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Soda Taxes, Soft Drink Consumption, And Children's Body Mass Index

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Abstract

Taxes on sugar-sweetened beverages have been proposed to combat obesity. Using data on state sales taxes for soda and individual-level data on children, we examine whether small taxes are likely to change consumption and weight gain or whether larger tax increases would be needed. We find that existing taxes on soda, which are typically not much higher than 4 percent in grocery stores, do not substantially affect overall levels of soda consumption or obesity rates. We do find, however, that subgroups of at-risk children—children who are already overweight, come from low-income families, or are African American—may be more sensitive than others to soda taxes, especially when soda is available at school. A greater impact of these small taxes could come from the dedication of the revenues they generate to other obesity prevention efforts rather than through their direct effect on consumption.

Carbonated soft drinks, or soda, and other sugar-sweetened beverages such as fruit punch, sweetened tea, and sports drinks are commonly targeted in anti-obesity initiatives. One of the most common—and most controversial—proposals is the notion of taxing these beverages, based on the success of tobacco excise taxes in reducing tobacco consumption.

A number of studies have found that soda consumption is price-sensitive, with a 10 percent increase in price leading to an 8 percent average reduction in consumption.¹ However, there is limited research on the extent to which increases in soft drink taxes would translate into reduced weight. No such evidence is available for children. A few recent studies found that higher soda taxes are very weakly associated with adolescent and adult weight levels.^{2–4}

In 2007 twenty-eight states taxed soda at a higher rate than the sales tax on other types of food.⁵ In this paper we estimate the potential effect of taxes on children's consumption and weight by taking advantage of existing variations in soda sales taxes and sales tax exemptions across states. Does the range of current state-level soda tax rates have a significant effect on consumption patterns and weight gain among children?

There are both practical and substantive reasons why proposals to tax soda or sugar-sweetened beverages are so prominent. Carbonated soft drinks or sugar-sweetened beverages are more easily defined than other categories of snack items, which makes it easier to implement such

taxes. Youth have increased their consumption of calories from sugar-sweetened beverages continuously since the 1970s; by now, more than 200 calories daily, or 10 percent of daily energy needs, come from sugar-sweetened beverages. These are calories that otherwise meet no nutritional needs.^{6,7} Soda accounts for most of the consumption of sugar-sweetened beverages.^{6,7}

Reviews of the literature show that consumption of sugar-sweetened beverages is associated with higher energy intake, lower nutrient intake, and increased weight gain or risk for obesity. Even though no single food is responsible for the energy imbalance, the intake of sugar-sweetened beverages by itself is much higher than the energy imbalance that underlies the obesity epidemic among youth.⁷⁻⁹

High-profile taxes on soda or sweetened beverages have been introduced at the local, state, and federal levels. The City of San Francisco proposed in 2007 to levy a fee on sugar-sweetened beverages to recapture medical care costs attributable to obesity.¹⁰ In 2009, New York State's executive budget proposed an additional 18 percent sales tax on nondiet soft drinks and fruit drinks containing less than 70 percent natural fruit juice.¹¹ The stated goal was that "by increasing the price, [the tax] will discourage individuals, especially children and teenagers, from excessive consumption of these beverages."¹¹ However, the proposal has since been dropped.

In connection with discussions on how to finance health care reform,¹² the U.S. Senate held hearings on soft drink taxes in May 2009. The industry then launched an aggressive national anti-soft drink tax campaign in the summer of 2009.¹³

Study Data And Methods

DATA

EARLY CHILDHOOD LONGITUDINAL STUDY—KINDERGARTEN COHORT—We combined individual-level national data from the Early Childhood Longitudinal Study—Kindergarten Cohort (ECLS-K) with data on state-level grocery store soda tax rates that were in effect during the year in which the longitudinal study data were collected. We examined children's body mass index (BMI, weight in kilograms divided by height in meters squared), total consumption of sugar-sweetened beverages in the past week, and consumption of such beverages at school.

