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Could a tax on unhealthy products sold for weight loss reduce consumer use? A novel estimation of potential taxation effects

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ABSTRACT

Abuse of widely available, over-the-counter (OTC) drugs and supplements such as diet pills, laxatives, and diuretics by adolescents for weight control is well-documented, yet manufacturers and retailers can sell them to minors without restriction. The aim of our study was to estimate the effect of added taxation of OTC drugs and dietary supplements sold for weight loss on household purchases of these products. With data from 60,538 U.S. households in the 2012 waves of the Nielsen/IRi National Consumer Panel (NCP) and the Nielsen/IRi Retail Scanner (NRS) datasets, we conducted analyses in 2017 to tally annual quantities and expenditures on OTC drugs or dietary supplements making weight-loss, cleanse/detox, or diuretic claims. We estimated the percent reduction in household purchases due to a simulated 20% added tax on each category. Among the 14,151 households reporting at least one purchase in the three claims categories, a 20% higher average price of weight-loss products was associated with a 5.2% lower purchases of those products. Among households with children ages 12 to 17 years old present, purchases were 17.5% lower, and among households with a daughter present, purchases were 10.3% lower. Taxation may be an effective public health strategy to reduce purchasing of potentially dangerous OTC drugs and supplements sold for weight loss, especially for households that include children ages 12–17 years old or a daughter.

1. Introduction

Abuse of widely available, over-the-counter (OTC) drugs and supplements such as diet pills, laxatives, and diuretics by adolescents and adults for weight control is well-documented in the epidemiological literature (Blanck et al., 2007; Centers for Disease Control and Prevention, 2011; Neumark-Sztainer et al., 2002) and can signal the onset of eating disordered behaviors and symptoms (Roerig et al., 2010; Steffen et al., 2010). Nationally in the United States, it is estimated that 21% of women and 10% of men have used weight-loss supplements in their lifetimes, and young adult women ages 18–34 years have the highest prevalence of past-year use at 17% (Blanck et al., 2007). Laxatives, of which colon cleanse/detox supplements are a subtype, and diuretics are commonly abused in weight control attempts. The lifetime prevalence in the general U.S. population of laxative abuse for weight control has been estimated to be 4% (Neims et al., 1995). Among people with bulimia nervosa or other similar eating disorders, lifetime estimates of abuse of laxatives for weight control have ranged from 15% to as much as 62% (Roerig et al., 2010). A national study of U.S. adults found 1.9% of women and 1.4% of men report using diuretics as a weight-loss method (Kruger et al., 2004). Weight-loss products are widely used by men and women and boys and girls of all racial, ethnic, and socioeconomic groups (Blanck et al., 2007; Neumark-Sztainer et al., 2002). Furthermore, recent research shows that low-income U.S. households spend more than double on weight-loss supplements in terms of proportion of total annual household income compared to higher-income households (Austin et al., 2017a).

Importantly, none of these products are medically recommended for healthy weight control or maintenance for people of any age (Blanck et al., 2007; Golden et al., 2016; Heinrich, 2002; Roerig et al., 2003; Steffen et al., 2007), with the possible exception of the OTC diet pill alli®. But even alli® has approval from the Food and Drug Administration only for ages 18 years and older and concerns have been raised by eating disorders experts (Cumella et al., 2007; McMahon, 2009). The American Academy of Pediatrics recently issued a report strongly cautioning against adolescents using any diet pills regardless of weight

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status (Golden et al., 2016).

The caution from medical experts regarding these products is well-grounded in the research evidence. A recent study from the Centers for Disease Control and Prevention estimated nearly 23,000 emergency room visits each year in the United States can be attributed to illness and injury caused by dietary supplements, with fully a third of these adverse events attributable to those sold for weight loss (Geller et al., 2015). Weight-loss supplements have been found in multiple studies to be adulterated with dangerous and sometimes banned ingredients (Cohen et al., 2017 (Epub ahead of print); Grundlingh et al., 2011; Yen and Ewald, 2012) linked to serious health conditions and injury, such as tachycardia, hypertension, myocardial infarction, stroke, gastrointestinal impairment, and liver injury so severe it can require transplant or cause death (Abdel-Rahman et al., 2011; Fong et al., 2009; Guyda, 2005). Abuse of laxatives and diuretics for weight control similarly can be deadly (Roerig et al., 2003; Steffen et al., 2007).

