Cost Effectiveness of Childhood Obesity Interventions

Evidence and Methods for CHOICES

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Introduction: The childhood obesity epidemic continues in the U.S., and fiscal crises are leading policymakers to ask not only whether an intervention works but also whether it offers value for money. However, cost-effectiveness analyses have been limited. This paper discusses methods and outcomes of four childhood obesity interventions: (1) sugar-sweetened beverage excise tax (SSB); (2) eliminating tax subsidy of TV advertising to children (TV AD); (3) early care and education policy change (ECE); and (4) active physical education (Active PE).

Methods: Cost-effectiveness models of nationwide implementation of interventions were estimated for a simulated cohort representative of the 2015 U.S. population over 10 years (2015–2025). A societal perspective was used; future outcomes were discounted at 3%. Data were analyzed in 2014. Effectiveness, implementation, and equity issues were reviewed.

Results: Population reach varied widely, and cost per BMI change ranged from $1.16 (TV AD) to $401 (Active PE). At 10 years, assuming maintenance of the intervention effect, three interventions would save net costs, with SSB and TV AD saving $55 and $38 for every dollar spent. The SSB intervention would avert disability-adjusted life years, and both SSB and TV AD would increase quality-adjusted life years. Both SSB ($12.5 billion) and TV AD ($80 million) would produce yearly tax revenue.

Conclusions: The cost effectiveness of these preventive interventions is greater than that seen for published clinical interventions to treat obesity. Cost-effectiveness evaluations of childhood obesity interventions can provide decision makers with information demonstrating best value for the money.

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Introduction

The childhood obesity epidemic has been growing for decades in countries throughout the world, and policymakers, scientists, and the public have all been engaged in a search for interventions that can reverse these trends. Many approaches have been tried, including programmatic and policy interventions that target either children only or the general population. This variety reflects the many forces that have been identified as driving the epidemic and influencing trends in obesity disparities.[1] The evidence base for effective interventions in the U.S. is evolving, but there have been limited quantitative and economic analyses of population-based interventions, as opposed to individual-based approaches, and few comparisons across multiple approaches.[2,3] With

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fiscal crises affecting both federal and state governments, U.S. policymakers are now asking not only whether an intervention works but also whether it offers good value for money spent and potential cost savings.

Cost-effectiveness analyses can provide just such information,[4–13] but there are substantial challenges in examining the cost effectiveness of childhood obesity interventions. One major challenge is that childhood interventions incur costs "up front" as they are implemented, but their most substantial health benefits (e.g., reductions in morbidity) are minimal until decades later at age 35 years and older, when obesity-related diseases become more prevalent.[14] Childhood interventions thus must have a sustained impact over a very long time period to affect these outcomes, and assuming that effects of childhood interventions persist over decades may be unrealistic.[6,15] Although there are examples of childhood obesity interventions showing effectiveness for 5 and 10 years,[16–19] to the authors' knowledge, no studies show effectiveness for 20–40 years. Therefore, the current analyses focused primarily on short-term and 10-year cost effectiveness, including cost per unit of BMI reduction and obesity-related healthcare costs averted.[5,20]

Though evidence for the long-term maintenance of childhood interventions is unclear, preventive intervention strategies in childhood still have great potential to avert adulthood obesity. Few children are born with obesity, and the changes needed to reduce childhood excess weight are much smaller than those needed to change adult excess weight.[21–23] There is substantial tracking of adolescent obesity into adulthood,[24,25] and it is clear that, once obesity is established in adulthood, treatment has limited effects on long-term outcomes.[26] Therefore, prevention of obesity in childhood is critical in the prevention of adult obesity, and the identification of cost-effective interventions that can be applied throughout childhood is a clear priority.[27]

In this paper, initial results are reported from the Childhood Obesity Intervention Cost-Effectiveness Study (CHOICES), a collaborative modeling effort to provide estimates of the effectiveness, costs, reach, and cost effectiveness of interventions to reduce childhood obesity in the U.S. Detailed description of data inputs, assumptions, and findings for each intervention are reported in separate papers.[28–31] This overview paper discusses the common approach and methods used in analyses, and compares results across the four studies.

