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Determinants of US household expenditures on fortified fruit juice

RESEARCH ARTICLE

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Abstract

Fortified fruit juice represents a growing segment in the otherwise contracting juice industry. Health concerns and changing food policy have driven US consumers to demand fruit juice fortified with micronutrients. Fruit-juice manufacturers have responded by expanding their portfolio to include juice products fortified with vitamins and minerals. This study is the first to analyze determinants of US household expenditures on fortified fruit juice. Collectively, results indicate fruit-juice fortification is a viable strategy for improving public health among demographic subgroups that are disproportionately vulnerable or at-risk for nutrient deficiencies. Findings suggest that fruit-juice manufacturers' fortification efforts are improving the nutritional intake of toddlers and children but are less effective at reaching other demographic subgroups (rural and minority-headed households) with high nutrient-deficiency incidence. Manufacturers should consider employing targeted marketing and outreach efforts to maximize improvement in dietary quality among fruit-juice consumers.

Keywords: fruit juice, fortification, expenditures, micronutrients, double-hurdle model

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1. Introduction

The \$16.6 billion US fruit-juice sector has experienced declines in sales and consumption for more than two decades (Harfmann, 2018). Juice is defined by the US Food and Drug Administration (FDA) as a beverage that contains 100% fruit and/or vegetable juice, while beverages containing less than 100% juice are referred to as juice 'beverages', 'cocktails' or 'drinks' (FDA, 2014).¹ Data collected by the United States Department of Agriculture's (USDA) Economic Research Service (ERS) indicates a 43% decrease in US juice consumption from 1998-2018 (USDA, 2020). This downward market trend is expected to continue, with US juice sector sales projected to decline an additional 7% from 2016 to 2021 (Mintel, 2017).

Health concerns and policy revisions are key drivers of the reduction in fruit-juice demand. While findings are mixed, studies link fruit-juice consumption to an increased risk for obesity, type 2 diabetes and dental cavities (Imamura *et al.*, 2015; Marshall *et al.*, 2003; Mozaffarian *et al.*, 2011; Shefferly *et al.*, 2016). Nutritionists note that while fruit juice is a natural source of vitamins and minerals, it is high in sugar and provides less dietary fiber than whole fruit. US food and nutrition policy revisions reflect these health concerns (Caswell, 2009; US-DHHS, 2015). The Supplemental Nutrition Assistance Program for Women, Infants and Children (WIC) revised food packages in 2007 to include 50% less fruit juice (USDA, 2013). Further, revised fruit-juice recommendations released by the American Academy of Pediatrics in 2018 suggest excluding juice from the diets of children under one year old and limiting its consumption among older children (Heyman and Abrams, 2017). Among adults, the 2015-2020 Dietary Guidelines for Americans (DGA) recommend that no more than 50% of fruit servings be obtained from juice (US-DHHS, 2015).

Consumers have correspondingly reduced their consumption of fruit juice, demanding products with less sugar and containing value-added health benefits (Scott, 2010). Fruit-juice manufacturers have responded to changing consumer preferences through product innovation, expanding their beverage portfolio to include juice products fortified with vitamins and minerals. Fortification is formally defined as the 'addition of one or more essential nutrients to a food, whether or not it is normally contained in the food, for the purpose of preventing or correcting a demonstrated deficiency of one or more nutrients in the population or specific population groups' (Codex, 1991). Improving public health through fortification is a goal in the sustainability plans of nearly all major US juice manufacturers, including The Coca-Cola Company, PepsiCo, Nestlé and Keurig Dr Pepper (Coca-Cola, 2019; Keurig, 2019; Nestlé, 2018; Pepsico, 2019). Fruit-juice products are voluntarily fortified with micronutrients identified by the 2015-2020 DGA as lacking in the US diet, including calcium and vitamins A, C, D and E (Bishai and Nalubola, 2002; Corbo *et al.*, 2014; Euromonitor, 2016; US-DHHS, 2015). Adequate micronutrient intake is critical for reducing the risk of diet-related chronic diseases. Nearly 10% of the US population has nutrition deficiencies, contributing to the \$3.24 trillion economic burden attributable to chronic disease (Buttorff *et al.*, 2017; US-CDC, 2012).