Despite the clearly documented risks and absence of medical endorsement, industries producing products abused for weight control sell them to minors without restriction (Pomeranz et al., 2015; Pomeranz et al., 2013). Yet viable legal avenues to redress this problem are available. Two legal research studies (Pomeranz et al., 2015; Pomeranz et al., 2013) applied systematic evaluation of health and consumer law to generate recommendations for policy changes with strong potential both to withstand legal challenge from industry and to achieve high impact to protect the health of young people. These recommendations include: banning the sale to minors of OTC drugs and dietary supplements that make weight-loss claims; restricting minors' access to these products; or adding excise or sales taxes on OTC drugs and dietary supplements that make weight-loss claims to reduce consumer purchasing.

Imposing excise or sales taxes has been shown to be a successful strategy to decrease consumption of other products known to have negative health effects, including sugar-sweetened beverages, alcohol, and tobacco, and can also be a revenue generator for government (Brownell and Frieden, 2009; Colchero et al., 2017; Cotti et al., 2015; Falbe et al., 2015; Fletcher et al., 2010; Lewitt et al., 1997; Wagenaar et al., 2010). One study found the price of tobacco was inversely related the tobacco use (Harris and Chan, 1999). This relationship was the strongest for 15–17 year olds, with price having the most impact on the probability that these adolescents use tobacco. Another study estimated that a 10% increase in the price of sugar-sweetened beverages would lead to a 12.6% decrease in purchases of those drinks (Smith et al., 2010). Evidence from taxation studies in a number of countries examined in a recent review suggests that taxes on unhealthful foods do lead to reduced consumption of those foods, and the researchers recommend that taxes be set at 20% or above to have a meaningful impact (Mytton et al., 2012). There is a lack of data, however, on the effects that added taxes might have on the use of weight-control products. Given this gap in the literature, we carried out a simulation study to estimate the effect of a 20% added sales or excise tax on purchasing at the household level of products making weight-loss claims. We hypothesized the added taxes would be associated with reduced household purchases of these products and that households with adolescents or daughters present would show larger estimated reductions in purchasing than other households.

2. Methods

We use data from the 2012 waves of the Nielsen/IRi National Consumer Panel (NCP) and the Nielsen/IRi Retail Scanner (NRS) datasets, calculated (or derived) based on data from the Nielsen Company (US), LLC and marketing databases provided by the Kilts Center for Marketing Data Center at the University of Chicago Booth School of Business, Copyright© 2018 The Nielsen Company (US), LLC. All Rights Reserved (Nielsen/IRi, 2012). We carried out our analyses in 2017. The unit of observation for analysis is an NCP household, which was aggregated from a panel of all purchases with scannable universal product codes (UPC) for each household in 2012, including those purchases made online. Neither database includes identifiable information; therefore, this study is not considered human subjects research. The authors have no financial conflicts of interest.

In order to enhance information about OTC drugs and dietary supplements purchased by participating households and therefore included in the NCP, we created an additional database documenting health-related claims made about these products through their packaging and advertising, including claims that the products have weight loss, cleansing/detox, and diuretic effects. We carried out web searches by product brand, description, and UPC and recorded health-related claims associated with the product. We then merged our new database with the NCP database so that we could analyze products in NCP by type of claim made about the product in packaging and advertising. The analytic sample consisted of 60,538 households, which is all households included in the 2012 panel year, and which forms a representative sample of the U.S. when accounting for survey weights.

We tallied annual quantities, expenditures on, and expenditure-weighted average unit prices of all dietary supplements products that have packaging or advertising making health-related claims in at least one the of the following categories: weight loss, cleansing/detox, or diuretic. Quantity units vary by product category, so we report percent changes in purchases.

Average prices can be calculated for only those products that a household purchases in the NCP; therefore, we replaced missing price data by merging in annual average UPC-level unit prices calculated from the NRS dataset. Each purchase was matched to the average of all recorded prices for each UPC in its given designated market area, thus re-creating as precisely as possible the price environment in which each household purchase decision was made. Because the very large NRS dataset includes prices from approximately 35,000 stores across the United States, representing > 50% of all food and drug transaction volumes in sampled markets, the resulting merged dataset offers substantial granularity in price environment for the product categories under study.