The CHOICES work is built on a framework developed for the Australian Assessing Cost-Effectiveness (ACE)[32,33] in Obesity[6] and ACE-Prevention modeling studies.[7] The CHOICES study is one of the first efforts to estimate the cost effectiveness of a range of nationally implemented childhood obesity interventions in the U.S.

Methods

The methods and results presented here are the outgrowth of collaborations among researchers at the Harvard School of Public Health and the Columbia University Mailman School of Public Health in the U.S., and Deakin and Queensland Universities in Australia. CHOICES methods were built on the ACE approach of using standard evaluation methods to develop a priority setting process that balances technical rigor with due process.[32,33]

The ACE approach was adapted by taking into account the U.S. experience in terms of population distributions, disease incidence, prevalence, and mortality, and a different approach to healthcare costing and cost offsets than those used in ACE. The emphasis was changed from a focus on disability-adjusted life years (DALYs) over the lifetime of a population cohort, to shorter-term changes in population health, including the outcomes of cost per BMI unit change for 2 years following an intervention, and 10-year healthcare costs, net costs, DALYs, and quality-adjusted life years (QALYs).[34] These changes aligned the modeled results with the timeframe of intervention studies used for evidence, make findings more relevant to concerns of U.S. policymakers, and avoid the need to assume sustained intervention effect over individuals' lifetimes.[15] In reporting results, recommendations of the U.S. Panel on Cost-Effectiveness in Health and Medicine were followed.[35] The current approach is called the CHOICES model; it has seven distinct methodologic components, described in detail below.

1. Selection and Recruitment of a Stakeholder Group

A stakeholder group was selected, representing multiple decision makers including U.S. policymakers, policy researchers, and nutrition and physical activity researchers and programmatic experts (Appendix 1, available online). This group provided advice concerning specification of the interventions, identification of data sources, and technical analyses, and assisted in addressing implementation issues.

2. Selection of Interventions

The four initial interventions were selected by the investigators to represent a broad range of nationally scalable strategies to reduce childhood obesity using a mix of both policy and programmatic strategies. Although the emphasis was on child and adolescent interventions, the first intervention targets the whole population. Details are provided in the four accompanying papers:

1. an excise tax of $0.01 per ounce of sugar-sweetened beverages, applied nationally and administered at the state level (SSB)[28];
2. elimination of the tax deductibility of advertising costs of TV advertisements for "nutritionally poor" foods and beverages seen by children and adolescents (TV AD)[29];
3. state policy requiring all public elementary schools in which physical education (PE) is currently provided to devote $\geq$50% of PE class time to moderate and vigorous physical activity (Active PE)[30]; and
4. state policy to make early child educational settings healthier by increasing physical activity, improving nutrition, and reducing screen time (ECE).[31]

3. Specification of the Intervention, Implementation Scenarios, and Costs

Interventions were specified including the setting (e.g., schools for Active PE, states for SSB), target population, and intervention activities. Whenever possible, the intervention specification was informed by available data on implementation, costs, and effectiveness in reducing BMI in adults or BMI *z*-score in children. However, empirical data for part of the model were sometimes not available; for example, no state has yet enacted an SSB excise tax as large as that modeled in the SSB intervention.[28] A hypothetical, national implementation scenario was thus specified that incorporated the best available data for each step along specified logic pathways from implementation and dissemination to outcomes. Logic models for each of the four interventions are included in Appendix 2 (available online); details concerning assumptions and evidence are provided in the relevant papers.

Intervention cost estimates follow published guidelines[36,37] and protocols as outlined in the ACE,[33,38] and adapted to the CHOICES model (Appendix 5, available online). Ten-year costs depended on the length of the intervention for a single cohort. For example, the SSB and TV AD interventions were assumed to be in effect (and incurring costs) throughout the 10-year period. By contrast, ECE was assumed to be in effect for children aged 3–5 years who attended one of these settings for at most 3 years. The Active PE intervention was assumed to have at most 6 years of intervention exposure for children aged 6–11 years. All costs were expressed in July 2014 dollars, adjusted for inflation using the U.S. Bureau of Labor Statistics Consumer Price Index (www.bls.gov/cpi/).

