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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 **Policy makers 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: a sugar-sweetened beverage excise tax; elimination of the tax subsidy for advertising unhealthy food to children; restaurant menu calorie labeling; nutrition standards for school meals; nutrition standards for all other food and beverages sold in schools; improved early care and education; and increased access to adolescent bariatric surgery. We used systematic reviews and a microsimulation model of national implementation of the interventions over the period 2015–25 to estimate their impact on obesity prevalence and their cost-effectiveness for reducing the body mass index of individuals. In our model, three of the seven interventions—excise tax, elimination of the tax deduction, and nutrition standards for food and beverages sold in schools outside of meals—saved more in health care costs than they cost to implement. Each of the three interventions prevented 129,000–576,000 cases of childhood obesity in 2025. Adolescent bariatric surgery had a negligible impact on obesity prevalence. Our results highlight the importance of primary prevention for policy makers aiming to reduce childhood obesity.**

The childhood obesity epidemic in the United States affects 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, simply asking what works without considering costs has led to the proliferation of obesity treatment and prevention initiatives with limited evaluative information. Little serious discussion has taken place about relative costs or cost-effectiveness. When we searched the PubMed database of the National Library of Medicine for articles published through 2014 containing the term *child obesity*, we found more than 31,000, but only 89 of these also contained the term *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) of 13.5 kg/m^2 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—that is, BMI scores that are standardized for age and sex) of the children before the intervention,[6] and treatments may reach too few children to have a substantial population-level impact. For example, bariatric surgery is used with only 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 is driven by an excess of about 33 extra kilocalories 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.[8,10] The typical adult with a BMI greater than 35 (about 14 percent of the adult population) consumes 500 kcal/day more than is needed to maintain a healthy body weight.[9] Improving energy balance via improved diet and physical activity early in childhood thus requires much smaller changes than 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 online Appendix A1,[11] there is clear evidence of the effectiveness of reducing the intake of sugar-sweetened beverages on reducing BMI and obesity prevalence.

There is also strong evidence that reducing television viewing and other screen time leads to significant reductions in BMI and obesity prevalence, mainly via dietary changes[12] (also documented in Appendix A2).[11] Despite growing evidence that targeted interventions can improve diet and reduce BMI and obesity prevalence, there is limited evidence concerning the cost-effectiveness of these approaches and the potential US population–level impact of either treatment or preventive interventions.

In this article we present results of an evidence review and microsimulation modeling project concerning the cost-effectiveness and population-level impact of seven interventions identified as potentially important strategies for addressing childhood obesity. We conducted systematic evidence reviews of the interventions' effectiveness and estimated costs and reach under specified implementation scenarios described in Appendices A1, A2, and A4–A8.[11] We developed a microsimulation model to assess key cost-effectiveness metrics of these interventions if they were to be implemented nationally.

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Study Data And Methods

We developed an evidence review process and microsimulation model to evaluate the cost-effectiveness of interventions for childhood obesity. Our modeling framework built on the Australian Assessing Cost-Effectiveness approach[13,14] in obesity[15] and prevention studies.[16] Our microsimulation model used US population, mortality, and health care cost data. We focused on outcomes of cost per BMI unit change over two years following an intervention and ten-year changes in obesity, health care costs, and net costs. We followed recommendations of the US Panel on Cost-Effectiveness in Health and Medicine in reporting our results, including using a 3 percent discount rate.[17]

Our approach has distinct methodological components designed to improve both the strength of evidence and the applicability of results to real-world decision making. We created a stakeholder group of thirty-two US policy makers, researchers, and nutrition and physical activity experts to provide advice concerning the selection of interventions, evaluation of 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, since many insurers pay for this treatment.[18]

INTERVENTIONS Our stakeholder group selected for the study seven interventions that are high on the treatment and prevention policy agenda (further details about the interventions are provided in the Appendices).[11] The interventions are as follows: an excise tax of one cent per ounce on sugar-sweetened beverages, applied nationally and administered at the state level; the elimination of the tax deductibility of advertising costs for television ads seen by children and adolescents for nutritionally poor foods and beverages; restaurant menu calorie labeling, modeled on the federal menu regulations to be implemented under the Affordable Care Act; implementation of nutrition standards for federally reimbursable school meals sold through the National School

