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Three Interventions That Reduce Childhood Obesity Are Projected To Save More Than They Cost To Implement

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Abstract

Policymakers seeking to reduce childhood obesity must prioritize investment in treatment and primary prevention. We estimated the cost-effectiveness of seven interventions high on the obesity policy agenda: 1) sugar-sweetened beverage excise tax; 2) elimination of tax subsidy for advertising unhealthy foods to youth; 3) restaurant menu calorie labeling; 4) nutrition standards for school meals; 5) nutrition standards for foods and beverages sold in schools; 6) improved early care and education; 7) increased adolescent bariatric surgery. We used systematic reviews and a microsimulation model of national intervention implementation over the period 2015–2025

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to estimate impact on obesity prevalence and cost-effectiveness for reducing body mass index. Three preventive interventions saved more in health care costs than they cost to implement, and prevented from 129,000 to 576,000 cases of childhood obesity. Adolescent bariatric surgery had negligible impact on obesity prevalence. Results highlight the importance of primary prevention for policymakers aiming to reduce childhood obesity.

Introduction

The childhood obesity epidemic in the United States impacts all segments of society. There is a clear need for action by governments, foundations, and other relevant institutions to address this public health problem. Controlling childhood obesity is complex because many risk behaviors are involved, shaped by multiple environments and requiring multiple intervention strategies.(1–4) However, asking simply "what works," without considering costs has led to the proliferation of hundreds of obesity treatment and prevention initiatives with limited evaluative information. Little serious discussion has taken place about the relative costs or cost-effectiveness of these strategies. Of the more than 31,382 published articles on "child obesity" in the National Institutes of Health Pub Med database (through 2014), only 89 also refer to "cost-effectiveness." Communities and health agencies have limited resources to address high rates of childhood obesity, and need to know how best to invest those resources.

There are two main approaches to altering the population prevalence of obesity in children: treating obesity after onset, and preventing excess weight gain (primary prevention). Many studies have documented the effectiveness of interventions using these two different approaches. For example, a meta-analysis of adolescent bariatric surgery studies indicates an average reduction in body mass index (BMI: kg/m^2) of 13.5 units following this procedure.(5) Some nonsurgical interventions to treat childhood obesity are effective, but effect sizes are small relative to the high BMIs (or BMI z-scores) of children pre-intervention,(6) and treatments may reach too few children to make a substantial population impact. Bariatric surgery for example is currently used with about 1,000 adolescents per year.(7)

The promise of primary prevention strategies during childhood has been bolstered by recent findings generated by mathematical models of the physiological development of excess weight in children, adolescents and adults.(8, 9) Modeling indicates that excess weight accumulates slowly, and excess weight gain among young children is due to relatively small changes in energy balance. For example, among children ages 2–5, average excess weight gain in the US is driven by an excess of about 33 extra kcal per day.(10) Changes needed to prevent excess weight gain and prevent obesity are thus quite small in childhood. By adolescence, however, excess weight has accumulated for more than a decade, with an average imbalance of almost 200 extra kcal/day.(10, 11) The typical adult with a BMI greater than 35 (about 14% of the adult population) consumes an extra 500 kcal per day greater than needed to maintain a healthy bodyweight.(9) Improving energy balance via improved diet and physical activity early in childhood thus requires much smaller changes compared to those needed once obesity is established in adolescence and adulthood.

In addition, a large body of experimental evidence indicates that certain behavioral changes can reduce BMI and obesity prevalence in children. For example, as documented in Appendix A1, there is clear evidence of the effectiveness of reducing intake of sugar sweetened beverages (SSB) on reducing BMI and obesity prevalence.(12)

There is also strong evidence that reduced viewing of television and other screen time leads to significant reductions in BMI and obesity prevalence, mainly via dietary changes.(13) (Appendix A3)(12). Despite growing evidence that targeted interventions can improve diet and reduce BMI and obesity prevalence, we have very limited evidence concerning the cost-effectiveness of these approaches and the potential population impact of either treatment or preventive interventions in the US.