Elasticities describing the price-response relationships between product categories were estimated using the Quadratic Almost Ideal Demand System (QUAIDS), a frequently used structural model of demand (Banks et al., 1997). The model was modified to account for the relatively high censoring at zero for the product categories under analysis. We report the following estimated parameters: expenditure elasticities (percent change in a product category's purchases divided by a 1% increase in total household expenditure), uncompensated price elasticities (unadjusted percent change in a product category's purchases divided by a 1% increase in a product category's average price), compensated price elasticities (percent change in a product category's purchases divided by a 1% increase in a product category's average price, adjusted for constant utility). Own-price elasticities refer to the relationship between a product category's purchases and its own average price, while cross-price elasticities refer to the relationship between a product category's purchases and another category's average price. Estimation was conducted in accordance with the estimating equations developed in the Technical Appendix, using Stata version MP14.0 (StataCorp, College Station, Texas).

3. Results

Table 1 displays a summary of the demographic characteristics for the analytic samples. The listed demographic characteristics, which include household size, age composition of the household head(s), and the self-reported race/ethnicity of the household, were used as control variables when adjusting for censoring at zero purchases.

Before reporting results from the QUAIDS model estimation, we first display summary statistics of input parameters for the QUAIDS model in Appendix Tables 1 and 2, including those used to account for censored

Table 1
Nielsen consumer panel household characteristics, 2012 survey.

	Full sample	Age 12–17 present	Age 18–25 present	Daughter present	Son present	Single females	Single males	Race Asian	Race Black	Race other	Race White
Household size composition											
1 Member	25.3%	0.0%	0.9%	0.0%	0.0%	67.9%	74.9%	12.9%	32.8%	19.5%	25.1%
2 Members	41.9%	5.2%	10.0%	6.2%	7.5%	18.6%	17.5%	35.9%	32.8%	37.1%	43.4%
3 Members	14.0%	25.4%	34.5%	27.9%	30.6%	7.8%	4.8%	18.9%	15.0%	16.6%	13.6%
4 Members	11.6%	36.9%	30.8%	37.7%	36.2%	3.5%	1.9%	20.1%	11.1%	15.5%	11.2%
5 Members	4.5%	18.5%	14.3%	17.3%	16.1%	1.3%	0.6%	7.9%	4.8%	6.4%	4.2%
6+ Members	2.7%	14.0%	9.5%	11.0%	9.7%	0.9%	0.3%	4.4%	3.5%	4.9%	2.4%
Household head age composition											
No female head	10.1%	2.2%	3.4%	2.0%	2.5%	0.0%	100.0%	7.7%	9.9%	11.3%	10.1%
Female head age < 40 years	11.4%	16.5%	8.8%	25.6%	24.8%	8.1%	0.0%	22.0%	11.6%	18.8%	10.6%
Female head age 40–54 years	31.2%	68.9%	62.2%	53.2%	52.3%	29.0%	0.0%	41.4%	34.9%	36.9%	30.1%
Female head age 55–64 years	26.5%	10.0%	22.1%	13.7%	15.2%	30.4%	0.0%	18.2%	27.4%	21.7%	26.9%
Female head age 65+ years	20.8%	2.3%	3.4%	5.6%	5.2%	32.5%	0.0%	10.8%	16.1%	11.2%	22.2%
No male head	26.1%	14.6%	19.3%	14.9%	15.3%	100.0%	0.0%	12.9%	42.3%	20.2%	25.0%
Male head age < 40 years	8.2%	9.6%	6.8%	18.6%	17.7%	0.0%	7.9%	16.3%	6.7%	14.3%	7.8%
Male head age 40–54 years	24.9%	59.0%	44.4%	46.7%	45.4%	0.0%	34.3%	37.8%	21.7%	32.0%	24.5%
Male head age 55–64 years	21.7%	14.1%	24.9%	14.9%	16.1%	0.0%	31.6%	21.0%	18.4%	21.1%	22.1%
Male head age 65+ years	19.1%	2.7%	4.6%	5.0%	5.5%	0.0%	26.2%	11.9%	11.0%	12.5%	20.6%
Household race composition											
Race White	83.0%	78.2%	78.9%	78.7%	80.0%	79.5%	83.4%	0.0%	0.0%	0.0%	100.0%
Race Black/African American	9.7%	11.5%	11.6%	10.8%	10.0%	15.8%	9.5%	0.0%	100.0%	0.0%	0.0%
Race Asian	3.0%	4.1%	3.5%	4.6%	4.5%	1.5%	2.3%	100.0%	0.0%	0.0%	0.0%
Race other	4.3%	6.2%	6.0%	5.9%	5.5%	3.3%	4.8%	0.0%	0.0%	100.0%	0.0%
Household ethnicity composition											
Hispanic origin	22.3%	91.8%	92.1%	91.6%	91.9%	97.0%	96.4%	94.2%	97.3%	51.5%	96.7%
Non-Hispanic origin	77.7%	8.2%	7.9%	8.4%	8.1%	3.0%	3.6%	5.8%	2.7%	48.5%	3.3%
N	60,538	7592	6931	12,237	13,296	15,796	6112	1810	5896	2573	50,259

