



# The healthfulness of food and beverage purchases after the federal food package revisions: The case of two New England states

Tatiana Andreyeva PhD<sup>a,\*</sup>, Amanda S. Tripp PhD<sup>b,c</sup>

<sup>a</sup> Department of Agricultural and Resource Economics, Rudd Center for Food Policy & Obesity, University of Connecticut, Hartford, CT, United States

<sup>b</sup> Yale School of Public Health, Yale University, New Haven, CT, United States

<sup>c</sup> The Lewin Group, Falls Church, VA, United States

## ARTICLE INFO

### Article history:

Received 2 February 2016

Received in revised form 8 August 2016

Accepted 12 August 2016

Available online 13 August 2016

### Keywords:

WIC

Food purchases

Food spending

Dietary quality

Food policy

Scanner data

## ABSTRACT

**Objective.** In 2009, the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) implemented new food packages to improve dietary intake among WIC participants. This paper examines how the healthfulness of food purchases among low-income households changed following this reform.

**Methods.** Point-of-sale data for 2137 WIC-participating and 1303 comparison households were obtained from a regional supermarket chain. The healthfulness of purchased foods and beverages was determined per their saturated fat, sugar, and sodium content. A pre-post assessment (2009–2010) of the product basket healthfulness was completed using generalized estimating equation models. Data were analyzed in 2015.

**Results.** At baseline, healthy products accounted for most of the food volume purchased by WIC participants, but beverages were dominated by moderation (less healthy) items. With new subsidies for fruit, vegetables and whole grains, the WIC revisions increased the volume of healthy food purchases of WIC-participating households by 3.9% and reduced moderation foods by 1.8%. The biggest improvements were reductions in moderation beverages (down by 24.7% in volume), driven by milk fat restrictions in the WIC food package revisions. The healthfulness of the product basket increased post-WIC revisions; mainly due to a reduction in the volume of moderation food and beverages purchased (down by 15.5%) rather than growth in healthy products (up by 1.9%). No similar improvements were seen in a comparison group of low-income nonparticipants.

**Conclusions.** After the WIC revisions, the healthfulness of participant purchases improved, particularly for beverages. Efforts to encourage healthy eating by people receiving federal food assistance are paying off.

© 2016 Elsevier Inc. All rights reserved.

## 1. Background

For many American families, poor diet quality is a significant barrier to improving health and prolonging a disease-free lifespan. This is especially true for low-income families that have economic, time and access barriers to putting nutritious meals on the table. Poor diets in low-income communities are the result of both compositional and environmental factors (Dubowitz et al., 2008; Booth et al., 2001; Lovasi et al., 2009), including disparities in access to healthy food (Powell et al., 2007; Small and McDermott, 2006), higher prices, and poor product quality (Dubowitz et al., 2008; Andreyeva et al., 2008; Block and Koubas, 2006).

Federal food assistance programs support one in four American households in achieving adequate nutrition (Vilsack, 2011). Economic incentives provided by these programs could be one strategy to improving the food environment and diet quality in low-income communities

and reducing inequalities. The Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) provides a set of nutrient-dense foods (via WIC food packages), nutrition education, and medical referrals to 8.0 million participants (U.S. Department of Agriculture, 2015), including 51% of infants born in the U.S., 28% of children age five and under, 29% of pregnant women, and 30% of postpartum women (Oliveira and Frazão, 2015). Because of its broad reach and targeted impact at a critical age of human growth and development, WIC has considerable potential for early intervention to establish healthier eating habits in low-income populations.

The WIC food packages were initially revised in 2007 to increase participants' consumption of fruits, vegetables and whole grains while reducing saturated fat, cholesterol and sugar intake. Additional goals were to promote breastfeeding, provide WIC participants with a wider variety of food options and give states greater flexibility in administering the program (Institute of Medicine for the National Academies, 2005; U.S. Department of Agriculture, 2014a). Designed as cost-neutral changes, the WIC revisions were implemented in all states by October 2009 and finalized in 2014. The changes included the addition of whole grain products, fruit and vegetable cash value vouchers,

\* Corresponding author at: Rudd Center for Food Policy & Obesity, University of Connecticut, 1 Constitution Plaza, Hartford, CT 06103, United States.

E-mail address: [tatiana.andreyeva@uconn.edu](mailto:tatiana.andreyeva@uconn.edu) (T. Andreyeva).

reductions in milk, cheese and juice allowances, restrictions on milk fat content, and incentives to encourage breastfeeding. The revisions provided a unique natural experiment to assess the ability of food assistance policy to improve diet quality in low-income populations.

