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CAN TAXING SUGARY SODA INFLUENCE CONSUMPTION AND AVOID UNANTICIPATED CONSEQUENCES?

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This article is part of a series of Policy Issues articles on Soda Tax. You can also find articles on Should Soft Drinks be Taxed More Heavily?, Sugar-Sweetened Beverage Taxation as Public Health Policy-Lessons from Tobacco, Soda Taxes and Substitution Effects: Will Obesity be Affected?, Better Milk than Cola: Soft Drink Taxes and Substitution Effects, Evaluating Excise Taxes: The Need to Consider Brand Advertising, and Caloric Sweetened Beverage Taxes: The Good/Food/Bad Food Trap as part of this theme.

Sugary soda intake has increased sharply over the last several decades among all age groups and is now the single most important source of calories in the United States. (Block, G., 2004; Nielsen and Popkin, 2004; Wang, Bleich, and Gortmaker, 2008). Because of evidence linking heavy consumption of these beverages to weight gain and adverse health outcomes (Malik, Schulze, and Hu, 2006; Vartanian, Schwartz, and Brownell, 2007; Vermunt, Pasman, and Kardinaal, 2003), policy-makers and public health leaders are promoting soda taxes as a means to decrease consumption and raise funds for public health and obesity control programs (Brownell, K.D. et al., 2009; Brownell and Frieden, 2009). The push towards a soda tax has been buoyed by evidence of a declining price of soda (Brownell and Frieden, 2009; Duffey, K.J. et al., 2010). Because the inflation-adjusted price of soda has declined by as much as 48% over 20 years, a tax increase would have a small impact on the historical price, therefore, making its implementation more feasible.

Currently, 33 states have taxes on soda with an average tax rate of 5% (impactTEEN, 2011). Twenty one of these states have a tax specifically targeting soda, with an average of 6%; the other states have general taxes on food products that also apply to soft drinks. Currently, all of these states levy sales taxes on soft drinks, rather than excises taxes. Excises taxes, which are commonly proposed as the tax most likely to affect soda consumption, are levied by weight or volume of the product. In contrast, sales taxes are levied as a percent of the cost of the item (Brownell, K.D. et al., 2009). While the revenue benefits of these taxes seem clear (Center for Science in the Public Interest, 2011), the health impacts of such taxes remain uncertain. In this article, we discuss the possible benefits and unintended consequences of a sugary soda tax.

Will Tax Increases Affect Sugary Soda Consumption?

Several observational studies have estimated the potential impact of taxation on sales of sugary soft drinks. These studies typically have estimated the price elasticity of demand, which is a measure of the likely change in demand for—or sales of—a product that would result from a change in price. In an analysis based on surveys of households, Finkelstein and colleages estimated that a tax on sugary soda would reduce demand, with a price elasticity of demand of -0.7, meaning that for every 10% tax, sales would fall by 7% (Finkelstein, E.A. et al., 2010). Results varied according to household income levels with elasticities ranging from -1.0 for households in the third income quartile and -0.5 in the lowest income quartile. Accounting for likely substitution of other sugary beverages for soda after a tax, they concluded that a 20% tax on sugary soda would result in an average decline of 4.2 kcal/day, 0.32 kg/year loss in body weight, and revenue generation of over $800 million annually, with most of the price burden of a tax borne by higher-income groups. They projected a higher price burden on higher-income households because those with lower income are more likely to switch to low-cost sodas after price increases than higher-income households. A tax on all sugar-sweetened beverages, including “fruit drinks” and sports drinks, would lead to a greater effect on

body weight and revenue. Duffey and colleagues found similar results when examining a cohort of adults followed over 20 years, linked to regional pricing data, but found a larger impact on weight perhaps because they could not account for food and beverage substitution effects (Duffey, K.J. et al., 2010).

