Associations between soda prices and intake: Evidence from 24-h dietary recall data

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ABSTRACT

Although taxes on regular soda and other forms of sugar-sweetened beverages have been proposed as a disincentive to consumption, little is known about the association of soda price with soda intake status or the potential heterogeneity across sub-population groups based on age. Such estimates cannot be obtained from aggregated sales or household purchase data because they do not break down soda intake by individuals. To fill this gap in the literature, the 24-h dietary recall data from the U.S. National Health and Nutrition Examination Surveys (1999–2008) have been merged with soda prices from the Council for Community and Economic Research (C2ER). The variation in soda prices across zip codes and over the years were used to identify the associations of soda prices with the prevalence of sugar-sweetened regular soda intake and caloric intake from soda for children ($N = 8032$), adolescents ($N = 6501$), and adults ($N = 14,141$). The analyses were further stratified by gender, race/ethnicity and income-based socioeconomic status. A 10% higher soda price was associated with lower prevalence (i.e., probability) of regular soda intake by 3.4%, 4.6% and 4.0% for children, adolescents, and adults, respectively, and lower caloric intake from soda by 8.1%, 5.2%, and 6.6%, respectively. The strongest negative associations between soda prices and regular soda intake were found among children and adults; the weakest negative associations were found among minority children and adolescents. By using individual-level data from the 24-h dietary recall data, we identified substantial heterogeneity in the association of soda price with regular soda intake. Our results add to the growing literature suggesting that higher soda prices are associated with reduced regular soda intake.

Introduction

Intake of regular carbonated soft drinks (soda) and other forms of sugar-sweetened beverages (SSBs) is associated with increased caloric intake, obesity, and type-2 diabetes (Malik et al., 2006; Vartanian et al., 2007; Malik et al., 2010). Cross-national evidence from 75 countries indicates soda intake is significantly associated with national incidence of diabetes and obesity (Basu et al., 2013). In the U.S., soda and SSBs are the largest source of added sugars (Reedy and Krebs-Smith, 2010; Welsh et al., 2011) and their intake is associated with childhood obesity (Ludwig et al., 2001), adult mortality from cardiovascular diseases (Yang et al., 2014), and increased risk of dental caries (Sheiham and James, 2014). Reducing caloric intake from added sugars is one of the latest

public health priorities, as the World Health Organization has recently released draft guidelines encouraging people to halve their daily intake of sugar (World Health Organization, 2014).

Following the success of tobacco taxes at reducing tobacco use, taxes have been increasingly proposed by policymakers and public health officials aiming at reducing intake of soda and SSBs (Brownell et al., 2009; Powell et al., 2013). In addition to reducing consumption, studies report that taxes on soda and SSBs will also generate additional revenues (Andreyeva et al., 2011) and reduce obesity-related health expenditures (Wang et al., 2012; Brownell and Frieden, 2009; Finkelstein et al., 2010; Smith et al., 2010). The projected impacts of such taxes have been typically calculated using the price elasticity of demand, a common metric which reports the estimated impacts in terms of the percentage change in quantity as a result of a one percent change in price (Andreyeva et al., 2010; Powell et al., 2013). Recent review studies found the estimated price elasticity of demand for SSBs to be −1.2 and estimated price elasticity for soda to be about −0.79 to −0.86,

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which means that a 10% increase in soda price is associated with 7.9% to 8.6% decrease in soda intake (Andreyeva et al., 2010; Powell et al., 2013).

However, these estimates have been derived from aggregated national sales or household purchase data that do not break down soda intake by individuals (Powell et al., 2013). Very little is known about the price elasticities of soda prevalence (i.e., soda intake status), although such estimates are routinely reported for modeling initiation and cessation behaviors for tobacco products (Chaloupka and Warner, 2000). Many of the previous studies also combined diet and non-diet soda in their estimation, which made their estimates less relevant to public health concerns of SSBs (Powell et al., 2013).

To date, only one study (Duffey et al., 2010) examined the association between soda price and individual-level soda intake among adults but not the potential heterogeneity across sub-population groups based on age or race/ethnicity. Adolescents are generally found to be more responsive to price than adults for tobacco and alcohol products (Xu and Chaloupka, 2011; International Agency for Research on Cancer, 2011; Hersch, 2000). However, consumption of soda is considerably different than those of alcohol and tobacco products, which have different behavioral and legal consequences than those of soda as their addictive properties are well established and their sales to minors are illegal (Etter, 2006; The National Minimum Drinking Age Act of 1984, 1984). Fletcher et al. (2010) using the National Health and Nutrition Examination Survey (NHANES) found state soda tax rates to be negatively associated with caloric intake from soda but they were not significant. Unlike soda prices, the current state soda tax rates may be too low for researchers to obtain significant results (Powell et al., 2013).