Notes: Sample percentages for the 2012 National Consumer Panel household survey analytic sample (N = 60,538). Columns represent sub-sample restriction criteria, while rows represent household characteristics.

purchases. For each product category, the expenditure share reported in Appendix Table 2 is the proportion of expenditures allocated to that category, relative to the total of purchases in those three categories. Only 14,151 of 60,538 households report at least one purchase of dietary supplements in any of the three categories across the year, so it is important to account for the possibility that households purchasing these products may differ in important ways from those not making any purchases. Of the households that made any purchases, 85.6% of the expenditure was allocated to weight-loss products, 10.7% was allocated to cleanse/detox products, and 3.6% was allocated to diuretic products.

The density and cumulative probabilities displayed in Appendix Table 2 are the predicted values from the probit regressions reported in Appendix Table 1, which estimate whether each household purchased any of each product category under study. These probabilities, which account for selection by observable household characteristics into purchasing any product, are used to adjust the expenditure share equations when estimating the QUAIDS model, as described in detail in the Technical Appendix.

Appendix Table 2 also includes summary statistics for the price per unit, in dollars, for each product category. The mean price per unit faced by households was 57 cents for weight-loss products, 55 cents for cleanse/detox products, and 19 cents for diuretic products. Note that these prices are not prices paid for the actual products purchased, but are instead estimates of the average posted price in retail outlets near the household, as identified in the NRS and described earlier. In this sense, the prices used in estimation more accurately represent those potentially subjected to policy intervention.

After estimating the QUAIDS model, we used the resulting own-price elasticity estimates to simulate the effect that a hypothetical 20% tax on each product would have on purchases of that product type for the full sample and for each of several important population subgroups. Because the uncompensated own-price elasticity can be interpreted as the percent change in quantity divided by a percent change in price for a product type, each simulated purchase percent change was calculated by multiplying the corresponding uncompensated own-price elasticity by 20. Alongside the simulated percent changes in purchases, 95% confidence intervals are reported.

Expenditure and price elasticities, obtained from estimating the QUAIDS model, are reported in Tables 2 and 3. Table 2 indicates that as a household increases its budget allocated toward the three product categories under study, there is a higher expenditure on weight-loss and cleanse/detox products but no statistically significant change in expenditures on diuretic products. For example, a 10% increase in the budget allocated to the three studied categories is estimated to yield a 2.97% increase in expenditures on weight-loss products.

Next, Table 3 reports own- and cross-price elasticities for the uncompensated and compensated demand equations. The uncompensated price elasticities, reported in the top panel and which are relevant for most policy applications, show significant decreases in product purchases in each category. Generally speaking, weight-loss products may be considered price inelastic (the uncompensated price elasticity is between 0 and −1), where a 10% increase in the price is expected to

Table 2
QUAIDS model: estimated expenditure elasticities.

		95% confidence interval	
	Expenditure elasticity	Low	High
Weight loss products	0.269	0.081	0.457
Cleanse and detox products	0.100	0.030	0.170
Diuretic products	0.387	−0.279	1.053

Notes: The sample is restricted to households with at least one purchase in any category (N = 14,151). Expenditure elasticity is the (unitless) ratio of the percent quantity response to the same percent increase in expenditure, as described in the Technical Appendix.