Despite overall fruit-juice sector contraction, fortified fruit-juice sales have increased year-over-year. From 2015 to 2016, shelf-stable and refrigerated fortified-juice sales increased 17.7 and 7.5%, respectively (Del Buono, 2017). A 2014 report compiled by Mintel indicates that 40% of consumers who purchase fruit juice look for vitamin and/or mineral fortified varieties (Mintel, 2014). Characterization of this consumer market for fortified fruit juice is essential for the success of beverage industry efforts to improve public health through fortification. Specifically, a consumer profile for fortified fruit juice will inform whether fortified-juice products are being purchased by US demographic groups that are disproportionately vulnerable or at-risk for nutrient deficiencies, including young children and individuals with low-income, low educational attainment and/or that identify as a racial and/or ethnic minority (Rehm *et al.*, 2016; Thomson *et al.*, 2019; Viteri *et al.*, 2002). To date, no study has characterized the consumer market for fortified fruit juice and existing research on the emerging market is limited. Three past studies analyzed consumer willingness to pay

¹ Note that fruit juice can contain non-juice ingredients, such as added vitamins and minerals, preservatives and sweeteners, so long as they do not result in a diminution of the juice soluble solids (FDA, 2014).

for nutrients in fruit juice, finding consumers are willing to pay a premium for added calcium and vitamin D (Leschewski *et al.*, 2016; Szathvary and Trestini, 2014; Weemaes and Riethmuller, 2001).

The objective of this study is to analyze the determinants of US household expenditures on fortified fruit juice. Specific determinants considered include sociodemographic characteristics, nutritional knowledge and preferences, and shopping habits. A key implication of this study is identification of a fortified fruit-juice consumer profile. The resulting consumer profile will inform juice-manufacturers' sustainability plans and related targeted marketing efforts to encourage fortified-juice purchases among Americans with nutrient deficiencies.

2. Background

The literature on fruit-juice demand and consumption is well established. Three prior studies analyze consumer willingness-to-pay for nutrients and related health claims in fruit juice (Leschewski *et al.*, 2016; Szathvary and Trestini, 2014; Weemaes and Riethmuller, 2001). Collectively, results from these studies provide evidence that consumers consciously consider the nutritional composition of fruit juice and are willing-to-pay a premium for added nutrients and related health claims. Leschewski *et al.* (2016) specifically find US consumers are willing-to-pay a premium for calcium, vitamin C and vitamin D in fruit juice. Similarly, Szathvary and Trestini (2014) and Weemaes and Riethmuller (2001) find that Italian and Australian consumers are willing to pay more for fruit juice labeled with a nutrition claim.

Irrespective of nutritional content, the prior literature further suggests that price, income, sociodemographic characteristics, health preferences and nutritional knowledge collectively influence US fruit-juice demand and consumption. Prior studies produce inconsistent findings regarding the relationship between fruit-juice price and quantity demand. Several studies indicate that fruit juice is own-price elastic, that is, juice demand is highly responsive to changes in juice price (Dharmasena and Capps, 2012; Kinnucan *et al.*, 2001; Smith *et al.*, 2010). Other studies alternatively find that fruit juice is own-price inelastic (Okrent and MacEwan, 2014; Yen *et al.*, 2004; Zheng *et al.*, 2008). In contrast, prior research consistently indicates that fruit-juice demand increases with income, i.e. fruit juice is a normal good (Dharmasena and Capps, 2012; Kinnucan *et al.*, 2001; Okrent and MacEwan, 2014; Smith *et al.*, 2010; Yen *et al.*, 2004; Zheng *et al.*, 2008).

Estimated cross-price elasticities further indicate that fruit-juice demand is responsive to the price of other beverage categories. In general, prior studies find that low and high fat milk, coffee and tea and bottled water are complements for fruit juice, while soft drinks, sports drinks and soy, rice and almond milk are substitutes for fruit juice (Dharmasena and Capps, 2012; Kinnucan *et al.*, 2001; Okrent and MacEwan, 2014; Smith *et al.*, 2010; Yen *et al.*, 2004; Zheng *et al.*, 2008). Several demand analyses also consider the effect of advertising. Okrent and MacEwan (2014) find no significant relationship, while Kinnucan *et al.* (2001) and Heng *et al.* (2018) find that fruit-juice advertising and advertising awareness positively affect juice demand.

