -11.8, -9.1). Sleeve gastrectomy resulted in an intermediate reduction of -14.5 kg m2; (95%CI -17.3, -11.7).10

**Appendix Exhibit A8.1. Model Linking Bariatric Surgery to Change in BMI**

∆ BMI

Bariatric Surgery

**SOURCE Authors’ model NOTES BMI is body mass index (kg/m2).**

**Reach**

* We assumed that all adolescents with a BMI of >=40 are eligible, however, few will actually be offered the procedure (about 2 in a 1000 currently receive the surgery).
* We assumed that 1.56% of eligible adolescents actually have the evaluation for the procedure.
* We assumed that only 60% of adolescents evaluated and offered the surgical procedure will actually follow through to completion. (Note: Number referred to surgery 4600/0.6 = 7,667, which is a 40 percent drop-out rate.)
* We assumed that at baseline there is an estimated one quarter population coverage of this procedure by Medicaid.12 Moreover, the rate of use among those eligible would increase if Medicaid (and other insurance coverage) increased under policy change. We assumed this to be 4 times the current rate.

Based on our survey of adolescent bariatric centers (unpublished data), about 60% of referred patients ultimately undergo surgery; extrapolated to the number of potentially eligible patients, about 4,600 severely obese adolescents would undergo surgery in our primary scenario.

**Costs**

Previously published cost estimates for surgical weight loss vary by procedure type. In our scenario, we assume that 43% of patients undergo RYGB, 51% undergo sleeve gastrectomy, and 6% undergo LAGB (author’s unpublished analysis of the most recent KIDS data). We include outpatient pre-procedural evaluation and diagnostic testing, the hospital admission, and physician fees.8,11 We estimate costs from the study of Weiner et al.11 With data on the relative frequency of each procedure type, we estimate the overall cost of surgical weight loss as a whole.

In the primary scenario, the surgical weight loss intervention would reach 4600 severely obese adolescents with a BMI + ≥ 40 kg/m2 in the first year. To implement bariatric surgery for the benefitting population in the primary scenario, the annual cost would be $26,174,836.00.

**Appendix Exhibit A8.2 (table)**

**Caption: Key Model Variable to Evaluate Bariatric Surgery Effect on BMI**

**Sources/Notes: SOURCE** Sources for each model input parameter are noted in the table. **NOTES** Mean value and 95% uncertainty interval based on 1,000 simulations drawn from parameter-specific distributions. RGYB is Roux-en-Y gastric bypass, Sleeve is sleeve gastrectomy, LAGB is laparoscopic adjustable gastric banding. BMI is body mass index.

|  |  |  |  |
| --- | --- | --- | --- |
| **Parameters** | **Mean Value** | **95% Uncertainty Interval** | **Sources and Modeling Assumptions** |
| Change in BMI resulting from bariatric surgery proceduresRYGBSleeveLAGB | -17.9-10.5-14.5 | (-20.1, -14.3)(-11.8,-9.1)(-0.17.3, -11.7) | Samples drawn from normal distributions with means and standard deviations based systematic review and meta-analysis by Black et al.10  |

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