Lifetime Direct Medical Costs of Childhood Obesity

abstract

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BACKGROUND AND OBJECTIVES: An estimate of the lifetime medical costs of an obese child provides a benchmark of the potential per capita savings that could accrue from successful childhood obesity prevention efforts. We reviewed the literature to identify the best current estimate of the incremental lifetime per capita medical cost of an obese child in the United States today relative to a normal weight child.

METHODS: We searched PubMed and Web of Science for US-based studies published within the 15 years preceding May 2013 from which lifetime medical cost estimates can be extracted or imputed. Two reviewers independently screened search results and extracted data from eligible articles. All estimates were inflated to 2012 dollars and discounted to reflect costs from the perspective of a 10-year-old child today.

RESULTS: We identified 6 studies. The incremental lifetime direct medical cost from the perspective of a 10-year-old obese child relative to a 10-year-old normal weight child ranges from $12 660 to $19 630 when weight gain through adulthood among normal weight children is accounted for and from $16 310 to $39 080 when this adjustment is not made.

CONCLUSIONS: We recommend use of an estimate of $19 000 as the incremental lifetime medical cost of an obese child relative to a normal weight child who maintains normal weight throughout adulthood. The alternative estimate, which considers the reality of eventual weight gain among normal weight youth, is $12 660. Additional research is needed to include estimates of indirect costs of childhood obesity. *Pediatrics* 2014;133:854–862

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KEY WORDS

childhood obesity, lifetime medical cost, cost of illness

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Roughly one-third of adults in the United States are obese.[1] Adult obesity is an independent risk factor for a wide range of noncommunicable diseases, including cardiovascular disease,[2] type 2 diabetes, metabolic syndrome,[3] sleep apnea,[4] and arthritis.[5–9] It is a significant cause of disability,[10–12] excess mortality,[13–16] lower productivity,[17] and higher medical costs.[18–20] Moreover, without significant intervention, it is estimated that half or more of the American adult population will be obese by 2030,[21,22] further eroding the health of the population and straining the health care system. Thus, a reduction in adult obesity prevalence has the potential to realize substantial health and economic benefits.

One of the primary strategies to address adult obesity is prevention efforts targeting youth. Although recently released data reveal slight decreases in childhood obesity prevalence in some states,[23] nearly a fifth of children aged between 6 and 19 years remain obese, more than twice the prevalence just 2 decades ago.[24,25] Moreover, the prevalence of extreme childhood obesity (BMI for age ≥99th percentile based on the 2000 Centers for Disease Control and Prevention growth charts) continues to increase,[26] and longitudinal studies show that 77% to 92% of obese teenagers remain obese in adulthood.[27–29] Thus, addressing adult obesity necessitates tackling childhood obesity. Not surprisingly, the US Task Force on Childhood Obesity has set the goal of reducing obesity prevalence among youth to 5% by 2030.[30]

Efforts to address childhood obesity come at a significant cost. The recent improvements cited earlier may be a result of the resources that have already been channeled toward childhood obesity prevention and treatment efforts. For example, in 2007 the Robert Wood Johnson Foundation pledged $500 million to fund such initiatives over the next 5 years.[31] In 2010, the California Endowment announced a 10-year, $1-billion program to build health-promoting communities across the state, partly in efforts to address childhood obesity.[32] The federal government and many state and local governments have also allocated resources directly for childhood obesity prevention efforts.

Policymakers are routinely asked to justify the value of childhood obesity prevention efforts, in both health and economic terms. One strategy for quantifying the economic value is to document the incremental lifetime costs of an obese child relative to a normal weight child. This estimate, which can also be used in cost-effectiveness analyses, provides a benchmark of the potential per capita savings that could accrue from successful obesity prevention and treatment efforts. Thus, the goal of this article is to review and update the literature to identify the best current estimate of the incremental lifetime per capita medical cost of an obese child in the United States today relative to a normal weight child. We also report the total excess costs of childhood obesity for 1 age cohort, 10-year-old children with obesity, in efforts to provide an estimate of the magnitude of these costs in aggregate.