Sociodemographic factors examined in the literature include gender, age, household size, race/ethnicity, educational attainment and marital status. Prior studies consistently find that racial/ethnic minorities (non-Hispanic Black and Hispanic) have greater fruit-juice demand and consumption than non-Hispanic whites and that juice demand is greater among college educated individuals (Demydas, 2011; Drewnowski and Rehm, 2015; Heng *et al.*, 2018; Herrick *et al.*, 2015). Further, the majority of prior studies indicate that fruit-juice consumption is greatest among young children and decreases with age (Drewnowski and Rehm, 2015; Herrick *et al.*, 2016). Correspondingly, Yen *et al.* (2004) find that the number of infants and children aged 1-3 is positively related to juice demand among low-income households. There is also some evidence that females and unmarried individuals are more likely to consume juice (Demydas, 2011).

A 2004 study by Yen *et al.* considers the effect of nutritional knowledge and health preferences on low-income households' fruit-juice demand. Results provide evidence that nutrition information, measured as the number of sources (nutrition labels, newspapers, advertisements, etc.) a household uses to obtain nutrient

and diet information, is positively related to juice demand among low-income households. The analysis also considers health preferences, measured as household perceived importance of dairy consumption and sugar moderation. Unlike nutritional knowledge, results indicate that health preferences do not significantly affect low-income households' fruit-juice demand.

While not considered specifically for fruit juice, the literature suggests that food purchase decisions are also influenced by consumer shopping habits. Several studies find that the nutritional quality of food purchases varies across store types (Caspi *et al.*, 2016; Stern *et al.*, 2016; Volpe and Okrent, 2012). Specifically, the nutritional quality of food purchases at traditional retailers (e.g. supermarkets, superstore and grocery stores) tends to exceed those at non-traditional retailers (e.g. convenience stores, dollar stores, pharmacies). There is also evidence that shopping frequency negatively affects the healthfulness of food purchases, with frequent shoppers more likely to buy less healthful 'temptation foods' (Rudi and Cakir, 2017).

In summary, the literature indicates that sociodemographics, income, prices, advertising, nutritional knowledge and preferences, and shopping habits should be considered as determinants of fortified fruit-juice expenditures.

3. Data

All analyses are conducted using the National Household Food Acquisition and Purchase Survey (FoodAPS) public-use dataset (USDA, 2019). Funded by the USDA ERS and Food and Nutrition Service (FNS) from 2012-2013, FoodAPS is a nationally representative survey of 4,826 US households. The dataset consists of food diaries which characterize household food at home and away from home purchases and acquisitions over a one-week period.

In order to distinguish the determinants of fortified fruit-juice expenditures from those of all fruit juice, this study's sample is conditioned on making a juice purchase. Fruit-juice purchases are identified using the What We Eat in America (WWEIA) food categories provided in FoodAPS. Specific categories comprising juice purchases are 'citrus juice', 'apple juice' and 'other fruit juice' (USDA-ERS, 2016). Only fruit-juice purchases made at food stores are included in this analysis given that fortification status is typically not discernable to consumers at food away from home retailers such as restaurants and other eating places.²

3.1 Fortification status

The fortification status of each fruit-juice item purchased is determined by linking FoodAPS to the USDA's 2013-2014 Food and Nutrient Database for Dietary Studies (FNDDS) (USDA-ARS, 2016). Juice items with an FNDDS fortification identifier code of 1 'fortified item', 2 'contains fortified ingredients' or 2a 'contains fortified ingredients including margarine/milk/flour' are classified as fortified, while fruit-juice items with a code of 0 'unfortified item' are classified as unfortified. Household expenditures on fortified fruit juice are then obtained by summing fortified fruit-juice item level expenditures.