4. Intervention Effects

Intervention effects on BMI were estimated using an evidence review process that took into account study quality and was in general agreement with Cochrane guidelines and the GRADE approach (Appendix 3, available online).[39,40] Evidence reviews were grounded in logic models that link the intervention to behavioral changes and shifts in energy balance (e.g., changes in energy intake and physical activity) and in turn to changes in BMI (Appendix 2, available online). For all the modeled interventions there was direct evidence linking behavior change to BMI. The SSB intervention also required additional econometric evidence linking increased price to lower consumption.

5. Modeling Short-Term and 10-Year Cost Effectiveness

A Markov cohort simulation model was developed for calculating costs and effectiveness of the interventions through their impact on BMI changes. In the short term, this was estimated as cost per BMI unit reduced over 2 years, and for 10 years the model calculated obesity-related healthcare costs. In the case of the SSB intervention, the model also calculated obesity-related disease incidence and DALYs for the 2015–2025 period. DALY outcomes were not reported for the other three interventions because subjects will be aged <30 years at 10-year follow-up and relative risks of obesity related diseases are 1.0 at age <35 years.[14,41] Improvements in QALYs were also estimated, using published estimates of obesity-related quality of life among adults aged ≥ 18 years.[42] Because no ECE cohort members and few in the Active PE interventions would be adults after 10 years, QALY improvements were not reported for these interventions. The model used a proportional multistate life table[43,44] to simulate the morbidity and mortality experience of the 2015 population of the U.S. (aged ≥ 2 years in 2015) followed for 10 years or until death or age 100 years. The model was based on a spreadsheet version used for ACE Prevention,[7,45] but modified with U.S. population, healthcare costs, morbidity, and mortality data. These results were replicated in a compiled programming language (JAVA) and data were analyzed in 2014. Further details are in Appendix 4, available online.

The impact on obesity-related healthcare costs was calculated based on nationally representative analyses indicating excess healthcare costs associated with obesity among children and adults.[5,46] The assumption was not made, as in the ACE studies,[6,7] that healthcare cost offsets occur only after obesity-related disease onset. Rather, excess healthcare costs linked to obesity at all ages, including childhood and adolescence, were taken into account. Appendix 5 (available online) provides further detail.

For all interventions, effects on BMI change were assumed to occur after 1 year. This assumption approximates the time to full effect following changes in energy balance in children.[23,47] Costs of intervention implementation during this first year of the modeling timeframe were included. Estimates of intervention costs did not include one-time start-up costs, and yearly costs were those incurred when the intervention was fully operational. A modified societal perspective on costs was used. For the primary interventions, it was assumed that effects were sustained over 10 years. For policy changes like the SSB and TV AD interventions, sustaining an effect for 10 years can be considered reasonable. All input parameters of the models and their distributions and assumptions are detailed in the individual papers. All results are expressed in 2014 U.S. dollars and future outcomes are discounted at 3% annually.

6. Performing Uncertainty and Sensitivity Analyses and Calculating Cost and Cost Effectiveness

Probabilistic sensitivity analyses were used extensively by simultaneously sampling all parameter values from predetermined distributions. Results are reported as 95% uncertainty intervals (UIs; around point estimates). UIs were estimated by taking the 2.5 and 97.5 percentile values from simulated data, to describe the uncertainty surrounding the outcome measures as a result of the joint uncertainties surrounding input parameters.[48] To estimate costs per BMI units reduced over 2 years, @Risk software, version 6.0, was used to calculate 95% UIs from 10,000 iterations of the model. In estimating 10-year healthcare costs, net costs, net cost saved per dollar spent, and DALY and QALY outcomes, UIs were calculated using Monte Carlo simulations programmed in JAVA from 1,000,000 iterations of the model. Model uncertainty was also assessed by modifying the primary scenario with alternative logic pathways; these are described in the individual papers.

7. Implementation and Equity Considerations

The stakeholder group was engaged in reviewing findings in light of implementation and equity issues,[32] including quality of evidence, equity, acceptability, feasibility, sustainability, side effects, and social and policy norms. These implementation issues combined with cost effectiveness results provide a more complete picture for decision makers.