To fill these gaps in knowledge, this study used nationally representative individual-level 24-h dietary recall data in the U.S. to examine the associations between regular soda price and the prevalence of regular soda intake and overall caloric intake from soda by age, race/ethnicity, and income-based socioeconomic status (SES).

Methods

The National Health and Nutrition Examination Survey

The NHANES is a nationally representative survey containing detailed information on the health and nutrition status of the population in the U.S. Detailed descriptions of the NHANES are available elsewhere (Centers for Disease Control and Prevention (CDC) National Center for Health Statistics (NCHS), 2011). The surveys are conducted biennially but approximately half of respondents are surveyed in each year. We therefore obtained a 10-year annual sample by assembling five consecutive waves of NHANES from 1999 to 2008 (i.e., 1999–2000, 2001–2002, 2003–2004, 2005–2006 and 2007–2008). A confidential restricted-access version of the NHANES provided the actual interview year for estimation and data linkage purposes.

In this present study, external annual regular soda price and median household income data were merged to the respondents in the NHANES by the actual interview year and by zip code provided by the restricted-access version of the NHANES. After individuals with missing data were excluded from the merged data set, the sample consisted of children (aged 2–11, $N = 8032$), adolescents (aged 12–18, $N = 6501$), and adults (aged 19–65, $N = 14,141$). Because the NHANES does not provide household identifiers, children's and adolescents' intake patterns were not directly linked to those of adults. Medical examination survey weights from each wave were used in all analyses based on the suggested methodology (Centers for Disease Control and Prevention, 2013).

Regular soda intake and control variables

Sugar-sweetened regular soda (hereafter denoted as soda) intake measures were based on the NHANES 24-h dietary recall data obtained during an interview conducted in person by trained dietary interviewers in a mobile examination center. We did not use the 2nd dietary recall data obtained during a follow-up phone survey due to the differences in collection methods and the smaller sample size.

We constructed three measures of soda intake to examine the association between soda price and various levels of soda intake. First, the prevalence of soda intake was indicated with a value of 1 if any soda was drunk and 0 if not. Second, conditional caloric intake from soda was constructed by summing all caloric intake from soda intake for soda drinkers only. Third, overall caloric intake from soda was constructed by summing all caloric intake from soda intake for both soda drinkers and non-drinkers; thus, a value of 0 was assigned to non-drinkers. By construction, the sample mean for overall caloric intake from soda is equivalent to per capita caloric intake from soda.

Control variables in the multivariate analyses consisted of age, gender, race/ethnicity, marital status, income-based SES indicators, and educational achievement. Race/ethnicity was measured as binary indicators for non-Hispanic black (black), non-Hispanic white (white), Hispanic, and other races (consisting mostly of Asians, Native Americans and other racial categories with small numbers of individuals). Income-based SES was indicated by two levels of federal poverty-income-level: poor as families with income less than or equal to 185% of the federal poverty level (FPL) and non-poor with income greater than 185% of the FPL. Education was measured as a series of binary indicators for less than high school, high school, college, and beyond college education.

For children and adolescents, marital status and educational achievements were replaced with those of the household representative. Each regression also controlled for whether the 24-h dietary recall occurred on the weekend versus the weekday.

Soda price and local area median household income

We obtained representative quarterly soda prices of coca-cola 2-l bottles across more than 300 US cities for 1999–2008 from the Council for Community and Economic Research (C2ER), formally known as the American Chamber of Commerce Researchers Association or ACCRA. Although C2ER is representative of prices paid by middle to upper income households (Council for Community and Economic Research, 2014), C2ER prices have been widely used in health and nutrition studies because of the national coverage they provide (Beydoun et al., 2011). Previous studies have linked C2ER/ACCRA food prices to the NHANES and its dietary predecessor (the Continuing Survey of Food Intakes by Individuals) to examine the association between food prices and nutritional status (Lakdawalla et al., 2005), dietary quality (Beydoun et al., 2011), and adolescent obesity (Grossman et al., 2014; Beydoun et al., 2011). C2ER soda and food prices have been recently used to examine childhood obesity and food security (Morrissey et al., 2014).

In this present study, quarterly soda prices in C2ER were converted into yearly averages and deflated by the Bureau of Labor Statistics Consumer Price Index to 2008 dollars. Following other studies that have used C2ER prices (Grossman et al., 2014; Powell, 2009;Khan et al., 2012; Chou et al., 2004; Powell et al., 2012), the deflated yearly price data were matched to the NHANES sample. The match was based on the physically closest city match available in the C2ER using the shortest distance between the centroid points of the respondent's zip code in NHANES and the C2ER city. Therefore, each zip code in NHANES was assigned annual soda