3.2 Explanatory variables

In addition to food diaries, all FoodAPS participants completed entry and exit interviews to characterize their household. Based on prior literature, this analysis examines the relationship between fortified-juice expenditures and three categories of explanatory variables: (1) sociodemographic characteristics; (2) nutritional knowledge and preferences; and (3) shopping habits. Sociodemographic factors considered include income, food assistance program participation, region, race/ethnicity, education-level, sex and household age composition. Binary indicators of nutrition facts panel usage and nutrition education program participation are included as measures of household nutritional knowledge and preferences, while the number of weekly

² Food stores include supermarkets, superstores, grocery stores, club stores, convenience stores, dollar stores, gas stations and pharmacies.

shopping trips and primary store type are included to characterize household shopping habits. All explanatory variables considered in this analysis are defined in Table 1.

4. Methods

Classical demand theory provides a theoretical framework from which to analyze fortified fruit-juice expenditures. According to the theory, households choose consumption bundles which maximize their utility subject to their budget constraint as follows:

$$\begin{aligned} \max_q u(q|D) \\ \text{st } Y = \sum_{i=1}^n p_i q_i, \end{aligned} \quad (1)$$

where q is a vector of goods (including fortified fruit juice), p is a vector of corresponding prices, D is a vector of household characteristics and Y represents household income.

Table 1. Description of variables.^{1,2}

	Variable description	Unit or base variable
Dependent variables		
Purchase ^a	The household purchased fortified fruit juice	No purchase
Expenditures ^b	Household fortified fruit-juice expenditures	\$/week
Sociodemographics		
Income ^b	Average monthly household income	\$/month
WIC ^a	Household member(s) receive WIC benefits	Non-WIC
SNAP ^a	Household receives SNAP benefits	Non-SNAP
Northeast ^a	Census region is Northeast	West
Midwest ^a	Census region is Midwest	West
South ^a	Census region is South	West
Rural ^a	Household is in a rural census tract	Urban
Non-Hispanic Black ^a	Respondent is non-Hispanic Black	Non-Hispanic White
Non-Hispanic Asian ^a	Respondent is non-Hispanic Asian	Non-Hispanic White
Hispanic ^a	Respondent is Spanish, Hispanic, or Latino	Non-Hispanic White
Other race/ethnicity ^a	Respondent is non-Hispanic other	Non-Hispanic White
College ^a	Respondent has a bachelor's degree or higher	< BA degree
Female ^a	Respondent is female	Male
Toddlers ^b	Household members aged 2-4 years	#
Children ^{b,c}	Household members aged 5-17 years	#
Adults ^b	Household members aged 18-59 years	#
Seniors ^b	Household members aged 60+ years	#
Nutritional knowledge and preferences		
Nutrition Facts Panel ^a	Respondent uses Nutrition Facts Panel 'always' or 'most of the time'	Infrequent use
Nutrition education ^a	Respondent participated in nutrition education	No education
Shopping habits		
Shopping trips ^b	Household food shopping trips per week	#
Traditional store ^a	Household's primary store is a supermarket	Non-traditional

¹ ^a = binary variable; ^b = continuous variable; ^c = an alternative classification of children, with separate variables for children aged 5-12 years and 13-17 years, was considered. Coefficient estimates were similar across classification schemes. Thus, the aggregated specification for children aged 5-17 was used for simplicity.

² SNAP = Supplemental Nutrition Assistance Program; WIC = Special Supplemental Nutrition Assistance Program for Women, Infants and Children.

Assuming a continuous, increasing, quasi-concave utility function, constrained optimization of Equation 1 results in Marshallian demand functions defined as:

$$q^* = Q(\mathbf{p}, Y|\mathbf{D}). \quad (2)$$

Given that information on fruit-juice prices faced by each household is not available in the FoodAPS public-use dataset, this study assumes all households face the same relative prices (Yen and Jensen, 1996). The corresponding expenditure function can thus be defined as:

$$E = e(Y|\mathbf{D}). \quad (3)$$

A key concern in modeling fortified fruit-juice expenditures is the large share of sample households, 50%, that did not purchase fortified fruit juice. Zero expenditures are a common issue when using survey data to analyze household expenditures (Deaton and Irish, 1984). Failure to account for zero expenditures when modeling Equation 3 can result in biased and inconsistent estimates (Wooldridge, 2010). The Tobit model, double-hurdle model and the infrequency of purchase model are commonly employed to account for zero expenditures in studies examining disaggregate food demand. These models are appropriate when zero expenditures represent true non-consumption, as opposed to unobserved or missing values (Cragg, 1971; Keen, 1986; Tobin, 1958). The standard Tobit model is often criticized for its restrictive assumption that the same set of parameters and variables determine both the probability of purchase and level of expenditures for a good (Cragg, 1971; Keen, 1986; Sharpe *et al.*, 2001; Yen 1994).