A review of 14 studies that provided estimates for the price elasticity of demand for soda, defined differently and often broadly, found a pooled elasticity of -0.8 with a range of -0.1 to -3.2 (Andreyeva, Long, and Brownell, 2010). Each of the studies included data from observational sources, including time-series data, household surveys, and food store scanners. When included studies were restricted to those that defined soda as “soft drinks, carbonated soft drinks, soda, and soda or fruit ades”, the elasticity was -1.0. Only one study in this review was available to compare the elasticity of sugary soda with that of low-calorie soda and showed that low-calorie soda is more elastic (Bergtold, Akobundu, and Peterson, 2004). Reasons for greater price responsiveness with low-calorie soda are unclear, and more studies would be needed to determine whether there is a true difference between these soda types. The overall elasticity for sugary soda was of a similar magnitude of that estimated for “food away from home”, juice, beef, and pork (Andreyeva, Long, and Brownell, 2010).

Observational data have limitations for determining the impact of a tax because of challenges in sorting out factors that influence both price and sales—supply and demand. Experimental data, when a price change is implemented by the research team, can better isolate the impact of the change on sales. We recently published an experimental study to estimate the price elasticity of demand for regular soda (Block, J.P. et al., 2010). During this experiment, we increased the price of regular soda by 35% in a hospital cafeteria in Boston, Massachusetts, for one month, after a two week baseline phase during which existing prices were posted. The price change was associated with a 26% reduction in sales of regular soda, translating to an elasticity of -0.7. This study also included an education phase, with posted educational materials on the health benefits of reducing sugary soda intake; this phase had no independent effect on soda sales.

The convergence of elasticity estimates from varying study designs and populations demonstrate a likely reduction in sales of approximately 8% from a 10% sugary soda tax. However, much remains unknown about the other impacts of a soft drink tax. While some studies demonstrate a likely reduction, though often quite modest, in weight from soda taxes (Duffey, K.J. et al., 2010; Finkelstein et al., 2010; Fletcher, Frisvold, and Tefft, 2010a; Schroeter, Lusk, and Tyner, 2008; Sturm, R. et al., 2010), others estimate no effect from existing state taxes on soda or proposed taxes (Fletcher, Frisvold, and Tefft, 2010b, 2010c; Powell, Chriqui, and Chaloupka, 2009). We also do not know if the elasticity will depend entirely on the level of the price change or whether the type of tax will determine its effectiveness. Perhaps soda sales will be inelastic to small price increases, which may not be noticed by consumers. Because of the salience of taxation, an excise tax also may be more effective than a sales tax (Brownell,K.D. et al., 2009). An excise tax would be more likely to be part of the actual item price whereby a sales tax may only be imposed at the register, after a consumer has made the decision to purchase the item (Chetty, Looney, and Kroft, 2009).

The effects of a soda tax on health may depend primarily on the substitution patterns of those who cease buying soda as a result of a tax. Existing literature is uncertain about the effects of a soda tax on other beverage or food consumption. In an analysis of state soft drink taxes, Fletcher, Frisvold, and Tefft (2010b) found evidence that whole milk consumption rose among children and adolescents in response to soda sales taxes, possibly offsetting the benefits of a reduction on sugary soda sales on weight because of the similar calorie content of soda and whole milk. However, other benefits of a substitution by whole milk, such as improving intake of calcium and vitamin D, may result, especially for children who are vitamin D deficient (Mansbach, Ginde, and Camargo, 2009). They did not examine water as a possible substitute for soda and found no evidence for changes in juice consumption after soda taxes; authors did not speculate on why they did not see such a juice substitution. In our experiment in the hospital cafeteria, we found some suggestion that customers chose diet soda as an alternative after we increased the price for sugary soda (Block, J.P., 2010). Specifically, we found an increase in sales of diet soda of 20% when we raised the price of regular soda by 35%—and during that time we found a 26% drop in regular soda sales—but no effect on water sales. However, we also saw some changes in diet soda sales at a comparison site, at which there were no interventions, suggesting that perhaps the diet soda sales changes reflected more of a temporal trend than an actual response to our intervention. Coffee sales significantly increased after we raised the price of regular soda as well. Perhaps our results on substitutes were different than prior studies because our study focused on adults, in contrast to that by Fletcher, Frisvold, and Tefft, which focused on children and adolescents. Coffee and diet sodas may be more appealing to adults than children.