Our determination of the most appropriate estimate is based on the quality and generalizability of the included studies. An appropriate estimate incorporates the following core components: differential costs by age and BMI from childhood until death, differential life expectancy for those at higher BMI values, and discounting to take into account the time value of money. Additionally, whereas most obese children will remain obese in adulthood,[33,34] roughly two-thirds of normal weight children will eventually become overweight or obese[28,29,35] and incur the resulting increase in health care costs and reduced life expectancy. If one believes that a particular childhood obesity intervention will only delay eventual increases in weight, as opposed to keeping a child at a normal weight throughout life, then an appropriate estimate of the incremental lifetime medical costs of an obese child relative to a normal weight child should take this eventual weight gain into consideration. Otherwise, the results would be biased in favor of higher estimates of potential savings. We present results under both scenarios because the appropriate estimate to report and use will depend on the context of the question at hand.

LITERATURE SEARCH

To identify candidate estimates, we conducted a systematic literature search in May 2013 using PubMed and Web of Science. Figure 1 depicts the literature search and article selection process. The search terms “obesity”, “child”, “adolescent”, “cost of illness”, and “lifetime cost” were used for PubMed. These terms were entered as free text and as Medical Subject Headings terms where applicable. The search results of like terms, such as “cost of illness” and “lifetime cost”, were combined using the OR function. The AND function was then used to retrieve studies that matched all 3 search themes: obesity, age group, and cost. When the search terms were applied to the Web of Science database, only 58 articles were retrieved. Therefore, the search terms “obesity” and “cost” were used to generate additional articles. A total of 2779 articles were identified by using both databases. Duplicates of 11 studies that appeared on both databases were removed. Of the remaining 2768 studies, 2675 were excluded because they did not report direct medical costs of obesity. The full-text articles of 93 remaining studies were assessed for eligibility. Of these, 42 studies were

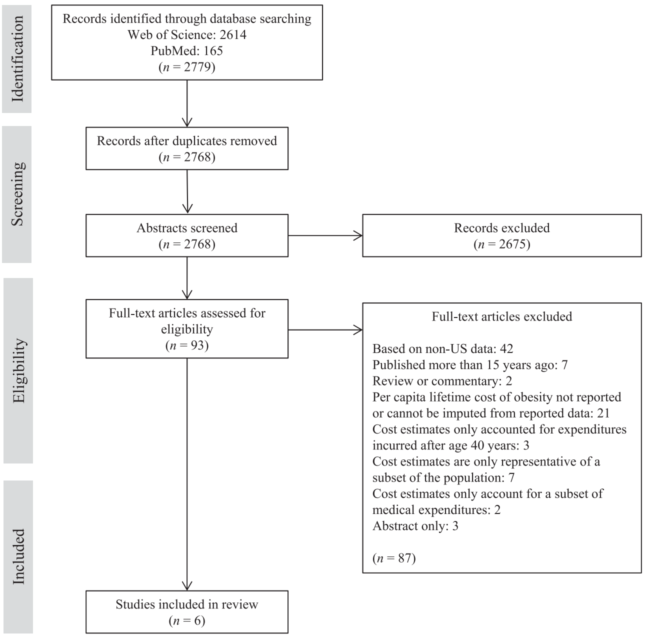

FIGURE 1
Study selection.

excluded because they were not based on US data. Another 45 studies were excluded because they were published >15 years ago and thus are unlikely to reflect today's medical cost profile, the per-person lifetime cost of obesity was not reported or could not be determined from the reported data, or they were reviews or commentaries. The reference lists of these reviews and the 6 shortlisted articles[36–41] were manually reviewed but did not yield additional articles for inclusion in the review. Column 1 of Table 1 provides the lead author and year of the 6 included studies.

Evaluation of Existing Unadjusted Estimates

The identified studies were evaluated in context of the core components listed earlier. Table 2 provides a summary of the key features of the selected studies.

Differential Costs by Age and BMI From Childhood Until Death

All studies recognized that direct lifetime medical costs are higher for obese people than for those of normal weight. However, not all studies accounted for the differential costs starting from childhood. Thompson et al[36] began accounting for differential costs in the age range of 34 to 44 years. Finkelstein et al[38] and Tucker et al[37] began accounting for differential costs beginning at age 20, whereas Wang et al[39] assumed that obese people start accruing obesity-related medical costs at age 40. They then discounted their estimates to reflect the perspective of a 17-year-old.[39] Only Ma and Frick[41] accounted for higher medical costs beginning as early as 6 years of age, and Trasande[40] started at age 12.