The Early Childhood Longitudinal Study—Kindergarten Cohort is a panel data set of elementary school students that began with a nationally representative cohort of U.S. kindergartners in the fall of 1998 and followed them over time. Data on food consumption were collected in fifth grade (spring 2004) but not in earlier waves, and height and weight were measured by study staff in all waves. This is a distinct advantage of this data set, because most other data sets only have self- or parent-reported height and weight.

The child food consumption questionnaire asked: "During the past seven days, how many times did you drink soda, sports drinks, not 100 percent juice?" There were seven response categories, which we converted into a continuous measure. Children were asked how many times they bought those drinks in the past week at school, if available. Given that soda consumption accounts for the majority of sugar-sweetened beverage consumption among children,^{6,7} we refer to these drinks as "soda" in the remainder of the paper and in the exhibits, even though the survey question includes other sugar-sweetened beverages.

We have data on soda consumption and soda purchases at school from 7,414 children and data on BMI for 7,300 children. More details on data, methods, and results can be found in the online Appendix.¹⁴

The dependent variables in this analysis were soda consumption in the past week, soda purchases at school, and change in BMI between the third and fifth grades.

Other individual-level control variables included the child's age in months; race and ethnicity indicators, with non-Hispanic white as the reference group; female; a continuous income measure plus additional indicators of family income under \$25,000 and over \$75,000; indicator variables of the mother's education level (less than high school, some college, and college degree, with high school diploma as the reference group); parents' reports of number of times the child engaged in vigorous physical activity per week; weekly television hours; and two scales of parent-child interaction (one about help with homework, the other about how often they talk about school and friends). When analyzing BMI, we also included birth weight.

STATE LEVEL DATA ON SODA TAXES—Data on state-level sales tax rates for soda purchased through grocery stores came from data collected for the Robert Wood Johnson Foundation–supported Bridging the Gap program. The term “states” includes the fifty states and the District of Columbia. Sales tax rates were compiled from state statutory and administrative laws via primary legal research and were verified by the states.⁵ The sales tax rates we used here were specific to carbonated drinks and did not necessarily apply to other sugar-sweetened beverages such as fruit punch or sports drinks. For purposes of this analysis, taxes on carbonated drinks are referred to as soda taxes.

To match the tax data to the fifth-grade wave of the Early Childhood Longitudinal Study individual-level data collected in the spring of 2004, we used tax rates that were in effect in January 2004. Our primary measures were, first, the difference between taxes on soda versus those on other food sold in grocery stores; and second, an indicator of whether the soda tax rate was greater than the general food tax rate. We considered differences because we wished to estimate the effect of price changes for soda, not the effect of cost-of-living increases where all prices change in the same way. New soda taxes would change the prices differentially.

STATISTICAL METHODS

We used specification tests to find statistical models that best fit the data.¹⁴ For the relationship between taxes and consumption, the best-fitting model is a gamma regression model with a log link; for taxes and BMI, it is ordinary least squares. Because coefficients in nonlinear models are hard to interpret, we show the marginal effect (or the discrete change of a dummy variable from 0 to 1) at the mean in the exhibits. In other words, the numbers show our estimated effect of a one-percentage-point change in the tax rate or a switch from 0 to 1 for a dichotomous variable. A more detailed explanation of the analytic models and methods is included in the online Appendix.¹⁴ The variation in tax rates is cross-sectional (that is, tax differences across states in 2004), even if the individual outcome variable (BMI change) is longitudinal.

STUDY LIMITATIONS

One limitation of the study is that the sample size has little statistical power to detect small policy effects, even though there is good statistical power to estimate the effects of individual behavior, such as television watching. The clustered sampling design at the school level further reduces the statistical power.

Another limitation is that the sales tax differentials were for carbonated soft drinks versus other types of food, while the Early Childhood Longitudinal Study questions used for this analysis included carbonated soft drinks and other sugar-sweetened beverages.