Concern remains that sugary beverage substitutes, such as juices or sugar-sweetened water, could be a substitute for soda after taxation, especially because of the increasing popularity of these drinks over the course of time (Nielsen and Popkin, 2004; Wang, Bleich, and Gortmaker, 2008). Further research should examine the actual

impacts of levels and structure of taxation through experiments that may also examine taxation effects on weight as well as any beverage substitution patterns that could offset benefits of taxation.

Unintended Health Consequences of Soda Taxes from Switching to Diet Drinks

Despite limited evidence that customers would consider switching to artificially-sweetened beverages after taxation, these beverages are often recommended alternatives for sugary soda. Thus, understanding the potential health effects of this potential substitution is critical. Despite some disagreement by beverage industry-supported persons (Allison and Mattes, 2009), the weight of evidence demonstrates clearly that sugary soda has an negative impact on health (Dhingra, R. et al., 2007; Palmer, J.R. et al., 2008; Schulze, M.B. et al., 2004). Systematic reviews of studies have found that sugary soda consumption is associated with higher energy intake and weight gain among both adults and children and an increased risk of diabetes among adults (Malik, Schulze, and Hu, 2006; Vartanian, Schwartz, and Brownell, 2007; Vermunt, Pasman, and Kardinaal, 2003). Intriguing experimental data from DiMeglio and Mattes (2000) found that sugary beverages may be more harmful than solid sugar. In a crossover experiment, 15 subjects consumed either 450 calories per day of regular soda or jelly beans. During the time they consumed the regular soda, total daily calorie intake increased and subjects gained weight, suggesting that other calorie intake was not offset by the soda intake. In contrast, during the jelly bean phase, there was no change in total daily calorie intake because subjects compensated by reducing their intake of other foods.

However, concerns have arisen that artificially-sweetened beverages may be as harmful, if not more so, than sugary beverages. Among 9,514 subjects followed for a mean of nine years, Lutsey, Steffen, and Stevens (2008) found that high consumption of diet soda was associated with a 34% increased risk of developing metabolic syndrome in adjusted analyses. Consumption of sugary beverages, which included regular soda and juices, was also associated with development of metabolic syndrome in early models but not in the fully-adjusted final model controlling for demographics, behaviors, and other food intake. Similar results were found in a cross-sectional study of 6,154 subjects. Subjects drinking one or more diet soft drinks daily had a 53% higher risk of metabolic syndrome than those drinking less than 1 diet or regular soft drink per week (Dhingra, R. et al., 2007).

Other studies have examined the link between consumption of these beverages and diabetes. In a study of 5,011, Nettleton and colleagues found a 38% higher risk of developing diabetes over a period of up to seven years for subjects consuming one or more diet sodas daily, compared to none (Nettleton, J.A. et al., 2009). Associations of diet soda consumption with the development of metabolic syndrome were not significant in final models controlling for adiposity as well as demographic and behavioral factors.

When all of these studies are considered together, it appears that many, if not all, of the apparent adverse effects reported for artificially sweetened beverages may be due to reverse causation—individuals may switch to artificial sweeteners because of weight gain or blood glucose abnormalities. The studies that properly account for possible reverse causation, by using longitudinal data on subjects over time and controlling for dieting behaviors and weight, find no clear association between artificially-sweetened beverage consumption and metabolic risk. For example, a study of over 91,000 subjects in the Nurses' Health Study found no increased incidence of diabetes among high consumers of artificially-sweetened beverages; authors did find higher incidence of diabetes among high consumers of sugar-sweetened beverages (Schulze, M.B. et al., 2004). Similar relationships were also seen in a large prospective study of men (de Koning, L. et al., 2011).