Although all studies incorporated higher annual medical cost estimates for obese people, the approach differed across studies. Thompson et al[36] accounted for higher costs by estimating the excess risk borne by obese people of 5 obesity-related medical conditions: hypertension, hypercholesterolemia, type 2 diabetes, coronary heart disease, and stroke, and multiplying the population attributable fraction for obese people by the estimated direct medical costs of each condition. They estimated different risk profiles for 3 distinct decades of life from 35 to 64 years. Tucker et al[37] assumed that direct medical costs increased by 2.3% for each BMI unit above 25 and by 1.3% for each additional year in age based on published estimates.[42]

Four studies used multivariate regression analyses to predict annual direct medical costs of individuals as a function of BMI while controlling for other characteristics such as gender, age, race or ethnicity, insurance, income, and education.[38–41] In 2 studies,[38,39] interaction terms of BMI or BMI category with age were used to generate age-specific estimates of the incremental costs for those in selected BMI categories. Trasande[40] and Ma and Frick,[41] on the other hand, assumed a single incremental cost of adult obesity that did not vary by age. This increases the likelihood of overstating lifetime costs, because annual obesity-related costs have been shown to start small and increase with age.[38,43,44] Trasande[40] accounted for this overstatement by reducing his final estimate by 38%.

All the studies stratified the age- and BMI-specific medical costs by gender. Three studies[37,38,41] also stratified the costs by race or ethnicity, and 1 study[41] further stratified results by smoking status.

Differential Life Expectancy by BMI

It is well documented that obesity decreases life expectancy.[15,16,45–50] Therefore, it is imperative for studies of lifetime costs to account for differential life expectancy between normal weight and heavier adults.

Five out of 6 studies considered the elevated mortality risk of heavier people in their estimates of lifetime costs.[36–39,41] Thompson et al[36] calculated the life expectancy of people with different BMI and comorbidity profiles from published and unpublished sources. Tucker et al[37]

TABLE 1 Summary of Studies Reviewed

Source	Longest Lifespan Covered	Primary Datasets Used	BMI Levels Compared	Stratification	Adjustment for Life Expectancy by BMI	Accounted for Changes in BMI Over Life Course	Unadjusted Estimates Abstracted Directly From the Studies
Tucker et al 2006[37]	20 y to death	Direct medical costs as reported by Burton et al (1998)[64]	34 vs 24	Gender Race or ethnicity White Black	Applied survival probabilities published by Fontaine et al 2003[15]	Yes, using equation developed by Heo et al (2003)[51]	In 2004 US dollars White Male: $8700 Female: $12 000 Black Male: $7180 Female: $12 240
Trasande 2010[40]	12 y to death	Nationwide Inpatient Sample, 2005[65]	BMI >95th percentile for age and gender	Gender	Author accounted for obesity-related medical costs from age 12 to 55	Yes	In 2005 US dollars
		MEPS 2002–2005[44] 6–19 y	>30 vs 18.5–25				Male: $15 850 Female: $15 830
Thompson et al 1999[36]	34–44 to 99 y	NHANES III	32.5 vs 22.5	Gender	LE = Sum of annual probabilities of survival from any of the 3 given age ranges	No	In 1996 US dollars
		Framingham Heart Study US Vital Statistics Social Security Administration data					Male: $9100 Female: $8600
Wang et al 2010[39]	40 y to death	MEPS 2000 >18 y	>30 vs 18.5–25	Gender	LE calculated by Finkelstein et al[16]	No	In 2007 dollars Male: $10 310 Female: $9340
Finkelstein et al 2008[38]	20 y to death	MEPS 2001–2004 >18 y	>30 vs 21–25	Gender Race or ethnicity White Black	LE calculated by Finkelstein et al[16]	No	In 2007 US dollars[a] White Male: $16 560 Female: $24 780 Black Male: $13 120 Female: $13 922
Ma and Frick 2011[41]	6 y to death	NHANES MEPS 2006 >18 y 6–17 y	>30 vs 18.5–25	Gender Smoking status Race or ethnicity White Black Hispanic	LE calculated by Finkelstein et al[16]	No	In 2006 US dollars White Male: $32 320 ($28 682)[b] Female: $40 870 ($37 260)[b] Black Male: $25 960 ($22 590)[b] Female: $37 030 ($33 780)[b] Hispanic Male: $23 180 ($19 110)[b] Female: $30770 ($27 590)[b]

All studies used an annual discount rate of 3%, and all studies used the Consumer Price Index, reported by the US Bureau of Labor Statistics, to inflate prices. LE, life expectancy; MEPS, Medical Expenditure Panel Survey; NHANES, National Health and Nutrition Examination Survey.