In this paper we present results of an evidence review and microsimulation modeling project concerning the cost-effectiveness and population impact of seven interventions identified as potentially important strategies to address childhood obesity. We conducted systematic evidence reviews of intervention effectiveness, and estimated costs and reach under specified implementation scenarios as detailed in Appendices A1 and A3-A8.(12)We developed a microsimulation model to assess key cost-effectiveness metrics of these interventions if they were to be implemented nationally.

Study Methods and Data

We developed an evidence review process and microsimulation model to evaluate the cost effectiveness of interventions for childhood obesity. Our modeling framework builds on the Australian Assessing Cost-Effectiveness (15, 16) in obesity(17) and prevention studies.(18) Our microsimulation model uses US population, mortality data and health care cost data. We focused on outcomes of cost per BMI unit change over two years following an intervention, and 10 year changes in obesity, health care costs, and net costs.[1]

Our approach has distinct methodological components designed to improve both the strength of evidence and applicability of results to real world decision-making. We created a stakeholder group of 32 US policymakers, researchers, and nutrition and physical activity experts to provide advice concerning interventions to evaluate, data, analyses, and implementation and equity issues. This group advised us to look broadly for interventions to evaluate across settings and sectors. The clinical subgroup selected adolescent bariatric surgery as an important benchmark clinical intervention to evaluate, as currently many Medicaid programs and other insurers pay for this treatment.(20)

Our stakeholder group selected for the study seven interventions that are high on the treatment and prevention policy agenda (further details of the interventions are provided in the supplementary appendices.(12)):

1. An excise tax of one cent per ounce of sugar sweetened beverages, applied nationally and administered at the state level (“SSB Excise Tax”).

[1]We have followed recommendations of the US Panel on Cost-Effectiveness in Health and Medicine in reporting results, including a 3% discount rate (19)

2. Elimination of the tax deductibility of advertising costs of TV advertisements for "nutritionally-poor" foods and beverages seen by children and adolescents ("Ad Tax Deduction").
3. Restaurant menu calorie labeling ("Restaurant Calorie Labeling"), modeled on the federal menu regulations implemented under the Patient Protection and Affordable Care Act of 2010.
4. Implementation of nutrition standards for federally reimbursable school meals sold through the National School Lunch and School Breakfast Programs ("School Meals"), per the USDA January 2012 Final Rule as required by the Healthy, Hunger-Free Kids Act of 2010.
5. Implementation of nutrition standards for all foods and beverages sold in schools outside of reimbursable school meals ("Smart Snacks in School"), per the USDA June 2013 Interim Final Rule as required by the Healthy, Hunger-Free Kids Act of 2010
6. Improved early childhood education policies and practices: national dissemination of the Nutrition and Physical Activity Self Assessment for Child Care ("NAP SACC") program
7. A nation-wide four-fold increase in utilization of adolescent bariatric surgery ("Bariatric Surgery").

Intervention Specifications, Implementation Scenarios and Costs

We specified a national implementation scenario for each of the interventions using the best available data for population eligibility and costs at each level of implementation from recruitment to outcomes. Costing follows standard guidelines(21, 22) (see Appendix A2 for details of models and costing). All costs were calculated in 2014 dollars, adjusted for inflation using the U.S Bureau of Labor Statistics Consumer Price Index.

Evidence Reviews of Intervention Effects

For all interventions we estimated the effects on BMI using an evidence review process consistent with Cochrane guidelines and the GRADE approach.(23, 24) Details of the evidence reviews for the interventions are in Appendices A1 and A3-A8.(12)

Microsimulation Model

We developed a microsimulation model to calculate costs and effectiveness of the interventions through their impact on BMI changes, obesity prevalence, and obesity-related health care costs over ten years (2015–2025). This is a stochastic, discrete-time, individual-level microsimulation model of the population in the United States to simulate the experience of the population from 2015–2025. The model uses data from the US Census, American Community Survey, Behavioral Risk Factor Surveillance System, National Health and Nutrition Examination Surveys, the National Survey on Children's Health, and longitudinal data concerning weight and height from five publicly accessible sources.[2] We use smoking initiation and cessation rates from the National Health Interview Surveys and mortality rates by smoking and BMI from the NIH-AARP Diet and Health Study. Details of the data, analyses, and model are in Appendix A2, and key model input parameters are listed in Appendix Exhibit A2.1.(12)

Effects on obesity-related health care costs are based on national analyses indicating excess health care costs associated with obesity among children and adults (see Appendix A2)(12). We assumed that each intervention took time to decrease BMI, typically 18–36 months.(9, 11) Estimates of intervention costs included one-time start-up and ongoing costs, as well as enforcement and compliance cost, but did not include costs of passing a policy. The intervention annual costs are the average of the discounted total costs.