Table 3
QUAIDS model: estimated price elasticities.

	Weight loss	Cleanse and detox	Diuretic
Uncompensated			
Weight loss	−0.260***	0.004	−0.003
	(0.101)	(0.005)	(0.003)
Cleanse and detox	0.004	−0.105***	0.004***
	(0.004)	(0.025)	(0.001)
Diuretic	−0.027	−0.047	−0.998***
	(0.024)	(0.038)	(0.017)
Compensated			
Weight loss	−0.030	0.033	0.007
	(0.020)	(0.013)	(0.004)
Cleanse and detox	0.090***	−0.094***	0.007***
	(0.034)	(0.023)	(0.002)
Diuretic	0.305	−0.006	−0.984***
	(0.306)	(0.072)	(0.005)

Notes: The sample is restricted to households with at least one purchase in any category (N = 14,151). Price elasticity is the (unitless) ratio of the percent quantity response to the same percent increase in price, as described in the Technical Appendix. Standard errors are reported in parentheses.
*** Indicates p-value < 0.01.

decrease purchases by 2.87%. On the other hand, cleanse/detox and diuretic products may be considered unitary elastic, where a specific percent price increase is matched by approximately the same percent purchase quantity decrease. There is relatively little evidence for cross-price effects (the table's off-diagonal results), with the lone statistically significant estimate, between cleanse/detox and diuretic products, being positive and quite small in magnitude, suggesting that they may be substitute products.

The results of the tax simulations are displayed in Table 4. Among all households, a simulated 20% tax corresponds to a 5.2% decrease in purchases of products with weight-loss claims, but a closer examination reveals that the detectable effects are concentrated in certain notable subgroups. In particular, households with a child age 12–17 years old present would decrease purchases by 17.5% in response to a simulated 20% tax, and households with a daughter present would decrease purchases by 10.3% (both significant at the 95% level). Generally, cleanse/detox products are found to have relatively small purchase responses to a simulated tax, i.e. inelastic responses, while diuretic products have larger purchase responses, i.e. near unitary elastic (the simulated percent change in quantity, divided by 20%, is close to 1).

4. Discussion

OTC drugs and supplements used by consumers for weight control are medically ill-advised and potentially dangerous but also widespread. Consumers of all ages can purchase diet pills, laxatives, and diuretics without restriction with the intention to abuse them for weight control (Pomeranz et al., 2015; Pomeranz et al., 2013), leading to substantial public health harm due to their association with eating disorders (Roerig et al., 2003; Steffen et al., 2007) and with illness and injury requiring emergency room intervention (Geller et al., 2015). There have been calls for increased attention to public health policy interventions to protect consumers, especially adolescents, from these products (Pomeranz et al., 2015; Pomeranz et al., 2013). In the present study, we examined one such proposed policy intervention: Increased taxes to reduce consumer purchasing and use. Taxation could also raise revenue for government to sponsor public health efforts to promote healthful strategies for weight maintenance or specifically to support eating disorders prevention efforts. Our results provide the strongest evidence to date that taxation may provide some measure of protection for perhaps the most vulnerable consumers: households with a teen, and particularly a daughter, present.

Our findings suggest that price policies intended to raise revenue from or influence the purchasing behavior of weight-loss, cleanse/detox, and diuretic OTC drugs and dietary supplements will vary by product category. Cleanse/detox products were found to be the least price responsive product category for the entire population, and weight-loss products also showed a modest price response for the full sample. Because these products were found to be price inelastic, a tax on those products would have relatively little influence on overall purchasing behavior but still would be effective in raising revenue. However, specific population subgroups that may be of particular policy interest, for example, households with children aged 12–17 years old or daughters present, may be more substantially influenced in their purchases of weight-loss products. Comparatively, a tax on diuretic dietary supplements would result in a greater decrease in purchases of those

Table 4
Simulated 20% tax effect on own quantity.