[a] Estimates obtained by calculating the weighted average of estimates for people with Class I and Class II/III obesity.

[b] Estimates for smokers in parentheses.

TABLE 2 Summary of Study Attributes

Accounted for	Tucker et al 2006[37]	Trasande 2010[40]	Thompson et al 1999[36]	Wang et al 2010[39]	Finkelstein et al 2008[38]	Ma and Frick 2011[41]
Starting age for direct medical cost accrual (y)	20	12[a]	35	40	20	6
Differential direct medical cost by age and BMI	Yes	Yes	Yes	Yes	Yes	Yes
Differential life expectancy by BMI	Yes	No	Yes	Yes	Yes	Yes
Time value of money	Yes	Yes	Yes	Yes	Yes	Yes
Weight transitions over the life course	Yes	Yes	No	No	No	No

[a] Trasande also examined ages 6, 12, and 19 y in a sensitivity analysis. The body of the article contained calculations based on the cohort of 12-y-olds in 2005.

relied on published survival probabilities[15] to account for differential life expectancy across BMI categories. The remaining 3 studies[38,39,41] based their life expectancy estimates on results presented by Finkelstein et al,[16] who reported differential life expectancy as a function of BMI category, smoking status, race, and gender. Ma and Frick[41] applied the estimates directly in their calculations. Wang et al,[39] on the other hand, collapsed the smoking status and race or ethnicity categories to generate weighted average life expectancy at age 40 for both genders. Finkelstein et al[38] generated estimates for each stratum separately. Trasande[40] did not directly account for differential life expectancy by BMI status but rather limited the accrual of incremental direct medical costs attributable to obesity to 35 years beginning at age 20. He then further reduced the medical expenditures by 38% so that the present value of adult obesity-attributable medical expenditures was not overestimated.

Discounting to Account for the Time Value of Money

All studies applied a 3% discount rate for calculating lifetime cost estimates.

BMI Transitions Over the Lifetime

Only 2 studies incorporated weight transitions over time. Tucker et al[37] applied a BMI growth curve equation developed by Heo et al[51] that allowed for estimating costs incurred by people who start out at normal weight but who become overweight or obese as they age. Their analysis also recognized that BMI continues to creep up over time for people who start out obese. Trasande[40] did not include weight transitions directly but did adjust his cost estimates by incorporating the probability that some normal and overweight children develop obesity in adulthood. The transition probabilities Trasande used are based on a small sample ($n = 347$) of predominantly white, suburban, and rural-dwelling people who participated in the Fels Longitudinal Study from 1929 to 1991.[52,53] Thus the data may not be representative of the contemporary population.

Adjustments Made to Facilitate Comparison Across Studies

To update the cost estimates to 2012 dollars and facilitate meaningful comparisons across the included studies, several additional calculations were needed. Trasande[40] did not report per capita lifetime medical costs but presented aggregate statistics. These estimates were divided by population counts to generate gender-specific per capita cost estimates. Wang et al[39] reported lifetime medical costs saved after age 40 when the prevalence of obesity is decreased by 1 percentage point in adolescence. Combining this information with BMI-specific life expectancy and age-related medical cost data reported by the authors allowed for imputing per capita lifetime cost estimates. For studies that reported lifetime medical costs over a range of BMI values,[36,37,39] the incremental lifetime cost of obesity was conservatively computed as the difference between the cost estimates for someone in the Obese I (BMI 30–35) and the normal weight range.