Several hypotheses have arisen to explain potential associations between artificial sweeteners and metabolic disorders: the promotion of hunger (Blundell and Hill, 1986; Rogers and Blundell, 1989; Tordoff and Alleva, 1990b) or the overcompensation of food intake because of miscalculation of the calorie deficit achieved by consumption of diet soda. However, evidence for these pathways has not been borne out through investigation. Repeated experimental studies have found no significant effect of consumption of artificially-sweetened food or beverages on hunger, calorie consumption, macronutrient preferences, or general food appeal, when compared to sugar-sweetened foods, water, or sugar-sweetened beverages (Black, R.M. et al., 1991; Rolls, Hetherington, and Laster, 1988; Rolls, Kim, and Fedoroff, 1990). In fact, several of these studies demonstrate clearly that consuming sugar-sweetened beverages or food, prior to or during a meal, leads to overall more calorie consumption than when consuming artificially-sweetened beverages or food because of the higher calorie content of the sugar-sweetened item (Anton, S.D. et al., 2010; Rolls, Kim, and Fedoroff, 1990). For example, a study of 19 normal weight—body mass index [BMI] 18.5 – 25 kg/m2—and 12 obese—BMI ≥ 30 kg/ m2—subjects tested whether eating an appetizer sweetened with sucrose, aspartame or stevia—a sweet calorie-free botanical product—affected post-appetizer food consumption (Anton, S.D. et al., 2010). Post-appetizer food consumption was equivalent regardless of which appetizer was consumed, and total daily calorie consumption was higher when consuming the sucrose appetizer because of its higher calorie content compared to the aspartame and stevia appetizers. Similar results have been found in studies of children (Anderson, G.H. et al.,

1989; Birch, McPhee, and Sullivan, 1989). Longer term studies, but still only 10 weeks or less, have found consistent results, demonstrating reduced energy intake when sugar sweeteners are replaced by artificial sweeteners (Naismith and Rhodes, 1995; Porikos, Hesser, and van Itallie, 1982; Raben, A. et al., , 2002; Tordoff and Alleva, 1990a).

Studies also have examined the impact of artificial-sweetened or sugary beverages on weight gain. Among 91,249 subjects in the Nurses' Health Study, followed between 1991 and 1998, no excess weight gain was evident among consumers of artificially-sweetened soda (Schulze, M.B. et al., 2004 but was among high consumers of sugar-sweetened beverages. In a much-smaller study of 3,682 subjects in the San Antonio Heart Study, followed for seven to eight years, consumption of artifically-sweetened beverages was associated with a 47% increase in BMI compared to non-drinkers (Fowler, S.P. et al., 2008). This study did not comment on sugary soda intake.

Controlled studies that compare consumption of artificial sweeteners with sugar sweeteners have generally found weight loss with artificial sweeteners (Raben, A. et al., 2002; Tordoff and Alleva, 1990a). The longest trial to date to employ an artificial sweetener as part of a weight loss intervention was a study of 163 obese women who participated in a 19-week multidisciplinary weight-loss program (Blackburn, G.L. et al., 1997). The subjects were split into two groups with instructions to either abstain or use aspartame as part of their weight control strategy for 16 of the 19 weeks and during the two years following the completion of the active weight loss program. Women in both groups achieved similar weight loss during the active weight loss phase, but those in the aspartame group had less weight regain over the two years of follow-up and achieved more weight loss at the end of this period than the group abstaining from aspartame.

Systematic reviews that have assessed the metabolic and weight loss effects of artificial sweeteners compared to sugar sweeteners have concluded that the overall evidence supports no difference in effect on hunger, satiety, or food consumption following use of these products (Malik, V.S. et al., 2006; Mattes and Popkin, 2009; Renwick, A.G., 1994; Vermunt, Pasman, and Kardinaal, 2003). Also, they conclude that weight loss appears to follow transition from sugar-sweeteners to artificial sweeteners but stop short of endorsing the use of artificial sweeteners as a weight loss strategy because of some remaining concerns about their safety. Ongoing research examining relationships between artificial sweeteners and risk for cancer and preterm delivery will provide useful information on other potential negative health impacts of these sweeteners.

Concluding Thoughts

Taxing soda could serve an important role in generating revenue as well as impacting health. However, the explicit effects on health are unclear because of uncertainty about the patterns of beverage substitution. More research, especially experimental evidence, is needed to explore the level and type of tax that would be required to decrease consumption and how substitutions may impact overall calorie consumption and weight. However, transition to artificially-sweetened beverages due to a sugary soda tax would likely be associated with reduced weight and risk of diabetes. We still don't know if other negative health consequences might be associated with this transition, especially for children, and potential harms should be part of the consideration of unintended consequences of a soda tax. Despite no evidence to support likely substitutions of water for soda, perhaps any soda tax should be accompanied by an educational campaign to encourage people to choose water as the best alternative to soda.

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