Both the double-hurdle model and infrequency of purchase model overcome this restriction by allowing separate processes to determine a household's purchase and expenditure decisions. The double-hurdle model assumes zero expenditures result from economic factors (price, income), as well as non-economic factors such as tastes and preferences (Cragg, 1971). The infrequency of purchase model differs in that it attributes zero expenditures to either economic factors or to the survey period being shorter than the good's purchase cycle (Keen, 1986). In this analysis, it is unlikely that zero expenditures result from infrequency of purchase. Mintel estimates that 40% of fruit-juice consumers actively search for fortified varieties (Mintel, 2014). Within this study, 50% of sample households purchasing fruit juice bought a fortified product. This similarity suggests that the majority of fortified fruit-juice consumers in the study sample made a fortified fruit-juice purchase during the FoodAPS survey period. Correspondingly, fruit juice is a perishable product once opened, with a refrigerated life (5-7 days) shorter than the one-week FoodAPS survey period (Garden-Robinson, 2013).

This study thus operationalizes Equation 3 by implementing Cragg's double hurdle model (Cragg, 1971). This approach is employed in several prior studies analyzing determinants of household expenditures on beverages, including wine, alcohol and tea (Blaylock and Blisard, 1993; Chen *et al.*, 2020; Sharpe *et al.*, 2001; Yen, 1994). The model consists of two hurdles or steps: (1) the participation decision; and (2) the expenditure decision. In the case of fortified fruit juice, the participation decision models a household's decision to purchase fortified fruit juice, while the expenditure decision models a household's expenditure allocation to fortified fruit juice given purchase. Intuitively, this two-step decision process allows the sociodemographic, nutritional knowledge and preferences, and shopping characteristics that impact a household's decision to purchase fortified fruit juice to differ from those that impact the expenditure decision.

The log likelihood function for the double hurdle model is defined as follows:

$$l_i(\theta) = 1[q_i = 0] \log[1 - \Phi(\mathbf{x}_i\boldsymbol{\gamma})] + 1[q_i > 0] \log[\Phi(\mathbf{x}_i\boldsymbol{\gamma})] \\ + 1[q_i > 0] \left\{ -\log\left[\Phi\left(\frac{\mathbf{x}_i\boldsymbol{\beta}}{\sigma}\right)\right] + \log\left[\Phi\left(\frac{q_i - \mathbf{x}_i\boldsymbol{\beta}}{\sigma}\right)\right] - \log(\sigma) \right\} \quad (4)$$

Where q_i represents fortified fruit-juice expenditures of household i , x_i is a vector of explanatory variables (defined in Table 1), γ is a vector of parameters to be estimated for the participation decision, β is a vector of parameters to be estimated for the expenditure decision and σ is the variance of the error term (Wooldridge, 2010).

Double hurdle model estimates are obtained via maximum likelihood estimation using STATA 15.1 (StataCorp LLC, College Station, TX, USA). Average partial effects are calculated postestimation following the procedures outlined in Burke (2009). The participation average partial effect is defined as:

$$\frac{\partial P(q_i > 0 | x_i)}{\partial x_j} = \gamma_j \phi(x_i \gamma) \quad (5)$$

and measures how an explanatory variable affects the probability that a household purchases fortified fruit juice at the mean values of all other explanatory variables. Similarly, the conditional expenditure average partial effect measures how an explanatory variable affects expected fortified fruit-juice expenditures given purchase at the mean values of all other explanatory variables and is defined as:

$$\frac{\partial E(q_i | q_i > 0, x_i)}{\partial x_j} = \beta_j \left[1 - \lambda\left(\frac{x_i \beta}{\sigma}\right) \left\{ \frac{x_i \beta}{\sigma} + \lambda\left(\frac{x_i \beta}{\sigma}\right) \right\} \right] \quad (6)$$

where λ is the inverse Mills ratio.