Study Results

SUMMARY OF FINDINGS

CHILDREN'S SODA CONSUMPTION—Children report a mean consumption of more than six sodas per week (the median consumption is two sodas per week), with wide variance (Exhibit 1). Fifteen percent of children have zero consumption, 25 percent drink soda daily, and 10 percent consume two or more drinks a day. The much larger mean—three times greater than the median—is a reflection of the fact that there are a small number of children with much greater-than-average consumption.

The average number of soda purchases at school is small. Four-fifths of children buy no soda at school, although the remaining children average three soda purchases per school week.

BODY MASS INDEX PERCENTILE—The average BMI in the sample is situated at the sixty-seventh percentile of the growth charts. Growth charts are based on historical data. This means that in the past, 67 percent of the population had a lower BMI than the average BMI in this data. This statistic is a good indicator of the obesity problem. If children in the sample had the same weight distribution as the historical data on which the growth charts are based, the average should be around the fiftieth percentile.^{15,16}

The mean increase in BMI between third and fifth grades was 1.9, and the median increase was 1.5. In contrast, the median BMI increase for this age range according to the growth charts should have been 0.4. The change observed indicates a substantial excess weight gain for the children in this study.

BEHAVIOR—Two individual behaviors particularly relevant to obesity are TV watching, a sedentary behavior, and vigorous physical activity. The average TV time for our study was 7.6 hours per week, and the average number of days per week with vigorous activity was 3.8.

TAXES—For the children in the sample, the average tax on soda sold in grocery stores is 4.2 percent; it ranged from 0 to 7 percent. This is, on average, 3.5 percentage points higher than the tax on other types of food. Twenty states have a “differential tax” on soda—that is, a tax on soda greater than the tax on other food items. Sixty-five percent of the children in this sample live in states with differential taxes.

ASSOCIATIONS BETWEEN TAXES, SODA CONSUMPTION, AND BMI

Exhibit 2 reports effects of changes in state-level taxes (measured as the difference between sales taxes on soda and on other types of food) for the entire sample on the dependent variables listed: total soda consumption, soda purchases at school, and BMI change. Exhibit 3 repeats the analysis for various subgroups in the sample that are at risk for obesity—namely, at or above the eighty-fifth percentile for BMI (based on growth charts), children from low-income households, children who watch a great deal of TV, and African American children. Exhibit 4 explores the school findings in more depth by limiting the data to children who reported that sugar-sweetened beverages were available at school.

As noted earlier, we were interested in whether a state had a differential tax for soda (see column in exhibits labeled “higher soda tax indicator”), and, if so, by how much (see column labeled “higher soda tax amount.”) We were also interested in the effects these have on the mean values

of the dependent variables for both the entire sample (Exhibit 2) and the subgroups (Exhibits 3 and 4).

In Exhibit 2, column 1 (“higher soda tax amount”) shows the effect of a one-percentage-point increase in soda tax (in excess of tax on other food items), and column 2 (“higher soda tax indicator”) shows the effect of implementing the average differential tax rate from our sample. Consider the last row of Exhibit 2. This shows that an increase in the differential soda tax by one percentage point is associated with a 0.013 reduction in average BMI, while implementing the average differential tax rate would be associated with a 0.085 reduction in average BMI. Exhibits 3 and 4 may be interpreted similarly for the subgroups shown.¹⁷

TAXES AND CONSUMPTION—As shown in Exhibit 2, there was no significant relationship between differential soda taxes and overall soda consumption for the whole population. This means that, within the limitations of our analysis, increasing the differential tax on soda doesn’t affect total soda consumption. We found a significant relationship between differential soda taxes and BMI change from third to fifth grades. But this finding does not hold up under different statistical analysis,¹⁴ and the effect may be attributable to children who are already at risk for being overweight (Exhibit 3).