Table 1. Short Term Population Reach, Cost and Outcomes for Four Childhood Obesity Interventions in the U.S.

Intervention	Population reach (millions)	First year intervention cost $U.S. millions (UI)	Per person BMI unit reduction (UI)	Cost per unit BMI reduction $U.S. (UI)
Sugar sweetened beverage excise tax[28] (SSB) all ages	313	$51 ($36, $66)	0.08 (0.03, 0.20) (adult)	$3.16 ($1.24, $8.14)
Ages 2–19 years only	74	$51 ($36, $66)	0.16 (0.06, 0.37) (ages 2–19 years)	$8.54 ($3.33, $24.2)
Reduce tax subsidy of TV advertising[29] (TV AD)	74	$1.1 ($0.69, $1.42)	0.028 (0.011, 0.046)	$1.16 ($0.51, $2.63)
Early care and education policy changes[31] (ECE)	3.7	$4.8 ($−6.0, $12.6)	0.02 (0.01,0.04)	$57.80 ([a], $138)
State policy for active physical education[30] (PE)	17.6	$71 ($51, $96)	0.02 (0.003, 0.05)	$401 ($148, $3,100)

Note: Costs are in 2014 U.S. dollars.
[a]It is customary not to report negative incremental cost effectiveness ratios because they cannot be interpreted.[49]
UI, 95% Uncertainty Interval.

Results

Results of the four cost-effectiveness analyses are summarized in Tables 1 and 2. The short-term outcomes described in Table 1 included the population reached by the interventions— which varied greatly, from the 3.7 million children estimated to be impacted by the ECE intervention to the 313 million children and adults who would be affected by an SSB excise tax. The estimated annual cost of the interventions also varied substantially, ranging from a low of $1.1 (95% UI=$0.69, $1.42) million dollars per year (TV AD) to an estimated $71 (95% UI=$51, $96) million per year required to fund Active PE. Effectiveness as estimated from evidence reviews varied from a 0.02 (95% UI=0.003, 0.05) per person change in BMI (PE) to a change of 0.16 (95% UI=0.06, 0.37) for the SSB intervention among youth (Table 1).

The estimated cost effectiveness of the interventions for the first 2 years (Table 1) varied considerably more, ranging from a low of $1.16 (95% UI=$0.51, $2.63) per BMI unit change for TV AD, to $3.16 (95% UI=$1.24, $8.14) for SSB and $401 (95% UI=$148, $3,100) for the Active PE intervention.

Substantial variations in outcomes remained when a 10-year timeframe was adopted and healthcare cost savings were included (Table 2). For three of the four interventions, there would be potential net cost savings over the 2015–2025 period. The largest estimated savings, a total of $23.2 (95% UI=$8.88, $54.5) billion, were associated with the SSB intervention because this intervention would impact all age groups, and in particular would impact adults who already have obesity-related diseases and their associated healthcare costs. In uncertainty analysis, the likelihood of cost savings at 10 years was quite high (>99% following the first 2 years) for both the SSB and TV AD interventions, and an estimated 95% for ECE.

The TV AD intervention would result in an estimated $343 (95% UI=$129, $572) million saved over the decade. The ECE intervention would impact a much smaller population, and result in estimated cost savings over the decade of $43.2 (95% UI=$4.24, $133) million. The Active PE intervention would not result in any net cost savings over this period. The SSB intervention would save an estimated $55 (95% UI=$21, $140) for every dollar spent and the TV AD $38 (95% UI=$14, $74).

In addition, an estimated 101,000 (95% UI=35,000, 249,000) DALYs would be averted during 2015–2025 owing to the SSB excise tax. Because the other three interventions are exclusively focused on children, there was limited potential to affect obesity-related morbidity, mortality, and DALYs over the 10-year time horizon because of the low prevalence of obesity-related morbidity and mortality before age 35 years.[14] Likewise, the ECE and Active PE interventions would have minimal impact on adult QALYs within the modeling timeframe.