We used a “modified” societal perspective on costs, meaning there are several possible economic impacts of the interventions that we did not include, such as productivity losses associated with obesity or patient costs for things such as transportation to clinic visits or the value of time spent seeking or receiving medical care.[3]

We assumed that effects were sustained over the model timeframe -- an additional eight years after the two years of start-up. For policy changes like the SSB excise tax, the Ad Tax Deduction, and Restaurant Calorie Labeling, sustaining an effect for 10 years is reasonable, as the changed policy will continue over that period. For the school-based interventions (School Meals and Smart Snacks in School) we can assume that most children will be exposed to these for a substantial period of time –during grades 1 through 12 for example. For bariatric surgery we can also assume that the surgical change will persist over this time period.

Details of key input parameters for the interventions modeled where there is known variation, including their distributions and assumptions, are outlined in Appendices A1 and A3-A8.(12) All results are expressed in 2014 US dollars and discounted at 3% annually.

We calculated costs per BMI units reduced over two years (2015–2017). We estimated health care costs, net costs, and net cost saved per dollar spent over ten years (2015–2025), as this is a time frame frequently used in policy calculations. We inflated health care costs to 2014 dollars using the Medical Care Consumer Price Index. We estimated obesity cases prevented and changes in childhood obesity prevalence at the end of the analytic period in 2025.

Uncertainty and Sensitivity Analyses

We calculated probabilistic sensitivity analyses by simultaneously sampling all parameter values from predetermined distributions. We report 95% uncertainty intervals (around point estimates) in Exhibit 1, taking 2.5 and 97.5 percentile values from simulated data.(25) We calculated uncertainty intervals using Monte Carlo simulations programmed in JAVA over

[2]Data sources include the National Longitudinal Survey of Youth, the National Longitudinal Study of Adolescent to Adult Health, the Early Childhood Longitudinal Study-Kindergarten, the Panel Survey on Income Dynamics, and the NHANES I Epidemiologic Follow-up Study.

[3]It was reasonable to exclude these economic impacts because they are difficult to estimate systematically, and likely to be small within a 10 year period, relative to the intervention and health care costs.

1,000 iterations of the model for a population of one million simulated individuals scaled to the national population size.

Stakeholder Group Consultation

The stakeholder group assisted in reviewing additional considerations, including quality of evidence, equity, acceptability, feasibility, sustainability, side effects, and impact on social and policy norms.

Limitations

The results of this study are based on a simulation model that incorporates a broad range of data inputs. While we have included the best available evidence on population characteristics, likely trajectories of obesity prevalence and obesity-related health care costs, our ability to forecast precise impacts of all of the modeled interventions is limited by the uncertainty around each of these inputs and by the assumptions required to build the model (see Appendix A2)(12).

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.(26–28) The cohort model is limited in its ability to model heterogeneity of individual differences, exposure to the intervention, trajectories of BMI over the lifecourse, and cannot calculate population estimates for specific years. With the microsimulation model we are able to estimate the number of cases of obesity prevented. For both interventions, the cost per BMI unit reduction estimates were similar under both modeling approaches, and both interventions were cost-saving.

We modeled each of the interventions separately, limiting our ability to estimate their cumulative effects. Future obesity prevention simulation modeling should begin to evaluate the impact of simultaneous implementation of multiple interventions.

There is limited evidence directly linking the evaluated policies to change in population-level obesity prevalence. However, as detailed in Appendices A1 and A3-A8 (12), seven of the intervention strategies are supported by randomized trials or natural or quasi experimental evaluations(29) linking the policy or behavioral mechanism targeted by each policy directly to change in BMI. We have incorporated uncertainty for all of the underlying model inputs into the probabilistic uncertainty analyses (see Appendix A2.1)(12).