Exhibit 2 does not show the detailed results for other control variables, which are not of primary interest in this analysis. The most important predictors of total consumption (all significant at the 0.01 level) are increased hours of TV viewing (which leads to increased consumption) and mother with a college education, female, and Asian (which all lead to reduced consumption). The most important predictors of soda purchases at school (all significant at the 0.01 level) are African American and increased hours of TV viewing (both of which lead to increased soda purchases). The most important predictors of a larger BMI increase are African American and increased hours of TV, whereas higher income, mother with college education, and days with vigorous physical activity predict smaller BMI gains (all significant at the 0.01 level).

CHILDREN AT HIGHER RISK—Because Exhibit 3 deals with much smaller samples (subsets of the entire sample), statistical power is reduced. For the groups shown, higher differential soda taxes are associated with lower total consumption, although not in a way that is statistically significant. For children in low-income families, African Americans, or heavy TV watchers, higher differential taxes predict significantly lower consumption at school. Finally, higher taxes are also associated with significantly lower BMI gain for the heavier children.

CHILDREN WITH ACCESS TO SODA AT SCHOOL—Exhibit 4 shows results only for children who reported that sugar-sweetened beverages were available at school. The results become even stronger, and now differential soda taxes are also predictive of total consumption, indicating the role that schools play in consumption. Reductions in school purchases account for about one-third of the decline in consumption and for a bigger decline among African Americans. There are no significant associations with weight gain, which is therefore not reported in Exhibit 4.

Discussion

This study estimated whether small taxes on soda affect consumption behavior of children and their weight gain. The existing variation in taxes on soda is not very large—up to 7 percent, with a mean differential of 3.5 percent. Many proposals, even those put forward by advocates of “junk food” taxes, call for taxes that are well within the range of existing variation.¹⁸ Similar to the findings from previous studies that linked tax data to individual-level adolescent and adult population data on weight outcomes,^{2,4} our results suggest that such small taxes are

unlikely to have measurable effects on soda consumption or obesity among children overall. However, there may be more noticeable effects in population subgroups at higher risk for obesity.

We found statistically significant and substantively larger effects of differential soda sales taxes among children who are heavier, have lower family income, are African American, or watch a great deal of TV. This was particularly pronounced for children for whom sugar-sweetened beverages are available at school. For African Americans, the decline in soda purchases at school associated with any differential tax (1.4 drinks during the school week) accounted for more than half of the decline in total consumption (2.6 drinks).

Overall, the magnitudes are small, which may simply be a consequence of the small tax differentials in place. Larger increases (such as 18 percent, as was under consideration in New York State in 2009) would have larger effects than any existing differential sales tax.

EFFECT OF PLACE OF PURCHASE

Most of our statistically significant findings apply to soda purchases at school. One reason this outcome may be more sensitive is that as tax rates rise, posted prices (inclusive of taxes) in cafeterias or vending machines may jump to higher rounded price points. Consequently, the effect of a percentage sales tax may be higher than at grocery stores, where the tax is applied at the cash register. This would affect lower-income groups more. Previous studies for other types of food have reported larger price effects on BMI among heavier and lower-income children and youths.^{19–21}

Several more of our results would have been significant at the 5 percent level without the clustered sampling design effect described above. However, this would not change our conclusion that for the full population, the range of variation in taxes does not predict total consumption or BMI. Larger taxes could have more pronounced effects at the population level. Among children at higher risk for obesity, however, even taxes in the range of current rates can affect outcomes.

SODA TAX AMOUNTS

The range of existing soda tax rates is relatively small. That may arguably be the relevant comparison, as new taxes are likely to be relatively small. In that case, we should not expect noticeable behavior or weight changes for children in the general population. A greater impact of these small taxes could come from the dedication of the revenues they generate to other obesity prevention efforts rather than through their direct impact on children's consumption of soda.