5. Results

In total, 983, or 20%, of the 4,826 FoodAPS households purchased at least one fruit-juice item during the survey period. Of these households, 24 were removed from the sample due to missing observations. This resulted in a final study sample of 959 households.

5.1 Descriptive statistics

Descriptive statistics are presented in Table 2 for three groups of sample households: (1) households purchasing fruit juice (n=959); (2) households purchasing fortified fruit juice (n=481); and (3) households not purchasing fortified fruit juice (n=478). Note that means were weighted using household sampling weights and standard errors were calculated using the Jackknife Repeated Replication to account for the complex survey design of FoodAPS. Of the 959 sample households making a fruit-juice purchase, 50% purchased a fortified fruit-juice item. Given purchase, households spent an average of \$4.44 on fortified fruit juice per week.

The descriptive statistics reveal heterogeneity in the characteristics of sample households by fortified fruit-juice purchase status. Among sociodemographic characteristics, household composition by age exhibited the greatest variation across fortified fruit-juice purchase status. Households with a fortified fruit-juice purchase on average had a greater number of toddlers, children and adults, but fewer seniors than non-purchasing households. Fortified fruit-juice purchase also varied by food assistance program participation, rural-urban classification, race/ethnicity and educational attainment. In comparison to non-purchasers, a greater share of households purchasing fortified fruit juice participated in the Supplemental Nutrition Assistance Program (SNAP) and WIC and a smaller share lived in a rural area, were non-Hispanic Black, non-Hispanic Asian and non-Hispanic other. A college education was also less common among fortified fruit-juice purchasers than among non-purchasers. Monthly income, geographic region and gender were similar among sample households irrespective of purchase status.

Descriptive statistics also highlight differences in the nutritional knowledge and preferences and shopping habits of fortified fruit-juice purchasers and non-purchasers. Fortified fruit-juice purchasers were less likely to use the nutrition facts panel and to have participated in a nutrition education program than non-purchasers. Households purchasing fortified fruit juice were also more likely to shop at a supermarket as their primary store than are non-purchasers. In contrast, the number of household shopping trips was nearly identical among the two groups.

Table 2. Descriptive statistics by household fruit-juice purchase status.^{1,2}

	Purchase fruit juice (n=959)		Purchase fortified fruit juice (n=481)		No fortified fruit-juice purchase (n=478)	
	Mean	SE	Mean	SE	Mean	SE
Dependent variables						
Purchase	0.50	–	1.00	–	0.00	–
Expenditures	\$2.18	\$0.14	\$4.44	\$0.19	0.00	\$0.00
Sociodemographics						
WIC	0.05	–	0.07	–	0.03	–
SNAP	0.10	–	0.11	–	0.08	–
Income	\$5,959.37	\$259.74	\$5,966.13	\$323.34	\$5,952.86	\$314.38
Northeast	0.17	–	0.17	–	0.17	–
Midwest	0.30	–	0.29	–	0.31	–
South	0.33	–	0.34	–	0.33	–
Rural	0.33	–	0.30	–	0.36	–
Non-Hispanic Black	0.09	–	0.08	–	0.10	–
Non-Hispanic Asian	0.05	–	0.04	–	0.06	–
Non-Hispanic other	0.02	–	0.01	–	0.04	–
Hispanic	0.12	–	0.13	–	0.12	–
College	0.41	–	0.39	–	0.43	–
Female	0.74	–	0.73	–	0.75	–
Toddlers	0.20	0.03	0.28	0.05	0.13	0.02
Children	0.50	0.05	0.59	0.07	0.41	0.05
Adults	1.48	0.06	1.51	0.10	1.45	0.07
Seniors	0.50	0.04	0.48	0.06	0.52	0.04
Nutritional knowledge and preferences						
Nutrition Facts Panel	0.75	–	0.73	–	0.77	–
Nutrition education	0.07	–	0.05	–	0.09	–
Shopping habits						
Shopping trips	3.94	0.12	3.95	0.15	3.93	0.17
Traditional store	0.91	–	0.93	–	0.89	–

¹ Means are weighted. Jackknife Repeated Replication method used to estimate standard errors.