Two of the interventions would generate tax revenue. The SSB intervention would generate approximately $12.5 billion per year nationally,[28] and the TV AD intervention would raise about $80 million per year.[29] These tax revenues were not included in the net societal costs of the intervention (Table 2), but these revenues could be used to pay for other initiatives.

Discussion

The relative cost effectiveness of the four intervention studies reviewed here provides an important series of

Table 2. Estimated 10-Year Cost Effectiveness and Economic Outcomes for Childhood Obesity Interventions in the U.S., 2015–2025

Intervention	Health care costs U.S. $ millions (UI)	Probability of net cost saving	Net costs U.S.$ millions (UI)	DALYs averted[a] (UI)	QALYs gained[b] (UI)	Net cost saved per $ spent (UI)
Sugar-sweetened beverage excise tax[28] (SSB), all ages	−$23,600 (−$54,900, −$9,330)	1.00	−$23,200 (−$54,500, −$8,880)	101,000 (35,000, 249,000)	871,000 (342,000, 2,030,000)	$55 ($21, $140)
Reduce tax subsidy of TV advertising[29] (TV AD)	−$352 (−581, −138)	1.00	−$343 (−$572, −$129)	—[a]	4,540 (1,750, 7,500)	$38 ($14, $74)
Early care and education policy changes[31] (ECE)	−$52 (−$134, −$14)	0.95	−$43.2 (−$133, −$4.24)	—[a]	—[b]	$6 (−$52, $66)
State policy for active physical education[30] (Active PE)	−$61 (−$153,−$8)	0.003	$175 ($63, $277)	—[a]	—[b]	—

[a]DALYs were only reported for the SSB intervention because significant incidence does not begin until ages ≥35 years. No DALYS are averted for these childhood interventions within the 10-year follow-up because of the very low incidence of morbidity and mortality at ages ≤35 years.
[b]QALYs were only reported for the SSB and TV AD interventions; QALYs were not calculated for the ECE and Active PE interventions because few subjects over the 10 year period will fall into the age range of ≥18 years where QALY weights are defined.
DALY, disability-adjusted life year; QALY, quality-adjusted life year; UI, 95% uncertainty interval.

contrasts. The estimated costs, cost effectiveness, and reach of these interventions as they are brought to scale nationally vary dramatically. The cost per BMI unit change for three of the interventions varies from $1.16 to $57.80, and the most expensive was $401. Are these costs low or high? There are no established benchmarks for cost per unit changes in BMI, but one relevant comparison would be clinical interventions for obese children or adolescents. Although the research is limited, one recent randomized trial for a primary care–based intervention for overweight and obese children[50] cost about $1,000 per BMI unit change.[51] Evidence reviews of bariatric surgical interventions in youth indicate an average reduction of 13.5 BMI units over the first year,[52] with an average cost of bariatric surgery of about $28,700,[53] leading to a rough estimate of a cost of $2,100 per BMI unit change. These results suggest that some of the broad-reaching policy and preventive interventions studied here may produce changes in BMI at much lower cost than some commonly reimbursed medical treatments.

Perhaps more importantly, these analyses indicate that three of the interventions are cost saving within a 10-year period (two within 2 years): the estimated changes in BMI and obesity attributable to the interventions lead to lower rates of obesity and healthcare costs, offsetting intervention costs. Two of the interventions, SSB and TV AD, result in additional revenue ($12.5 billion per year and $80 million per year, respectively) that could be used for policy and programmatic work or to counteract equity issues through legislative earmarking.

In addition to these quantitative costs and outcomes, a wide range of other implementation and equity issues have been considered in evaluating the interventions Table 3). In general, high-quality evidence links the key behaviors with the outcome of BMI. However, there are many uncertainties regarding implementation of the interventions, including their feasibility and acceptability to stakeholders. All selected interventions were generally deemed feasible. There are SSB excise and sales taxes (albeit small ones) already in place in many states, and excise taxes on many other goods (alcohol, cigarettes, sport fishing gear). However, it is clear there will continue to be strong opposition from the beverage industry.[28] Three states already have ECE policies like those studied,[31] and many schools have implemented the examined Active PE intervention[30]; thus, it is clear these interventions are feasible, but budget concerns have been one important factor limiting their wider implementation. The change in taxation specified in the TV AD intervention is feasible as it is a change in a tax deduction, but because of first amendment concerns, the tax code change would need to be implemented and survive a