Because we have focused on obesity, we did not incorporate additional health improvements and health care cost reductions due to improvements in diet and physical activity independent of their impact on changes in BMI (for example, reductions in diabetes and heart disease).(30)

Study Results

There are large differences in the projected population reach (see Exhibit 1) of the interventions. The population reach of bariatric surgery is very limited, even assuming a four-fold increase in adolescents receiving the procedure. The most recent national data indicate that in 2012, among adolescents classified as having grade 3 obesity (a BMI of roughly 40 or above) less than 2 in 1,000 received the procedure (Appendix A9). The largest population reach among the interventions studied occurred with interventions affecting the whole population – as with the sugar-sweetened beverage excise tax and restaurant calorie labeling (307 million). The annual intervention cost of interventions was driven by both the cost per person and the population reach, and these also vary greatly. The differences in cost across interventions are large (more than 300-fold).

Differences across interventions in the intervention cost per BMI unit reduction varied more than 1,000 fold (see Exhibit 1). Eliminating the tax deduction for advertising nutritionally-poor foods to children on TV would reduce a BMI unit for $0.57 per person, while in contrast increasing access to bariatric surgery costs $1,390.

Three of the interventions studied were found to be cost saving across the range of modeled uncertainty (see Exhibit 2): the sugar-sweetened beverage Excise Tax, Ad Tax Deduction, and Smart Snacks in School. These interventions are projected to save more in reduced health care costs over the period studied than the interventions cost to implement. Perhaps more importantly, these interventions are projected to prevent respectively 576,000, 129,100, and 345,000 cases of childhood obesity in the year 2025. The net saving to society for each dollar spent is projected at $30.78, $32.53 and $4.56.

Restaurant menu calorie labeling was indicated to be cost-saving, although on average the uncertainty intervals were wide due to the wide confidence interval around the estimated per meal reduction in calories ordered or purchased as a result of the intervention (see Appendix A4). This uncertainty highlights the need for ongoing monitoring of this policy when it is implemented in 2016. Of note, a study of restaurant menu calorie labeling in King County, WA, found that 18 months after implementation of menu calorie labeling regulations, restaurants reduced the calorie content by 41 kcal per entrée,(31) a much larger effect than the 8 kcal per meal reduction estimated in this study.

The School Meals intervention would reach a very large population of children, with a substantial impact: an estimated 1,816,000 cases of childhood obesity would be prevented at a cost of $46 per BMI unit change. Improved early care and education policies (the “NAP SACC” intervention) reach a much smaller segment of the population (0.9 million), preventing 26,700 childhood obesity cases if implemented nationally, at a cost of $692 per BMI unit change.

The modeled preventive interventions could significantly reduce the overall prevalence of childhood obesity in the US. Currently, the prevalence of obesity among children and youth in the US is about 17%.(32) Based on our model, the largest reduction in childhood obesity prevalence compared to no intervention would occur with implementation of the School Meals intervention (reduction of 2.6%), followed by the SSB Tax (0.8%). Adding in the two other cost-saving interventions (Ad Tax Deduction and Smart Snacks in School) would reduce prevalence by an additional 0.7%. These multiple interventions could have a modest impact on obesity prevalence; even if all were implemented and assuming effects are additive, the overall impact is a reduction of 4.1% – or 2.9 million cases of childhood obesity prevented for the population in 2025.

Tax revenue

In addition to their effects on obesity, we estimate that both the SSB Excise Tax ($12.5 billion) and the TV AD Deduction interventions ($80 million) would lead to substantial yearly tax revenues. These were not included in calculating net costs.

Discussion

These results indicate that primary prevention of childhood obesity should be the remedy of choice. Four of the interventions studied here indicate the potential for cost savings – the interventions will cost less to implement than they save over the next 10 years in health care costs – and will result in substantial numbers of childhood obesity cases prevented. The SSB Excise Tax and, to a lesser extent removing the tax deduction for marketing nutritionally-poor food and beverages to children on TV, would also generate substantial revenue that could be used to fund other obesity prevention interventions. The SSB Excise Tax has been the focus of much policy discussion over recent years,(14, 33) and recent enactment of a one cent per ounce excise tax in Berkley, CA, as well as national implementation of a SSB excise tax in Mexico indicates growing political feasibility of this approach.