There is substantial interest in the impact of the WIC revisions on dietary and health outcomes in low-income populations. There is evidence that the WIC revisions have improved the availability and variety of healthy foods in underserved communities (Andreyeva et al., 2012; Altarum Institute, 2010; Hillier et al., 2012; Zenk et al., 2012; Havens et al., 2012; O'Malley et al., 2014), including in non-WIC stores that were not subject to the WIC regulations requiring to stock healthier foods (Andreyeva et al., 2012). A number of studies documented improvements in food choices aligned with the revisions: reduced participant purchases of juice (Andreyeva et al., 2013), whole milk and cheese (Andreyeva et al., 2014), and instead more fruit, vegetables (Andreyeva and Luedicke, 2014), low-fat milk (Andreyeva et al., 2014) and whole grain products (Andreyeva and Luedicke, 2013).

Importantly, the WIC food package revisions were associated with improved dietary intake of WIC participants (Schultz et al., 2015). In a national sample, WIC-participating children were found to have a 3.7 point higher Healthy Eating Index (HEI) compared to eligible nonparticipants (Tester et al., 2016). Further evidence of similar improvements were reported in the WIC National Food and Nutrition Survey (NAFTAN) (Spaulding et al., 2014), survey data from California (Whaley et al., 2012) and New York (Chiasson et al., 2013) and dietary assessments in Chicago (Kong et al., 2014). There was mixed evidence on breastfeeding initiation and intensity (Schultz et al., 2015), with only a small change in duration of breastfeeding (Wilde et al., 2012; Wilde et al., 2011) or increases in local populations such as Los Angeles County (Langellier et al., 2014). Finally, obesity rates among preschool-age children (Ogden et al., 2014; Ogden et al., 2016) and low-income young children in particular (Sekhobo et al., 2013; May et al., 2013) started to decline recently. For example, obesity rates among all U.S. children aged 2–5 yr declined from a peak of 13.9% in 2003–2004 before the WIC revisions to 8.4% in 2011–2012 and 9.4% in 2013–2014 (Ogden et al., 2016). It remains to be seen how the WIC revisions affect diet quality and obesity among WIC participants in the long term.

This paper contributes to the WIC evaluation literature by examining the healthfulness of the total product basket purchased by WIC-participating households after implementation of the WIC food package revisions in Connecticut and Massachusetts.

## 2. Research design

### 2.1. Data

The study is based on point-of-sale data from a supermarket chain with >60 stores in New England, U.S. This chain has a loyalty card system, which allows customers to benefit from store promotions and price discounts. A unique feature of the data is information on the source of funds used to pay for each purchase, including: SNAP benefits, WIC benefits, cash assistance or non-SNAP electronic benefit transfers (EBT), and other funds (e.g., cash). A household's redemption of benefits indicates program participation at the time of each transaction, which we use to measure a household's WIC, SNAP and non-SNAP EBT participation status. We do not have purchases made without the use of loyalty cards, which is a small share of all transactions (<5%, according to the supermarket). As using a loyalty card provides substantial price discounts on a variety of products, most customers, but especially more price-sensitive low-income households, have a strong incentive to use their card for all purchases. One loyalty card is assumed to represent one household, although in reality some families could have multiple cards or multiple households within the same extended family could share a single card.

### 2.2. Sample

The sample is drawn from low-income households that used WIC benefits when shopping at the grocery chain in January 2009–December 2010. We do not have data for households that never used WIC benefits to pay for any of their purchases (e.g., high-income families not receiving assistance). Approximately half of the sampled WIC households also used SNAP benefits. Due to de-identified nature of the point-of-sale data, no socio-demographic information was available.

As the WIC package revisions went into effect in both states on October 1, 2009, we selected a panel of 2137 households that shopped at the chain using WIC on a regular basis (at least quarterly) before and after the change: January–September 2009 (pre-revision) and January–September 2010 (post-revision). The period of October–December 2009 was excluded to isolate the effects of the transition period when both the old and new WIC packages were in circulation. A comparison sample of 1303 households was selected from former WIC households that were low-income due to a recent history of WIC participation, but were not expected to be affected by the WIC revisions as they were no longer participants. Specifically, households were selected into the comparison group if they used WIC benefits in the first quarter of 2009, but discontinued using WIC through the end of 2009 and all 2010 while still shopping regularly at the store.

We examined all purchases made by WIC-participating households during Jan–Sept 2009 and Jan–Sept 2010 ( $N = 199,085$  transactions in the two states). For comparison households, we assessed all their purchases during Apr–Sept 2009 and Apr–Sept 2010, excluding the time period when they participated in WIC (Jan–Mar 2009) and a matching 3-month period in 2010 ( $N = 58,050$  transactions). Household (or loyalty card) level data were aggregated at the monthly level; if a household made multiple purchases per month, purchases were summed.