Table 3. Implementation and Equity Issues for Four Childhood Obesity Interventions in the U.S.: CHOICES

Intervention	Quality of evidence[a]	Equity	Acceptability to stakeholders	Feasibility	Sustain-ability	Side effects	Social and policy norms
Sugar-sweetened beverage excise tax[28] (SSB)	High quality RCT for children; moderate quality for adults	Neutral: Regressive tax, but health benefits, earmarking potential	Beverage industry opposition; national public opinion increasingly positive	Excise taxes common: very feasible	Likely; examples of other excise taxes like tobacco	Reduced diabetes, CVD independent of BMI	Substantial potential for shift in social norms with publicity surrounding successful implementation
Reduce tax subsidy of TV advertising[29] (TV AD)	High quality RCT linking TV and BMI	Potential to reduce inequality; minority children watch more TV	Likely food, beverage, advertising industry opposition	Plausible feasibility; needs to be implemented and survive court challenge	Likely if implemented	Other media advertising may increase	Publicity concerning law could lead to increased support
Early child and education policy changes[31] (ECE)	High/moderate quality RCTs linking SSB, TV, PA to BMI	Potential for reduced disparities with policy change and increased disparities in family-based settings	Three states already have, so acceptable	States already regulate, so feasible; cost a limiting factor	Yes but system for monitoring needed	Other effects on CVD, diabetes risk, dental health, as well as effects in the home and on staff behaviors	Can increase awareness for issues among preschools
State policy for active physical education[30] (Active PE)	High quality RCT linking PA and BMI and moderate quality longitudinal study	Potential for negative effect on equity as only schools with PE can implement	Acceptable to policymakers; teachers require training	Feasible with training for staff; cost is major limiting factor	Likely but system for monitoring needed	Effects on fitness, reduced CVD health, classroom behavior, no harm to academic achievement	Can boost support for PA during school day

[a]Quality of evidence for the primary behavioral link to BMI, using GRADE rating.[40]
CVD, cardiovascular disease; PA, physical activity; PE, physical education; SSB, sugar-sweetened beverage.

court challenge.[29] This change would also likely be strongly opposed by beverage, food, broadcast, and advertising industries. Recently proposed legislation in the U.S. House of Representatives (H.R. 2831) and a more recent bill introduced in the Senate by Blumenthal and Harkin, the Stop Subsidizing Childhood Obesity Act of 2014, indicate interest in this approach.[29]

The "side effects" that the four interventions produce could have major importance, and are not captured in the current model that focuses on changes in BMI and obesity-related outcomes. For example, increasing physical activity levels improves students' physical and mental health,[54,55] and interventions that increase physical activity also show direct effects on cognitive functioning and ability to concentrate in class.[56–60] These positive additional outcomes are not included in the evaluation of the Active PE intervention, leading to likely underestimation of the impact of this intervention. The impact of the SSB excise tax is also likely underestimated as direct effects of the intervention on the incidence of diabetes and cardiovascular disease, independent of BMI, were not modeled.[61,62] One potential negative side effect of an SSB tax has been countered with evidence that these taxes would not adversely impact employment.[63]

Effects on equity are potentially important. Although the SSB tax is regressive in its costs, there is the potential for earmarking of tax revenues to offset this effect. In addition, children living in poverty may experience the largest effects of the intervention,[28] so it may be progressive in its benefits. The TV AD intervention has the potential to reduce disparities in obesity, as poor and minority children watch the most TV and could experience a more substantial effect of the reduction of TV advertising.[29,64,65] By contrast, the Active PE and ECE changes could increase disparities because poorer children have less access to PE in school or to center-based preschool programs that are most likely to implement changes.[66]

One potentially important area of impact for all of the interventions is on "social and policy norms," or the effect that increased public attention to an intervention would have on these outcomes. For example, the SSB excise tax and TV AD intervention could generate substantial public debate, and the attendant publicity and social media effects could lead to a shift in social norms, including increases in favorable public opinion as more people learn of the impact and benefits of the interventions. For example, recent evidence shows increased support for SSB taxes in public opinion polls, particularly if the focus is on children.[67]