The improvements in meal standards in the National School Lunch and Breakfast Programs as well as implementation of the first meaningful national competitive food standards make the Healthy, Hunger Free Kids Act of 2010 one of the most important national obesity prevention policy achievements in recent decades. Although improving nutrition standards for school meals was not intended primarily as an obesity reduction strategy, we estimated that improving the quality of school meals and setting limits on portion sizes would have the largest impact on reducing childhood obesity of any of the interventions evaluated in this study. Combined with new standards limiting unhealthy competitive foods in schools, we estimated that these policies will reduce 2.16 million cases of obesity in 2025.

The individual benefits of bariatric surgery and other intensive clinical interventions to treat obesity can be life changing.(34) Another promising new obesity treatment strategy employs low-cost technological approaches – computerized clinical decision support – to effectively reduce excess childhood weight.(35) While our study should in no way discourage ongoing investment in advancing the quality, reach, and cost-effectiveness of clinical obesity treatment, our results indicate that with current clinical practice, the US will not be able to treat our way out of the obesity epidemic. Instead, policymakers will need to expand investment in primary prevention, focusing on interventions with broad population reach, proven individual effectiveness, and low cost of implementation.

We modeled each of the interventions in this study separately to help policymakers prioritize investment in obesity prevention. However, as the results show, none of the interventions will by itself be sufficient to reverse the obesity epidemic. Instead, policymakers will need to develop a multi-faceted obesity prevention strategy that spans settings and reaches individuals across the life course.

Because the energy gap driving excess weight gain among young children is small, and adult obesity is difficult to reverse, interventions early in the life course have the best chance of making a meaningful impact on long-term obesity prevalence and related mortality and health care costs. However, early intervention will not be sufficient if young children at a healthy weight are subsequently introduced into environments that promote excess weight gain later in childhood and adulthood.

Interventions that improve early care and education using the NAP SACC model reach a smaller segment of the population compared to other preventive strategies, because of the smaller age range and voluntary implementation strategy. Despite the fact that it is the most costly of the six preventive interventions modeled when costs per BMI unit reduction are considered, this strategy still may be a good investment, considering that even small changes among very young children may be important for setting a healthier weight trajectory in childhood. Additionally, the program focuses on improvement in nutrition, physical activity, and screen time for all children and thus may have benefits for child development beyond reducing unhealthy weight gain. In contrast to substantial industry opposition to the evaluated tax policies, the NAP SACC intervention is a well-liked and widely adopted program.

While policymakers should consider the long-term effectiveness of interventions targeting young children, substantially reducing health care expenditures due to obesity in the near term will require implementation of strategies targeting both children and adults. We estimated that over the decade 2015–2025, the SSB Excise Tax would save $12.6 billion in obesity-related health care expenditures – primarily due to reductions in adult health care costs. Interventions that can achieve near-term health care cost savings among adults and reduce childhood obesity offer policymakers an opportunity to make long-term investments in children's health while also generating short-term returns.[4]

Conclusion

Reversing the tide of the childhood obesity epidemic will require sustained effort across all levels of government and civil society for the foreseeable future. To make these efforts effective and sustainable during a period of constrained public health resources, policymakers need to integrate the best available evidence on the potential effectiveness, reach, and cost of proposed obesity strategies in order to prioritize the highest value interventions.

Results from this study indicate a number of preventive interventions that have substantial population impact and are cost saving. An important question for policymakers is: why are they not actively pursuing cost-effective policies that can prevent childhood obesity, and cost less to implement than they will save for society?

Results also highlight the critical impact that existing investments in improvements to the school food environment will have on future obesity prevalence, and indicate the importance

[4]These results are consistent with previous research estimating the potential health care cost savings and health gains due to reducing childhood obesity, much of which resulted from preventing obesity during adulthood.(36)

of sustaining these preventive strategies. Furthermore, while many of the preventive interventions in childhood do not provide substantial health care cost savings (because most obesity-related health care costs occur later in adulthood), childhood interventions have the best chance of substantially reducing obesity prevalence and related mortality and healthcare costs in the long run.