On the other hand, the combination of a continuing obesity epidemic and states' financial difficulties in the economic downturn may lead to much larger changes. The 18 percent soda tax rate originally proposed in New York's Executive Budget is much larger than existing tax rates. Our estimated marginal effect of differential taxes on BMI increases between third and fifth grades is -0.013 BMI units at the population level. If effects were linear, an 18 percent differential soda tax would correspond to -0.23 BMI units, or a 20 percent reduction of the excess BMI gain. No other anti-obesity policy has demonstrated a reduction of that magnitude yet, so our results do not imply that excise taxes would be ineffective at the population level—only that small taxes in the range of existing differentials are unlikely to have visible effects at the population level.

The economic theory of the design and effects of taxes is fairly clear, although the empirical evidence is limited and estimates cover a wide range.¹ If reducing the consumption of sugar-sweetened beverages is the goal, rather than collecting money, taxes need to be linked to

consumption. An approach such as that considered in San Francisco, which would collect a fixed annual fee from retailers in order to sell sugar-sweetened beverages, fails that criterion.

EXCISE VERSUS SALES TAXES

A specific excise tax would be preferable to a sales tax. A tax levied per ounce would be easiest to implement, although it is possible, but more complicated, to levy a tax based on sugar content. The latter will encourage substitution to cheaper, larger-volume products, rather than a reduction in consumption. Also, an excise tax is preferable to a sales tax because it would be incorporated into the shelf price, making the higher costs more visible to consumers.

CONCLUDING COMMENTS

Efforts to reduce obesity are accelerating, and a common target is reducing the consumption of sugar-sweetened beverages. For youth, initiatives so far have sought to limit the sale of soda in schools, but schools are only one source of consumption. We can expect that many localities will implement taxes on a variety of foods deemed “junk” foods, most likely starting with sugar-sweetened beverages, in the near future. To have a measurable effect on consumption, taxes need to be tied to consumption, and they need to be larger than the existing state variation in sales taxes.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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16. Even though height and weight were measured by study staff, four observations had a BMI of under 10, which is not credible and likely to reflect measurement or recording errors. For change in BMI, we dropped the top and bottom 1 percent values to avoid the influence of gross measurement errors.
17. The multivariate regression models include the following control variables (unless they are dropped for collinearity in the subgroup analyses): age, female, a continuous income measure, indicators of family income (less than \$25,000 or more than \$75,000), three race/ethnicity dummies (African American, Hispanic, Asian), three maternal education dummies (less than high school, some college, completed college), days of vigorous physical activity, weekly hours of TV watching, and two scales of parent-child interaction. The BMI change regression also included birth weight.
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EXHIBIT 1**Descriptive Statistics For Outcome, Policy, And Child/Family Control Variables, Study Of Childhood Soda Consumption**

Variable	Mean/frequency	Standard deviation	Minimum	Maximum
DEPENDENT VARIABLES				
Number of drinks per week	6.1	7.5	0	28
Number of drinks bought at school per week	0.35	1.43	0	20
Body mass index (BMI)	20.5	4.6	7.7	47.3
BMI percentile	67	29	0	99.8
Change in BMI	1.91	1.63	-2.27	7.00
CHILD/FAMILY VARIABLES				
Age (months)	134.4	4.2	111	152
Annual family income (\$ thousands)	60.9	46.2	4	200 (top code)
Weekly hours of TV watching	7.6	4.0	0	31
Parent-child interaction—homework	4.5	3.1	0	11
Parent-child interaction—friends	5.3	0.9	0	6
Number of days per week with more than 20 minutes of vigorous physical activity	3.8	1.9	0	7
Female	49.8%	50	0	1
Family income under \$25,000	21.6%	41	0	1
Family income over \$75,000	35.1%	35	0	1
African American	14.2%	35	0	1
Hispanic	17.5%	38	0	1
Asian	2.3%	15	0	1
Mother has less than high school education	10.2%	30	0	1
Mother has high school diploma	24.3%	43	0	1
Mother has some college education	37.5%	48	0	1
Mother has completed college or higher degree	28.0%	45	0	1
TAX VARIABLES				
Tax on soda if sold through grocery store	4.2%	2.5	0	7
Differential soda—other food tax in grocery stores	3.5%	2.8	0	7
Indicator for higher soda tax	66%	47	0	1

SOURCE Authors' analysis of data from the Early Childhood Longitudinal Study—Kindergarten Cohort.