Lunch and School Breakfast Programs, modeled on US Department of Agriculture (USDA) regulations implemented under the Healthy, Hunger-Free Kids Act of 2010; implementation of nutrition standards for all foods and beverages sold in schools outside of reimbursable school meals, modeled on USDA regulations implemented under the Healthy, Hunger-Free Kids Act; improved early childhood education policies and practices, including the national dissemination of the Nutrition and Physical Activity Self-Assessment for Child Care (NAP SACC) program; and a nationwide fourfold increase in the use of adolescent 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 followed standard guidelines[19,20] (for details of models and costing, see Appendix A3).[11] All costs were calculated in 2014 dollars and adjusted for inflation using the Consumer Price Index for all nonmedical costs and the Medical Care Consumer Price Index for medical costs.

EVIDENCE REVIEWS OF INTERVENTION EFFECTS We estimated the effects of each of the seven interventions using an evidence review process consistent with the Grading of Recommendations Assessment, Development, and Evaluation (GRADE) approach[21] and guidelines from the Cochrane Collaboration.[22] Details of the evidence reviews for the interventions are provided in Appendices A1, A2, and A4–A8.[11]

MICROSIMULATION MODEL We developed a microsimulation model to calculate the costs and effectiveness of the interventions through their impact on BMI changes, obesity prevalence, and obesity-related health care costs over ten years (2015–25). This is a stochastic, discrete-time, individual-level microsimulation model of the US population designed to simulate the experience of the population from 2015 to 2025.

The model used data from the Census Bureau, American Community Survey, Behavioral Risk Factor Surveillance System, National Health and Nutrition Examination Surveys (NHANES), and National Survey of Children's Health. It also used longitudinal data about weight and height from the National Longitudinal Survey of Youth, National Longitudinal Study of Adolescent to Adult Health, Early Childhood Longitudinal Study—Kindergarten, Panel Survey of Income Dynamics, and NHANES I Epidemiologic Followup Study.

We used smoking initiation and cessation rates from the National Health Interview Surveys and mortality rates by smoking status and BMI from the NIH-AARP Diet and Health Study. Details of the data, analyses, and model are provided in Appendix A3, and key model input parameters are listed in Appendix Exhibit A3.1.[11]

The estimated effects of the interventions on health care costs were based on national analyses that indicated excess health care costs associated with obesity among children and adults (see Appendix A3).[11] We assumed that each intervention took time—typically 18–36 months—to decrease the BMI of individuals who received each intervention.[8,9] Estimates of intervention costs included one-time start-up and ongoing costs, as well as enforcement and compliance costs, but did not include costs of passing a policy. The annual costs for each intervention are the average of its discounted total costs.

We used a "modified" societal perspective on costs. This means that we did not include several possible economic impacts of the interventions, such as productivity losses associated with obesity or patient costs for items such as transportation to clinic visits or the value of time spent seeking or receiving medical care. It was reasonable to exclude these economic impacts because they are difficult to estimate systematically and likely to be small within a ten-year period, relative to the intervention and health care costs.

We assumed that effects were sustained over the model's time frame—that is, eight years after two start-up years. For policy changes such as the sugar-sweetened beverage excise tax, the elimination of the tax subsidy for advertising unhealthy food to children, and restaurant menu calorie labeling, sustaining an effect for ten years is reasonable, as the changed policy will continue over that period. For the interventions that set nutrition standards for school meals and other foods and beverages sold in schools, we can assume that most children will be exposed to these for a substantial period of time—for example, from first through twelfth grades. 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 from reviews of the relevant literature, including the parameters' distributions and assumptions, are outlined in Appendices A1, A2, and A4–A8.[11] As explained above, all results are expressed in 2014 US dollars and discounted at 3 percent annually.

We calculated costs per BMI units reduced over two years (2015–17). We estimated health care costs, net costs, and net costs saved per dollar spent over ten years (2015–25), since 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 in 2025, at the end of the period of analysis.