The second set of calculations related to obtaining the present value of the estimates provided in the various studies. For each exposition, we chose to present costs from the perspective of a 10-year-old obese child. As noted earlier, starting ages for the accrual of lifetime obesity-related medical costs differed across the selected studies. For each study, we used the youngest age or age range (and used the midpoint) as the starting age and the corresponding cost estimates. For comparability, once the starting age and the associated lifetime cost estimates were elicited, all estimates were inflated to 2012 dollars using the medical care portion of the Consumer Price Index for all urban consumers[54] and discounted to reflect costs from the perspective of a 10-year-old child today (note that the estimates of 1 study[41] were inflated for 4 years because their estimates began at age 6). Next, we filled in gaps for studies that did not account for increased costs in certain age ranges. The annual obesity-attributable medical cost per overweight child has been estimated at \$240 (2012 dollars) for children aged 8 to 13 years and \$320 (2012 dollars) for children aged 14 to 19 years old.[43] To account for costs between ages 20 and 39, we imputed estimates based on figures reported in Finkelstein et al.[38] We added the present value discounted costs for missing age ranges to the adjusted lifetime cost estimates for the 4 studies that needed this adjustment.[36–39]

Three studies reported separate estimates only by gender and age.[36,39,40] The remaining 3 studies reported separate estimates by race in addition to gender and age.[37,41,43] Ma and Frick[41] went a step further to report estimates by smoking status. To generate a single cost estimate, we calculated a weighted average of the estimates for given subpopulations included in each study, with weights based on the proportion of the 2011 US population ages 0 to 17 years who are non-Hispanic white, African American, and Hispanic males and females.[55] Similarly, the proportions of current smokers ages 14 to 17 years by gender and race estimated from the 2009 National Youth Tobacco Survey[56] were used to collapse the subcategories reported by Ma and Frick. Research shows that the majority of adult smokers begin smoking by age 18.[57] Thus, the estimates of smoking prevalence among high school students are reasonable approximations for the calculation of this weighted average.

RESULTS

After the adjustments discussed in the previous section are incorporated, the incremental lifetime direct medical cost from the perspective of a 10-year-old obese child relative to a 10-year-old normal weight child ranges from \$12 660 to \$19 630 when weight gain through adulthood among normal weight children is accounted for (based on 2 studies: Tucker et al[37] and Trasande[40]), and from \$16 310 to \$39 080 when such weight is not accounted for (based on 4 studies: Thompson et al,[36] Wang et al,[39] Finkelstein et al,[38] and Ma and Frick[41]). Table 3 summarizes the adjusted lifetime cost estimates overall, by gender and by gender and race (with and without smoking status).

Among the 4 studies[36,38,39,41] that do not account for weight gain among normal weight youth, Thompson et al,[36] at \$16 310, reported a slightly lower overall estimate than the other 3 because the authors accounted for only 5 obesity-related medical conditions. It has been shown that these conditions account for roughly 85% of obesity-related direct medical costs.[58] Inflating Thompson et al's estimate by 15% yields \$18 760, which is close to the estimates provided by Wang et al and Finkelstein et al.

Ma and Frick[41] reported the highest overall estimate, at \$39 080, significantly higher than those in the other studies. This results from their application of a single obesity-attributable annual medical cost of \$1910 in 2012 dollars from age 18 years to death; unlike Trasande,[40] they did not adjust their estimate to offset inflated costs at lower ages. Had they followed Trasande's approach, their overall estimate would have been \$20 470, only slightly higher than the other estimates that did not consider weight transitions.

TABLE 3 Summary of Adjusted Incremental Lifetime Direct Medical Cost Estimates From the Perspective of a 10-y-Old Child With Obesity Relative to a 10-y-Old Child With Normal Weight, in 2012 US Dollars

Characteristic	Tucker et al 2006[37]	Trasande 2010[40]	Thompson et al 1999[36]	Wang et al 2010[39]	Finkelstein et al 2008[38]	Ma and Frick 2011[41,a]
Study accounted for wt gain among normal wt children	Yes	Yes	No	No	No	No
Gender						
Male	\$10 840	\$19 650	\$16 210	\$19 300	\$16 420 (\$11 190, \$21 660)[b]	\$33 590
Female	\$14 490	\$19 620	\$16 410	\$18 950	\$22 290 (\$17 350, \$27 200)[b]	\$44 570
Race or ethnicity						
White						
Male	\$11 150	—	—	—	\$17 050 (\$12 240, \$21 900)[b]	\$38 680 (\$34 190)[c]
Female	\$14 440	—	—	—	\$24 280 (\$19 210, \$29 320)[b]	\$49 230 (\$44 780)[c]
Black or African American						
Male	\$9640	—	—	—	\$14 020 (\$7240, \$20 750)[b]	\$30 830 (\$26 670)[c]
Female	\$14 670	—	—	—	\$14 730 (\$10 310, \$19 170)[b]	\$44 490 (\$40 480)[c]
Hispanic						
Male	—	—	—	—	—	\$27 390 (\$22 380)[c]
Female	—	—	—	—	—	\$36 760 (\$32 840)[c]
Overall	\$12 660	\$19 630	\$16 310	\$19 120	\$19 350 (\$14 270, \$24 430)[b]	\$39 080[d]