	N	Weight loss			Cleanse and detox			Diuretic		
		Δ Quantity	95% confidence interval		Δ Quantity	95% confidence interval		Δ Quantity	95% confidence interval	
			Low	High		Low	High		Low	High
Full sample	14,151	−5.19%	−8.83%	−1.55%	−2.10%	−3.06%	−1.14%	−19.97%	−20.61%	−19.32%
Age 12–17 y present	1640	−17.52%	−27.15%	−7.89%	−3.05%	−6.70%	0.60%	−19.27%	−24.28%	−14.26%
Age 18–25 y present	1617	−5.59%	−13.99%	2.81%	2.28%	−0.63%	5.19%	−19.90%	−20.32%	−19.48%
Daughter present	2601	−10.28%	−16.97%	−3.59%	−2.78%	−4.83%	−0.72%	−19.68%	−21.87%	−17.48%
Son present	2764	−6.25%	−13.05%	0.55%	−3.20%	−5.42%	−0.98%	−20.34%	−21.61%	−19.08%
Single females	3738	−4.48%	−10.56%	1.60%	0.28%	−2.56%	3.13%	−18.17%	−21.92%	−14.42%
Single males	1048	7.51%	−1.31%	16.34%	−0.71%	−3.38%	1.96%	−19.91%	−20.22%	−19.60%
Race Asian	329	−8.46%	−18.63%	1.71%	−0.35%	−2.55%	1.86%	−19.94%	−20.66%	−19.23%
Race Black	1385	−3.64%	−12.41%	5.13%	−6.49%	−11.22%	−1.77%	−19.29%	−23.68%	−14.90%
Race other	610	−4.15%	−13.16%	4.86%	−4.46%	−7.66%	−1.25%	−20.23%	−22.09%	−18.36%
Race White	11,768	−4.06%	−10.51%	2.39%	−2.15%	−3.24%	−1.06%	−20.11%	−20.69%	−19.54%

Notes: The sample is restricted to households with at least one purchase in any category (N = 14,151). Δ Quantity estimates are the percent quantity change in response to a 20% increase in product category price. Columns represent product categories and rows represent further sample restrictions.

products, but it would also therefore be relatively less effective at raising revenue.

Our study drew on prior research showing that excise or sales taxes can be an effective strategy to decrease consumption of harmful products, such as sugar-sweetened beverages, alcohol, and tobacco (Brownell and Frieden, 2009; Colchero et al., 2017; Cotti et al., 2015; Falbe et al., 2015; Fletcher et al., 2010; Lewitt et al., 1997; Wagenaar et al., 2010). For instance, one study found that the price of tobacco was inversely related the tobacco use and that the relationship was strongest for 15–17-year-olds (Harris and Chan, 1999), and another estimated that a 12.6% decrease in purchases of sugar-sweetened beverages could be achieved with a 10% increase in the price of the product (Smith et al., 2010).

The political feasibility of policy initiatives to tax harmful consumer products has been widely discussed, most recently in the context of sugar-sweetened beverages (Backholer and Martin, 2017; Gostin, 2017; Purtle et al., 2018). In general, success of policy initiatives such as these is facilitated by a strong evidence base, identification of viable policy options, and favorable political will among policymakers and the public (Kingdon, 1995; Mello et al., 2006). Engendering political will, particularly when there is a strong opposition group – such as the soda industry's opposition to taxes – can require savvy message framing and reframing to steer public discourse such that supporting the initiative is consistent with community values (Lakoff, 2014; Purtle et al., 2018; Reinsborough and Canning, 2010). Philadelphia, which successfully passed a sugar-sweetened beverage tax in 2016, offers an excellent example of strategic reframing to boost political will (Purtle et al., 2018). Policymakers and advocates in the city observed that many other localities had previously been unsuccessful with similar legislation because the soda industry had effectively promoted counter-arguments to the health-protective efforts by casting the beverage taxes as overreach by a "nanny state." In response, leaders of the initiative in Philadelphia chose to instead frame the tax as a way to fund universal kindergarten, a highly popular program among residents and policymakers in the city, rather than emphasize health protection as a goal of the tax.