Uncertainty And Sensitivity Analyses We calculated probabilistic sensitivity analyses by simultaneously sampling all parameter values from predetermined distributions. We report 95 percent uncertainty intervals (around point estimates) in Exhibits 1 and 2, taking 2.5 and 97.5 percentile values from simulated data.[23] We calculated uncertainty intervals using Monte Carlo simulations programmed in Java over one thousand iterations of the model for a population of one million simulated individuals scaled to the national population size.

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

Limitations The study had several limitations. First, its results were based on a simulation model that incorporated a broad range of data inputs. While we 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 was limited by the uncertainty around each of these inputs and by the assumptions required to build the model (see Appendix A3).[11]

In previous publications we used a Markov cohort simulation model to estimate the impact of two of the interventions modeled here, the sugar-sweetened beverage excise tax and the elimination of the tax subsidy for advertising unhealthy food to children.[24–26] The cohort model was limited in its ability to model heterogeneity of individual differences, exposure to the intervention, and trajectories of BMI over the life course, and it could not calculate population estimates for specific years. With the microsimulation model, we were able to estimate the number of cases of obesity prevented. For both of these interventions, the estimated costs per BMI unit reduction were similar under both modeling approaches, and both interventions were cost-saving.

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

EXHIBIT 1

Population Reach And Cost For Seven Childhood Obesity Interventions In The United States, 2015–25

Intervention	Population reach (millions)	Intervention cost: Per year ($ millions)	Intervention cost: Per unit of BMI reduced ($)
Sugar-sweetened beverage excise tax	306.6	47.6	2.49
95% UI	306.3, 307.0	31.0, 63.8	0.62, 10.59
Restaurant menu calorie labeling	306.6	95.5	13.09
95% UI	306.3, 307.0	82.7, 108.5	−122.61, 154.42
Elimination of the tax subsidy for advertising unhealthy food to children	72.3	0.82	0.66
95% UI	71.9, 72.8	0.82, 0.82	0.27, 1.13
Nutrition standards for school meals	28.0	1,112	53
95% UI	27.8, 28.2	1,112, 1,112	−185, 186
Nutrition standards for all other food and beverages sold in schools	45.2	22.3	6.10
95% UI	45.0, 45.4	22.3, 22.3	2.34, 7.72
Improved early care and education policies and practices (NAP SACC)	1.18	76.0	613
95% UI	1.14, 1.23	75.8, 76.4	99, 730
Increased access to adolescent bariatric surgery	0.0049	30.3	1,611
95% UI	0.0025, 0.0077	20.9, 40.2	1,241, 2,337

Source Authors' calculations, based on the microsimulation model described in Appendix A3 (see Note 11 in text). **Notes** Costs are in 2014 dollars. Cost per body mass index (BMI) unit reduction is an incremental cost-effectiveness ratio. UI is uncertainty interval. NAP SACC is Nutrition and Physical Activity Self-Assessment for Child Care.

EXHIBIT 2

Estimated Ten-Year Cost-Effectiveness And Economic Outcomes For Seven Childhood Obesity Interventions In The United States, 2015–25

Intervention	Net costs ($ millions)	Cases of childhood obesity prevented as of 2025	Health care costs saved per dollar spent ($)
Sugar-sweetened beverage excise tax	−14,169	575,936	30.78
95% UI	−47,119, −2,645	131,794, 1,890,715	6.07, 112.94
Restaurant menu calorie labeling	−4,675	41,015	5.90
95% UI	−16,010, 6,284	−41,324, 122,396	−5.06, 18.00
Elimination of the tax subsidy for advertising unhealthy food to children	−260	129,061	32.53
95% UI	−431, −94	48,200, 212,365	12.42, 53.35
Nutrition standards for school meals	6,436	1,815,966	0.42
95% UI	2,458, 12,560	−547,074, 3,381,312	−0.13, 0.78
Nutrition standards for all other food and beverages sold in schools	−792	344,649	4.56
95% UI	−1,339, −251	163,023, 522,285	2.13, 7.01
Improved early care and education policies and practices (NAP SAAC)	731	38,385	0.04
95% UI	706, 754	8,258, 69,111	0.01, 0.07
Increased access to adolescent bariatric surgery	303	—[a]	—[a]
95% UI	209, 401	—[a]	—[a]

SOURCE Authors' calculations based on the microsimulation model described in Appendix A3 (see Note 11 in text). **NOTES** Costs are in 2014 dollars; negative net costs indicate cost savings. Cost-saving interventions result in at least $1 of health care costs saved per $1 spent on the intervention. UI is uncertainty interval. NAP SACC is Nutrition and Physical Activity Self-Assessment for Child Care. [a]Not applicable.