The focus of action for policymakers should be on implementing cost-effective preventive interventions, and ideally these interventions should have broad population impact. Particularly attractive are interventions affecting both children and adults, so that near-term health care cost savings can be achieved by reducing adult obesity and its health consequences, while laying the groundwork for long-term cost savings by also reducing childhood and adolescent obesity.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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EXHIBIT 1.

Population reach, intervention cost, and cost per BMI[a] change for seven childhood obesity interventions in the United States, 2015–2025, based on microsimulation model,[b] with 95% uncertainty intervals (95% UI).

Intervention	Population Reach (Millions)	Annual Intervention Cost ($US, millions)	Intervention Cost Per Unit BMI Reduction[c] ($US)
1) Sugar Sweetened Beverage Excise Tax (SSB Excise Tax)	306.6	$41.0	$2.15
95% uncertainty interval	306.3–307.0	26.7–55.0	0.53–9.14
2) Restaurant menu calorie labeling (Restaurant Calorie Labeling)	306.6	$82.4	$11.29
95% uncertainty interval	306.3–307.0	71.3–93.6	-105–133
3) Eliminate tax subsidy for advertising unhealthy child food (Ad Tax Deduction)	72.3	$0.71	$0.57
95% uncertainty interval	71.9–72.8	0.71–0.71	0.23–0.97
4) Nutrition standards for school meals (School Meals)	28.0	$959	$46
95% uncertainty interval	27.8–28.2	959–959	-160–161
5) Nutrition standards for all foods and beverages sold in schools (Smart Snacks in School)	45.2	$19.2	$5.26
95% uncertainty interval	45.0–45.4	19.2–19.2	2.01–6.66
6) Improved early care and education policies and practices: (NAP SACC)	0.90	$65.4	$692
95% uncertainty interval	0.86–0.94	65.2–65.7	111–965
7) Increased access to adolescent bariatric surgery (Bariatric)	0.0049	$26.2	$1389
95% uncertainty interval	0.0025–0.0077	18.0–34.6	1070–2016

NOTES

[a]BMI, Body Mass Index;

[b]Authors' calculations based on microsimulation model described in Appendix A2; costs are in 2014 dollars;

[c]Cost per BMI unit reduction is an incremental cost effectiveness ratio.

EXHIBIT 2.

Estimated 10 year cost effectiveness and economic outcomes for childhood obesity interventions in the US, 2015–2025 based on microsimulation model,[a] and 95% Uncertainty intervals (95% UI).

Intervention	Net costs[b] (US$ Millions) (negative numbers indicate cost savings)	Cases of Childhood Obesity Prevented (2025)	Health care costs saved per $spent[c] ($US)
1) Sugar Sweetened Beverage Excise Tax (SSB Excise Tax)	−$12,223	575,936	$30.78
95% uncertainty interval	−$40,645 – −2,281	131,794–1,890,715	6.07–112.94
2) Restaurant menu calorie labeling (Restaurant Calorie Labeling)	−4,032	41,015	$ 5.90
95% uncertainty interval	−$13,811–5,421	−41,324–122,396	−5.06–18.00
3) Eliminate tax subsidy for advertising unhealthy food to children (Ad Tax Deduction)	$−224	129,061	$32.53
95% uncertainty interval	−$372 – −81	48,200–212,365	$12.42–53.35
4) Nutrition standards for school meals (School Meals)	$5,552	1,815,966	$0.42
95% uncertainty interval	$2,120–10,834	−547,074 – 3,381,312	−0.13 – 0.78
5) Nutrition standards for all foods and beverages sold in schools (Smart Snacks in School)	−$684	344,649	$4.56
95% uncertainty interval	−$1,155 – −217)	163,023–522,285	$2.13–7.01
6) Improved early care and education policies and practices (NAPSAAC)	$637	26,728	$0.03
95% uncertainty interval	$622–652	4,450–48,603	$0.004–0.05
7) Increased access to bariatric surgery (Bariatric)	$262	--	---
95% uncertainty interval	$180–346		

Notes:

[a]Authors' calculations based on microsimulation model described in Appendix A2.

[b]Costs are in 2014 dollars.

[c]Cost saving interventions result in at least $1 of healthcare costs saved per $1 spent on the intervention.