With the present study, we extended the research on policy initiatives to add taxes on harmful consumer products by estimating potential effects that added taxes could have on purchases of weight-control products. Legal scholars propose several viable policy strategies to reduce consumer exposure, particularly adolescents, to unhealthy weight-control products (Pomeranz et al., 2015; Pomeranz et al., 2013). Proposed strategies include: adding excise or sales taxes on OTC drugs and dietary supplements that make weight-loss claims to reduce consumer purchasing, as we explore in the present study, and also banning the sale to minors of OTC drugs and dietary supplements that make weight-loss claims or restricting minors' access to these products in other ways, such as by placing them behind the counter in retail outlets and requiring consultation with a pharmacist before purchasing. Following on these recommendations from legal scholars, Massachusetts lawmakers introduced legislation to ban sale of OTC diet pills to minors in the state (Austin et al., 2017b). Policy initiatives such as this could be pursued in other states or on the municipal level in addition to efforts to add excise or sales taxes on OTC drugs and dietary supplements making weight-loss claims.

Several limitations to this study should be considered. Data represent purchases at the household level, which is meaningful but does not provide insight into which members or how many members of the household are using the products. In addition, the data do not provide information on whether products purchased were fully consumed by members of the household. With regards to the modeling strategy and available data, some limitations of the QUAIDS model estimation are that we assume the marginal price effects are the same for any size tax, and that the composition of products within each category does not change as its average price varies. Although we adjust expenditure-share equations with purchase probabilities based on observable characteristics to account for possible differences between households purchasing and those not purchasing these products, we are unable to account for possible unobserved characteristics influencing purchase decisions. We are also unable to estimate causal relationships between price and purchases, so the simulation results should be interpreted as associations and therefore suggestive of causal effects. Nevertheless, in the absence of experimental or quasi-experimental tax data, our study provides the first detailed quantitative analysis at the household level of the relationships between prices and OTC drugs and dietary supplements that make weight-loss, cleanse/detox, and diuretic claims.

5. Conclusion

OTC drugs and dietary supplements making claims of weight-loss, cleanse/detox, and diuretic effects are used widely, ubiquitously available to consumers of any age without restriction, and associated with myriad health risks, some deadly. Our findings suggest that a 20% tax on weight-loss OTC drugs and dietary supplements may lead to a nearly 20% reduction in purchasing by households with children ages 12 to 17 years old present and a > 10% reduction in purchasing by households with a daughter present. Taxation may be an effective public health strategy to reduce purchasing of these potentially dangerous OTC drugs and supplements and may be most protective for households with teens and daughters. New policy approaches, including taxation, to protect consumers from potentially harmful OTC drugs and supplements used for weight loss should be seriously considered.

Contributions of authors

S.B. Austin and N. Tefft were responsible for study conception, database creation, analyses, interpretation of results, and manuscript preparation. S.H. Liu was responsible for database creation, interpretation of results, and manuscript preparation.

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Human participant protection

The study database includes no identifiable information; therefore, this study is not human subjects research.

Conflict of interest statement

The authors have no conflicts of interest.

Appendix A

Appendix Table 1
Probit model estimates for any product purchase.