² SE = standard error; SNAP = Supplemental Nutrition Assistance Program; WIC = Special Supplemental Nutrition Assistance Program for Women, Infants and Children.

5.2 Double hurdle model estimates

Double hurdle model estimates are presented in Table 3. Coefficient estimates for the purchase and expenditure equations are presented in column 2 ‘purchase’ and column 3 ‘expenditure’ respectively. Participation and conditional expenditure average partial effects are presented in column 4 ‘purchase probability’ and column 5 ‘conditional expenditures’.

The probability of fortified fruit-juice purchase varies across several sociodemographic factors. When purchasing fruit juice, results indicate that each additional toddler in a household is associated with a 15% increase in the probability of the household purchasing fortified fruit juice. Similarly, each additional child aged 5-17 years is associated with a 6% increase in the probability of the household purchasing fortified fruit juice. In contrast, households located in a rural census tract are 8% less likely to purchase fortified fruit juice than those located in an urban census tract. Relative to households headed by non-Hispanic whites, non-Hispanic other race/ethnicity headed households are 34% less likely to purchase fortified fruit juice.

Table 3. Double hurdle model and average partial effect estimates (n=959).^{1,2}

	Purchase	Expenditure	Purchase probability	Conditional expenditures
Sociodemographics				
Income	0.00	0.00	0.00	0.00
WIC	-0.01	0.66	0.00	0.48
SNAP participant	0.19	-0.43	0.07	-0.31
Northeast	-0.11	0.30	-0.04	0.22
Midwest	-0.13	-0.25	-0.05	-0.18
South	-0.07	-0.05	-0.03	-0.04
Rural	-0.22*	-0.47	-0.08*	-0.34
Non-Hispanic Black	-0.33	-0.38	-0.12	-0.28
Non-Hispanic Asian	-0.38	2.90**	-0.14	2.11**
Hispanic	-0.21	-0.28	-0.08	-0.20
Other race/ethnicity	-1.07***	0.60	-0.34***	0.43
College	-0.08	0.64	-0.03	0.46
Female	-0.10	-0.60	0.04	-0.43
Toddlers	0.39**	-0.57	0.15**	-0.42
Children	0.15**	-0.01	0.06**	-0.01
Adults	-0.05	0.57**	-0.02	0.41**
Seniors	-0.01	0.40	0.00	0.29
Nutritional knowledge and preferences				
Nutrition Facts Panel	-0.09	-1.01*	-0.03	-0.74*
Nutrition education	-0.30	-0.67	-0.11	-0.48
Shopping habits				
Shopping trips	0.00	0.08	0.00	0.06
Traditional store	0.22	-1.26	0.08	-0.91
Constant	0.11	42.85***	—	—
F (21,6)	3.98			
Prob > F	0.05			

¹ Estimates are weighted. Jackknife Repeated Replication method used to estimate standard errors. *, ** and *** indicate significance at the 0.10, 0.05 and 0.01 level.

² SNAP = Supplemental Nutrition Assistance Program; WIC = Special Supplemental Nutrition Assistance Program for Women, Infants and Children.

Other races/ethnicities include households with heads identifying as non-Hispanic American Indian or Alaska Native, Native Hawaiian or Other Pacific Islander and multiple races.

This study finds no significant association ($P < 0.10$) between nutritional knowledge and preferences and fortified fruit-juice purchase. Results further suggest that household shopping frequency and primary store type are not significantly ($P < 0.10$) associated with the purchase of fortified fruit juice.

Given the decision to purchase fortified fruit juice, results from the second stage of the double hurdle model (the expenditure decision) indicate little difference in fortified fruit-juice expenditures across sociodemographic characteristics. Exceptions of note include race/ethnicity, household composition and Nutrition Facts Panel usage. Specifically, households headed by a non-Hispanic Asian spend \$2.11 more on fortified fruit juice given purchase than households with a non-Hispanic white head. Results further indicate that each additional adult in a household increase expenditure on fortified fruit juice given purchase by \$0.41. In contrast, households who indicate frequent use of the Nutrition Facts Panel spend \$0.74 less on fortified fruit juice given purchase than household who use indicate infrequent use.