Third, there is limited evidence that directly links the interventions we evaluated to change in population-level obesity prevalence. However, as detailed in Appendices A1, A2, and A4–A8,[11] six of the interventions were supported by randomized trials or natural or quasi-experimental evaluations[27] that linked the intervention or behavioral mechanism targeted by the intervention directly to reductions in BMI for recipients of each intervention. We incorporated uncertainty for all of the underlying model inputs into the probabilistic uncertainty analyses (see Appendix A3.1).[11]

Fourth, because we focused on obesity, we did not incorporate additional health improvements and health care cost reductions due to improvements in diet and physical activity that were independent of reductions in BMI (for example, reductions in diabetes and heart disease).[28]

Study Results

There were large differences in the projected population reach of the interventions (Exhibit 1). The reach of bariatric surgery, the smallest, was very limited, even assuming a fourfold increase in the number of adolescents who receive 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), fewer than two in a thousand received the procedure (Appendix A8).[11] The largest population reaches occurred with interventions that would affect the whole population, such as the sugar-sweetened beverage excise tax and restaurant menu calorie labeling—both of which would reach 307 million people.

The annual costs of the interventions were driven by both the cost per person and the population reach and varied greatly (Exhibit 1).

Differences across interventions in cost per BMI unit reduction varied more than 2,000-fold. Eliminating the tax deduction for advertising nutritionally poor food to children would reduce a BMI unit for $0.66 per person, while increasing access to bariatric surgery would reduce a BMI unit for $1,611.

Three of the interventions studied were found to be cost-saving across the range of modeled uncertainty: the sugar-sweetened beverage excise tax, eliminating the tax subsidy for advertising unhealthy food to children, and setting nutrition standards for food and beverages sold in schools outside of school meals (Exhibit 2). In other words, these interventions were projected to save more in reduced health costs over the period studied than the interventions would cost to implement. Perhaps more important, the interventions were projected to prevent 576,000, 129,100, and 345,000 cases of childhood obesity, respectively, in 2025. The net savings to society for each dollar spent were projected to be $30.78, $32.53, and $4.56, respectively.

Restaurant menu calorie labeling was also projected to be cost-saving (Exhibit 2), although on average the uncertainty intervals were wide because of the wide uncertainty interval around the estimated per meal reduction in calories ordered or purchased as a result of the intervention (see Appendix A4).[11] This uncertainty highlights the need for ongoing monitoring of this policy when it is implemented nationwide in 2016. Of note, a study of restaurant menu calorie labeling in King County, Washington, found that eighteen months after implementation of menu calorie labeling regulations, restaurants had reduced their calorie content by 41 kilocalories per entrée,[29] a much larger effect than the reduction of 8 kilocalories per meal estimated in this study.

Setting nutrition standards for school meals would reach a very large population of children and have a substantial impact: An estimated 1,816,000 cases of childhood obesity would be prevented, at a cost of $53 per BMI unit change (Exhibits 1 and 2). Improved early care and education policies and practices would reach a much smaller segment of the population (1.18 million), preventing 38,400 childhood obesity cases if implemented nationally, at a cost of $613 per BMI unit change.

The modeled preventive interventions could significantly reduce the overall prevalence of childhood obesity in the United States. Currently, the prevalence of obesity among children and youth is about 17 percent.[30] Based on our model, the largest reduction in childhood obesity prevalence compared to no intervention would occur with the implementation of nutrition standards for school meals (a reduction of 2.6 percent; data not shown), followed by the sugar-sweetened beverage excise tax (0.8 percent). Adding in the two other cost-saving interventions (elimination of the tax subsidy for advertising unhealthy food to children and setting nutrition standards for other foods and beverages sold in schools) would reduce prevalence by an additional 0.7 percent.