[a] Original estimates from this study were inflated by 4 y because their estimates began at age 6.
[b] The 95% confidence intervals are presented in parentheses.
[c] Estimates for smokers are presented in parentheses.
[d] This estimate is for smokers and nonsmokers combined.

Only Finkelstein et al[38] presented confidence intervals of their lifetime cost estimates (see Table 3). After we adjust Ma and Frick's estimate to account for overestimating costs at lower ages, the adjusted estimates of the studies that do not account for weight transitions[36,38,39,41] fall within the 95% confidence interval reported by Finkelstein et al.

Both Tucker et al[37] and Trasande[40] adjusted their estimates for weight gain among normal weight youth. Consistent with expectations, Tucker et al's estimates are much lower than those reported by the other 4 articles in this review. Trasande's estimate, on the other hand, is extremely close to those in the studies that do not make this adjustment. This suggests that Trasande's estimate may be inflated. Therefore, Tucker et al's estimate of \$12 660 may be a more appropriate estimate of the incremental costs of an obese 10-year-old versus a normal weight 10-year-old who has a high chance of future weight gain.

DISCUSSION AND RECOMMENDATIONS

Based on this analysis, the incremental lifetime medical cost of an obese child relative to a normal weight child who maintains normal weight throughout adulthood ranges between \$16 310 and \$19 350, with 3 of the 4 studies clustering closer to the upper bound estimate. If one considers eventual weight gain among normal weight youth, estimates range between \$12 660 and \$19 630, with the lower bound estimate being perhaps more likely because the upper bound estimate overlaps with the studies that do not allow for weight gain among normal weight youth. As noted earlier, which estimate is more appropriate for policy analyses will depend on the context of the question being considered.

To put these findings into perspective, multiplying the lifetime medical cost estimate of \$19 000 times the number of obese 10-year-olds today generates a total direct medical cost of obesity of roughly \$14 billion for this age alone. This is nearly twice the Department of Health and Human Services \$7.8-billion budget for the Head Start program in fiscal year 2012.[59] On a per capita basis, the cost of 1 year of college (including tuition, fees, books, room and board, and other expenses) at a public 4-year institution is roughly \$16 930.[60] Thus, each case of childhood obesity that could be prevented and maintained (at no cost) would allow for funding $\geq$1 year of a child's college education. When the most conservative estimate of \$12 660 is applied, the total direct medical cost for the same cohort of 10-year-olds falls to \$9.4 billion. Even so, this amount is 62 times the 2012 to 2013 funding for the nationwide Fresh Fruit and Vegetable Program, which has been shown to increase the consumption of fruits and vegetables among students in participating schools.[61,62]

It is worth reiterating that because the adverse health effects of obesity do not occur until well into adulthood and future costs are discounted, the lifetime cost of obesity is highly influenced by whether one focuses on children or adults. Ironically, the lifetime costs of obesity are actually greater for adults than for children. This is not to say that obesity prevention and treatment efforts should not target youth but only that the economic case for doing so is limited if one focuses solely on the incremental costs. This narrow view does not consider the reality that prevention efforts typically do not just target overweight youth. There is the potential to improve weight management among all youth that could last well into adulthood. The medical cost estimates also do not consider other benefits that could be achieved through successful obesity prevention efforts. They do not account for obesity's effect on health-related quality of life or on nonmedical costs. Research has shown that among full-time workers, the indirect costs of obesity, including increased absenteeism and presenteeism (reduced on-the-job productivity) account for 59% of the total.[63] Considering these or other nonmedical costs would further improve the business case for childhood (and adult) obesity prevention efforts. This should be an area of future research.

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