	Weight loss	Cleanse and detox	Diuretic
Household members (reference category: 1)			
2	0.04552	−0.15030***	−0.13829***
	(0.04462)	(0.02223)	(0.02172)
3	0.05252	−0.11098***	−0.09774***
	(0.05176)	(0.02579)	(0.02521)
4	0.09035	−0.07425***	−0.05934**
	(0.05783)	(0.02872)	(0.02808)
5	0.16765**	−0.02128	−0.02041
	(0.07733)	(0.03707)	(0.03615)
6	0.26503**	0.00190	0.01552
	(0.11653)	(0.05170)	(0.05056)
7	0.06112	0.02569	−0.01839
	(0.16267)	(0.08520)	(0.08178)
8	0.14714	0.12169	0.12141
	(0.28658)	(0.14631)	(0.14220)
9	0.10287	0.00933	0.01006
	(0.40508)	(0.20388)	(0.19849)
Female household head age (reference category: no female head)			
Under 25 years	0.06271	0.54823***	0.43087***
	(0.30614)	(0.16786)	(0.15424)
25–29 years	0.11538	0.16848**	0.14662**
	(0.15774)	(0.06749)	(0.06499)
30–34 years	−0.02459	0.08715*	0.08364*
	(0.09965)	(0.04811)	(0.04673)
35–39 years	−0.07754	−0.08698**	−0.06285
	(0.08283)	(0.04062)	(0.03967)
40–44 years	−0.11610	−0.10350***	−0.06012*
	(0.07292)	(0.03601)	(0.03525)
45–49 years	−0.15550**	−0.17587***	−0.15314***
	(0.06611)	(0.03260)	(0.03186)
50–54 years	−0.14346**	−0.19424***	−0.17869***
	(0.06283)	(0.03093)	(0.03017)
55–64 years	−0.12572**	−0.17441***	−0.17313***
	(0.05740)	(0.02816)	(0.02742)
65+ years	−0.09787*	−0.19661***	−0.17346***
	(0.05946)	(0.02901)	(0.02830)
Male household head age (reference category: no male head)			
Under 25 years	−0.15122	0.14871	0.40293**
	(0.32217)	(0.18992)	(0.20206)
25–29 years	0.49983**	0.20240**	0.21993***
	(0.24771)	(0.08122)	(0.07822)
30–34 years	0.23459**	0.23027***	0.26283***
	(0.11854)	(0.05270)	(0.05138)
35–39 years	0.07886	0.12802***	0.15497***
	(0.08464)	(0.04112)	(0.04030)
40–44 years	−0.02956	0.06906**	0.05387
	(0.06662)	(0.03383)	(0.03304)
45–49 years	0.03796	0.01446	0.02767
	(0.05996)	(0.02932)	(0.02876)
50–54 years	−0.02638	−0.00074	0.00829
	(0.05375)	(0.02681)	(0.02629)
55–64 years	0.00485	0.03216	0.03369
	(0.04678)	(0.02306)	(0.02257)
65+ years	−0.01614	−0.02362	−0.02338
	(0.04882)	(0.02384)	(0.02336)
Race (reference category: White)			

(continued on next page)

Appendix Table 1 (*continued*)

	Weight loss	Cleanse and detox	Diuretic
Black	−0.26395***	0.05526***	−0.01926
	(0.03495)	(0.02048)	(0.01970)
Asian	−0.09776	0.11470***	0.06890*
	(0.06900)	(0.03663)	(0.03540)
Other	−0.11425*	0.00245	−0.03403
	(0.06004)	(0.03212)	(0.03115)
Ethnicity (reference category: non-Hispanic)			
Hispanic	0.14357***	0.05164*	0.09894***
	(0.05387)	(0.02887)	(0.02801)

Notes: N = 60,538. Estimates are probit model coefficients on household characteristic indicator variables, and the model's dependent variable is an indicator for whether a household purchased any of the weight loss, cleanse and detox, or diuretic products. Heteroskedasticity-robust standard errors are reported in parentheses.

*** Indicates p-value < 0.01.

** Indicates p-value < 0.05.

* Indicates p-value < 0.1.

Appendix Table 2
QUAIDS model parameters: expenditure shares, prices, and censoring probabilities.

	Mean	Std dev	Min	Max
Weight loss products				
Expenditure share, w (N = 14,151)	0.856	0.308	0.000	1.000
Price, p (N = 60,538)	0.573	0.608	0.000	35.500
Density probability, ϕ (N = 60,538)	0.047	0.011	0.017	0.104
Cumulative probability, Φ (N = 60,538)	0.980	0.006	0.949	0.994
Cleanse & detox products				
Expenditure share, w (N = 14,151)	0.107	0.275	0.000	1.000
Price, p (N = 60,538)	0.549	1.163	0.000	39.990
Density probability, ϕ (N = 60,538)	0.272	0.026	0.064	0.318
Cumulative probability, Φ (N = 60,538)	0.807	0.029	0.749	0.972
Diuretic products				
Expenditure share, w (N = 14,151)	0.036	0.133	0.000	1.000
Price, p (N = 60,538)	0.191	0.058	0.000	1.499
Density probability, ϕ (N = 60,538)	0.287	0.025	0.061	0.344
Cumulative probability, Φ (N = 60,538)	0.789	0.030	0.707	0.973

Notes: See the Technical Appendix for parameter definitions. See the Methods section for details on how prices were constructed.

Appendix B. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ypmed.2018.05.022.

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