NOTES Summary statistics are weighted using wave 6 child weights. Summary statistics for child/family and tax variables are based on N = 7, 414 corresponding to the sample for total soda consumption, N = 7, 403 for soda consumption at school, N = 7, 300 for BMI, and N = 6, 866 for BMI change.

EXHIBIT 2

Associations Between Soda Taxes And Outcomes, Marginal Effects

Dependent variable	Higher soda tax amount	Higher soda tax indicator
Total drinks per week	-0.004	-0.006
Drinks bought at school	-0.010	-0.064*
BMI change	-0.013*	-0.085**

Source Authors' analysis of data from the Early Childhood Longitudinal Study—Kindergarten Cohort.

NOTES Sample sizes are available in the Exhibit 1 Notes. The estimated models are GLM with log link and gamma distribution for soda consumption, identity link and normal distribution (ordinary least squares regression) for BMI. A full version of this exhibit, with additional variables and robust standard errors, is available in the online Appendix, which can be accessed by clicking on the Appendix link in the box to the right of the article online.

* $p < 0.10$

** $p < 0.05$

EXHIBIT 3

Results For Subgroups At High Risk For Obesity, Marginal Effects

Outcome variable	Total consumption		School consumption		BMI change	
	Higher soda tax amount	Higher soda tax indicator	Higher soda tax amount	Higher soda tax indicator	Higher soda tax amount	Higher soda tax indicator
At risk of overweight (N = 2, 917 for total consumption)	-0.026	-0.078	-0.011	-0.067	-0.033**	-0.222**
Family income <\$25,000 (N = 1, 371 for total consumption)	-0.142*	-0.811	-0.039**	-0.239**	-0.000	-0.005
African American (N = 701 for total consumption)	-0.125	-0.767	-0.103***	-0.585***	0.029	0.086
9 hours or more of TV watching per week (N = 2, 345 for total consumption)	-0.073	-0.376	-0.029**	-0.178**	-0.014	-0.091

SOURCE Authors' analysis of data from the Early Childhood Longitudinal Study—Kindergarten Cohort.

NOTES Overweight is defined as body mass index at the eighty-fifth percentile or higher. A full version of this exhibit, with robust standard errors, is available in the online Appendix, which can be accessed by clicking on the Appendix link in the box to the right of the article online.

* $p < 0.10$

** $p < 0.05$

*** $p < 0.01$

EXHIBIT 4**Results For Subgroups At High Risk For Obesity, Subset Of Students Who Report Availability Of Soda At School**

Outcome variable	Total consumption		School consumption	
	Higher soda tax amount	Higher soda tax indicator	Higher soda tax amount	Higher soda tax indicator
All children reporting availability at school	-0.10*	-0.62**	-0.03**	-0.26**
At risk of overweight (N = 1, 108 for total consumption)	-0.165**	-1.046**	-0.023	-0.150
Family income <\$25,000 (N = 538 for total consumption)	-0.283**	-1.76**	-0.087**	-0.504**
African American (N = 301 for total consumption)	-0.500***	-2.62***	-0.252***	-1.41***
9 hours or more of TV watching per week (N = 951 for total consumption)	-0.225**	-1.35**	-0.063**	-0.385**

SOURCE Authors' analysis of data from the Early Childhood Longitudinal Study—Kindergarten Cohort.

NOTES Overweight is defined as body mass index at the eighty-fifth percentile or higher. A full version of this exhibit, with robust standard errors, is available in the online Appendix, which can be accessed by clicking on the Appendix link in the box to the right of the article online.

* $p < 0.10$

** $p < 0.05$

*** $p < 0.01$