## 3. Product identification and categorization

Each product sold at the chain has a unique Universal Product Code (UPC), which is linked to description of a product, department, category and sub-category in the store proprietary database. To retrieve nutrition information, product/container size and ingredients for all purchased UPCs, two syndicated databases were merged with the store UPC data: Gladson (Gladson, Nutrition database, 2011) and Information Resources, Inc. (IRI) (Information Resources Inc. Nutrition Data, 2014). Gladson was first matched (60% match by UPC), followed by IRI (83% match). Given its more recent records, IRI overrode Gladson if there was conflicting information. For UPCs that lacked information in the databases (e.g., store prepared foods, private label), online search was completed to look up individual UPCs.

The sample of WIC-participating and comparison households purchased a total of 29,204 unique food and beverage UPCs during the 18 months of our analysis. Non-food products were not included in this analysis. Each food and beverage UPC item was assigned to one of 12 categories and 44 sub-categories (Appendix 1) based on categorization in the USDA Food Intake Surveys: What We Eat in America, Food Categories 2001–2010 (U.S. Department of Agriculture, What We Eat in America, Food Categories, 2001–2010) and Food Patterns Equivalents Database 2005–2006 (Bowman et al., 2014). For categories that included grains, we categorized products as 100% whole grain, some whole grain, refined grain (0% whole grain), or no grain. We used the Food Patterns Equivalents Database methodology and a guide for the National School Lunch and Breakfast programs (U.S. Department of Agriculture, 2014b) to identify whole grain products. Two coders reviewed and verified all UPC coding and product categorizations.

### 3.1. Product healthfulness classification

Each food and beverage was classified as either a Healthy, Neutral or Moderation (less healthy) product based on criteria in the USDA

Economic Research Service study (Carlson and Frazão, 2012). The study classified primary food groups as Vegetables, Fruits, Dairy, Proteins, Grains and Mixed Dishes, and required minimal serving sizes to be considered meeting the recommended amount to provide nutrition. As our purchase data did not include consumption information, the recommended serving size was used to establish foods that would meet minimal thresholds. The ERS study classified consumption as healthy based on meeting the sodium, saturated fat and added sugar thresholds listed below. Consumption of foods above the threshold in any of the three areas was classified as moderation (unhealthy).

Category	Sodium	Saturated fat	Added sugar
Vegetable, fruit, dairy and grains	<480 mg per serving	<3 g per serving	<4 g per serving
Meat	<480 mg per serving	≤4 g per serving	<4 g per serving
Mixed dishes	<600 mg per serving	<5 g per serving	<5 g per serving

For vegetables, fruits, dairy, meat and grains, we used the same thresholds as the ERS study to categorize individual products. Because manufacturers only report total sugar, a number of assumptions were made regarding products containing naturally-occurring sugars, such as fruit, fruit juices and dairy. Specifically, all fruits and 100% fruit juices with no added sugar were considered below the threshold and healthy. Juices with added sugar were considered above the sugar threshold. Milk and cheese products with no added sugar were classified below threshold for sugar, but flavored milk with added sugar was a moderation product. Yogurts were considered below the added sugar threshold if total sugar was below 20 g per serving. Checks to evaluate differences in sugar content among products with no added sugar and those with added sugar were completed to validate our assumptions.

Because the serving size of many condiments and oils does not meet minimal serving sizes to be considered nutritive, these products were categorized differently. Oils below saturated fat threshold (e.g., olive oil) were classified as neutral products and oils above thresholds as moderation. Snack foods with some whole grain or 100% whole grain and meeting the thresholds for sodium, saturated fat and added sugar were classified as healthy. Snack foods, which met all thresholds, but not whole grain, were classified as neutral. All infant formula and baby foods were classified as neutral. Unsweetened bottled water was classified as healthy while diet and low-calorie beverages, coffee and tea were neutral. Sugar-sweetened beverages were classified as moderation. Appendix 1 presents the healthfulness distribution of purchased foods and beverages, with over half of purchased items (52%) categorized as moderation products.

## 4. Data analysis

### 4.1. Dependent variables

We calculated spending (measured in U.S. dollars) and the amount or volume purchased (measured in ounces) for healthy, neutral and moderation products and their totals before and after the WIC revisions. As beverages tend to be cheaper per ounce than solid food, we examined food separately from beverages.