6. Discussion

Driven largely by health concerns and policy revisions, fortification has emerged as a major trend in the US fruit-juice industry. This study adds to the literature as the first to analyze the determinants of US household expenditures on fortified fruit juice. Specific determinants considered include sociodemographic characteristics, nutritional knowledge and preferences and shopping habits.

A key implication of this study is identifying a fortified fruit-juice consumer profile to inform the sustainability plans of the juice industry. Interestingly, consumers exhibiting healthy lifestyle behaviors are not primary consumers of fruit juice fortified with vitamins and minerals. Nutrition Facts Panel usage and nutrition education program participation are not significant ($P < 0.10$) determinants of the decision to purchase fortified-juice products. Further, households who report frequent Nutrition Facts Panel usage spend \$0.74 less ($P < 0.05$) on fortified fruit juice given purchase than do other households. These households likely choose to purchase fortified fruit juice for its health benefits but limit the quantity they purchase given the health concerns associated with excessive juice consumption (Imamura *et al.*, 2015; Marshall *et al.*, 2003; Mozaffarian *et al.*, 2011; Shefferly *et al.*, 2016; US-DHHS, 2015). This finding is consistent with the 2015-2020 Dietary Guidelines for Americans which identify fruit juice as an important source of vitamins and minerals, but recommend obtaining no more than 50% of fruit servings from juice given that it contains less dietary fiber than whole fruit (US-DHHS, 2015).

Instead, results indicate that households with toddlers and/or children are key consumers of fortified fruit juice. Each additional toddler (2-4 years) and child (5-17 years) increases the likelihood that a household purchases fortified fruit juice by 15% ($P < 0.05$) and 6% ($P < 0.05$), respectively. This finding suggests that manufacturers' efforts to improve public health through fortification are reaching population subgroups that are particularly vulnerable to malnutrition. Vitamin and mineral deficiencies in early childhood have been linked to increased risk for long-term health problems, including anemia, stunted growth, rickets, blindness, neurologic damage and impaired cognitive ability (Viteri *et al.*, 2002).

In addition to primary consumers, this analysis also characterizes US population subgroups that are less likely to purchase fortified fruit juice. This characterization provides juice manufacturers with insight needed to effectively improve public health through fortification. Specifically, results identify rural and minority headed households as demographic subgroups with disproportionately high incidence of nutrient deficiencies that are less likely to select fortified products when purchasing fruit juice (Rehm *et al.*, 2016; Thomson *et al.*, 2019). Households located in a rural census tract are 8% ($P < 0.10$) less likely to purchase fortified fruit juice than urban households, while households headed by an individual whose race/ethnicity is non-Hispanic other are 34% ($P < 0.01$) less likely to purchase fortified fruit juice than non-Hispanic white households.

Overall, this study provides evidence that fruit-juice fortification has the potential to improve public health among US demographic subgroups that are disproportionately vulnerable or at-risk for nutrient deficiencies. Findings suggest that fruit-juice manufacturers' fortification efforts are likely improving the nutritional intake of US toddlers and children, but are less effective at reaching other demographic subgroups (rural and non-Hispanic other race/ethnicity headed households) with high nutrient deficiency incidence. The juice industry should target future fortified fruit-juice marketing and outreach efforts at rural and minority-headed households to maximize improvement in dietary quality among fruit-juice consumers.

6.1 Limitations

Despite its contribution to the literature, this study is subject to several limitations. A key limitation of note is that all analyses are conducted using cross-sectional data. Thus, findings from this analysis are indicative of an association, as opposed to causal relationship, between household characteristics and fortified fruit-juice expenditures. Further, this study was unable to consider all possible determinants of fortified fruit-juice expenditures identified by the literature. In particular, advertising and prices were excluded from this

analysis as they were not characterized in FoodAPS. Other general limitations of the FoodAPS dataset are well-documented and include self-report bias, misclassification of food purchases and acquisitions, and missing food item-level information (Wilde and Ismail, 2018).

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Conflict of interest

No conflicts of interest are reported by the authors of this paper.

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