The U.S. Food and Drug administration has recently conducted economic analyses of public health interventions in which the value of expected gains in health and healthcare cost savings were reduced based on the argument that these interventions would result in a loss of "consumer surplus." Leading economists have challenged this analysis as incorrect with regard to cigarette smoking; the authors believe the same critique can be made concerning interventions where market failures[1] have contributed to childhood obesity, as in the case of SSB. This is discussed further in Long et al.[28]

Evidence is accumulating that growth in obesity prevalence is beginning to flatten in some populations, although at historically high levels,[68] and the current results reaffirm a growing sense that some policy changes and interventions are effective in reducing obesity and are worthy of consideration by policymakers. Energy gap modeling of the determinants of obesity have indicated that young children have the smallest energy gaps to change, and hence would likely be the first group to show evidence for reversal of the epidemic,[8,21,23] consistent with recent evidence.[69,70] However, there is very limited evidence for the cost effectiveness of policy and programmatic interventions, as well as their impact on the energy gap and changes in childhood BMI and obesity.[22,71]

Limitations

There are a number of limitations to these cost-effectiveness analyses. First, none of the studied interventions have been implemented at the national scale. A second concerns the evidence base: although there is a strong intervention evidence base relating change in behaviors to change in BMI, much less is known about how to effectively translate and scale these interventions in community settings throughout the nation. Though effectiveness research indicates a high probability that interventions will make an impact, the population reach of this impact is uncertain because of the lack of implementation research.

The impact of interventions may also be underestimated, in part because only a limited set of outcomes was examined. The SSB model likely underestimates effects on outcomes because direct effects of changes in SSB on both diabetes[72] and cardiovascular disease[62] independent of BMI are not modeled. Physical activity effects are likely underestimated because the model does not take into account the effects of activity on cognitive function, mood, and academic performance of children.[73–75] The model also excludes potential health gains from earmarking tax revenues for health promotion. Previous tobacco control efforts set a precedent: CDC reported in 2007 that almost 90% of funding for state and local tobacco prevention programs came from excise taxes and tobacco settlement funds.[76]

Given the tracking of childhood obesity into adulthood,[77] limiting the evaluation to a 10-year time horizon may underestimate the long-term healthcare cost savings and reduction in morbidity and mortality associated with childhood obesity prevention efforts. There is good evidence that physical activity patterns track from childhood into adulthood,[78] and physical inactivity in adulthood is associated with higher healthcare costs,[79] independent of obesity and other risk factors.[80,81] Recent research indicates that these associations are evident among all age groups including early adulthood (ages 18–24 years), and that the strength of this relationship is similar to that seen for obesity.[82] These data thus indicate that reduced BMI and increased physical activity in childhood could lead to lower obesity levels and less inactivity in adulthood, leading to reductions in healthcare costs, disability, and premature death.

The findings from these four studies resonate with a number of the results from the ACE modeling efforts in Australia.[6,7,9,11,13] For example, some of the most cost-effective strategies were found to be policy interventions, in part because of their relatively low cost, broad population reach, and potential for sustainability. In the present study, the SSB, TV AD, and ECE policy interventions all show good cost effectiveness and potential to demonstrate substantial cost savings. These policy and preventive interventions may also produce changes in BMI at much lower cost than some commonly reimbursed clinical interventions.

Conclusions

One of the critical questions now is whether interventions with clear evidence for cost effectiveness and cost savings over this time period can actually be implemented. A related issue is whether the focus of dissemination and implementation should be local, state, or national. With partisan gridlock currently affecting Congress, perhaps more change will be happening at state and local levels in the near future. The present analysis indicates multiple cost-effective interventions (SSB, Active PE, ECE) at state levels. As further cost-effectiveness evaluations of policy and programmatic interventions are completed and the evidence base grows, policymakers should have more leverage to focus on strategies that can demonstrate best value for money.

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Appendix

Supplementary data

Supplementary data associated with this article can be found at http://dx.doi.org/10.1016/j.amepre.2015.03.032.