These interventions would have a modest impact on obesity prevalence. Even if all were implemented and the effects were additive, the overall impact would be a reduction of 4.1 percent, or 2.9 million cases of childhood obesity prevented for the population in 2025.

TAX REVENUE In addition to their effects on obesity, we estimated that both the sugar-sweetened beverage excise tax and the elimination of the tax subsidy for advertising unhealthy food to children would lead to substantial yearly tax revenues ($12.5 billion and $80 million, respectively). These revenues were not included in our calculations of net costs.

Discussion

These results indicate that primary prevention of childhood obesity should be the remedy of choice. Four of the interventions studied here have the potential for cost savings—that is, the interventions would cost less to implement than they would save over the next ten years in health care costs—and would result in substantial numbers of childhood obesity cases prevented.

The sugar-sweetened beverage excise tax—and, to a lesser extent, removing the tax deduction for advertising unhealthy food to children—would also generate substantial revenue that could be used to fund other obesity prevention interventions. The excise tax has been the focus of recent policy discussion,[25,31] and the recent enactment of an excise tax of one cent per ounce in Berkeley, California, and the national implementation of an excise tax in Mexico indicate the growing political feasibility of this approach.

The improvements in meal standards in the National School Lunch and School Breakfast Programs as well as implementation of the first meaningful national standards for all other foods and beverages sold in schools make the Healthy, Hunger-Free Kids Act 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 this intervention—which includes 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.

The individual benefits of bariatric surgery and other intensive clinical interventions to treat obesity can be life changing.[32] Another promising new obesity treatment strategy employs low-cost technological approaches—computerized clinical decision support—to effectively reduce excess childhood weight.[33] Our study should in no way discourage ongoing investment in advancing the quality, reach, and cost-effectiveness of clinical obesity treatment. However, our results indicate that with current clinical practice, the United States will not be able to treat its way out of the obesity epidemic. Instead, policy makers 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 intervention in this study separately to help policy makers prioritize investment in obesity prevention. However, as the results show, none of the interventions by itself would be sufficient to reverse the obesity epidemic. Instead, policy makers need to develop a multifaceted prevention strategy that spans settings and reaches individuals across the life course.

Because the energy gap that drives 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 having 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 in adulthood.

Increased access to adolescent bariatric surgery had the smallest reach and the highest cost per BMI unit reduction. Of the other six interventions that we analyzed, improving early care and education using the NAP SACC model both had the smallest reach, because of the intervention's relatively small age range and voluntary implementation strategy, and was the most costly per BMI unit reduction. Nonetheless, this intervention might still be a good investment, considering that even small changes among very young children can be important for setting a healthier weight trajectory in childhood.

Additionally, the intervention focuses on improvements in nutrition, physical activity, and screen time for all children and thus could have benefits for child development beyond reducing unhealthy weight gain. In contrast to the tax policies we evaluated, which have been met with opposition from industry, the NAP SACC program is well liked and has been widely adopted.

While policy makers should consider the long-term effectiveness of interventions that target young children, substantially reducing health care expenditures due to obesity in the near term will require implementation of strategies that target both children and adults. We estimated that over the decade 2015–25, the beverage excise tax would save $14.2 billion in net costs, primarily due to reductions in adult health care costs. Interventions that can achieve near-term health cost savings among adults and reduce childhood obesity offer policy makers an opportunity to make long-term investments in children's health while generating short-term returns. These results are consistent with previous research that estimated the potential health cost savings and health gains from reducing childhood obesity, much of which resulted from preventing obesity during adulthood.[34]

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, policy makers need to integrate the best available evidence on the potential effectiveness, reach, and cost of proposed obesity strategies to prioritize the highest-value interventions.

We found that a number of preventive interventions would have substantial population-level impacts and would be cost-saving. An important question for policy makers is, why are they not actively pursuing cost-effective policies that can prevent childhood obesity and that cost less to implement than they would save for society?

Our results also highlight the critical impact that existing investments in improvements to the school food environment would have on future obesity prevalence and indicate the importance 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 health care costs in the long run.

The focus of action for policy makers should be on implementing cost-effective preventive interventions, ideally ones that would have broad population-level impact. Particularly attractive are interventions that affect 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. ■

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11 To access the Appendix, click on the Appendix link in the box to the right of the article online.

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