### 4.2. Independent variables

Household-level controls included measures of SNAP participation and cash assistance receipt, shopping frequency (number of transactions), month, and state indicators. Socio-demographic characteristics of the census tracts, linked to census-level data from the 2006–2010 American Community Survey (U.S. Census Bureau, 2010), where households shopped were added to account for differences in prices, product selection and marketing across stores located in different neighborhoods/towns. To some extent, these could capture lacking household-

level socio-demographics. The weighted average of census-tract measures was calculated for households shopping in multiple stores based on frequency of store visits.

### 4.3. Regression modeling

As outcome variables (ounces purchased and spending) have a natural bound at zero and are positively skewed, we estimated generalized linear models (GLM) from the Poisson family with a logarithmic link function (Nichols, 2010). To account for repeated observations within households, we used generalized estimating equations (GEE) with exchangeable working correlation and robust standard errors (Hardin and Hilbe, 2003). GEE is an extension of GLM for longitudinal or clustered data. This model estimates the adjusted mean difference between the two time periods, controlling for covariates:

$$E[Y_{it}|X_i, X_{it}] = \exp.(\beta_0 + \beta_1 * REVISION_{it} + \beta_2 * SNAP_{it} + \beta_3 * EBT_{it} + \beta_4 * NTRANS_{it} + \beta_5 * T_{it} + \beta_6 * S_{it})$$

where  $REVISION_{it}$  is an indicator for the time period (1 for post-revision and 0 for pre-revision);  $SNAP_{it}$  is a household  $i$  that used SNAP benefits at time  $t$ ,  $EBT_{it}$  is receipt of cash assistance by household  $i$  at time  $t$ ,  $NTRANS_{it}$  is the number of transactions at time  $t$ ,  $T_{it}$  is a set of eight binary variables indicating the month of purchase, and  $S_{it}$  is a vector of store area covariates.

All regressions were estimated separately for WIC-participating and comparison households. We limited the time period for WIC households to match the comparison group (Apr–Sept 2009 and Apr–Sept 2010) in a sensitivity analysis. Additional analyses included estimation of models for each food sub-category as well as interaction tests to understand if the WIC revisions had differential effects on certain WIC households. Specifically, we considered presence of an infant in the household (based on purchases of baby food and/or infant formula), SNAP participation, low-/high-income area of the store location, and state.

This study was exempt by the university IRB from review due to secondary nature of de-identified data.

## 5. Results

Prior to the WIC revisions, foods and beverages purchased with WIC benefits accounted for 28% of product volume and 22% of expenditures among WIC-participating households (Table 1). In 2010, reduced allowances in the new WIC packages (especially milk and juice) contributed to the decline in the share of WIC-paid purchases: to 22% in volume and 19% in expenditures. Several products had a reduction in volume purchased: infant formula (down by 35%), milk (26%), 100% juice (20%), and eggs (30%) (Appendix 2). At the same time, produce and whole grain purchases increased due to the new WIC allowances. Overall, expenditures and purchases by WIC-participating households declined after the WIC revisions (volume declined by 6.2% and expenditures by 5.2%), driven entirely by a reduction in beverages. Comparison households reduced purchases of both food and beverages.

In 2009, beverages dominated WIC household purchases (Appendix 2), led by milk (22% of all food and beverage volume), sugary beverages (15%), and fruit juice (9%). Comparison households bought substantially less milk and 100% juice (10% and 4% respectively), potentially due to loss of WIC benefits providing these products. The most important contributor to their purchases were sugary beverages (20% of volume) and mixed dishes (12% of expenditures). The primary food category in baseline expenditures among WIC households (Appendix 3) was protein, followed by fruit and vegetables, dairy, snacks, mixed dishes and condiments, grains, dessert, baby food/formula, and non-dairy beverages. These patterns changed only slightly in 2010.

At baseline, healthy foods accounted for half of the food volume purchased by WIC households (466 oz of 940 oz, Table 2). Expenditure was,

**Table 1**

Descriptive statistics. Purchases of low-income households, 2009–2010.

	WIC households				Comparison households			
	Pre-revision		Post-revision		Pre-revision		Post-revision	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Purchased amounts	Ounces per month per household							
Total food & beverages	1992	1497	1869	1507	1339	1359	1275	1313
Total food	904	791	930	798	726	729	680	691
Total beverages	1088	855	939	838	613	742	595	733
WIC benefit purchases	549	492	408	395				
Non-WIC funds purchases	1443	1361	1460	1406				
Expenditure	Dollars (\$) per month per household							
Total food & beverages	215	172	204	169	153	155	141	144
Total food	158	141	160	140	130	133	120	124
Total beverages	57	54	44	43	23	29	22	26
WIC benefit spending	48	51	40	43				
Non-WIC spending	190	178	185	175				
Household-level controls (monthly)								
Number of transactions	6	4	5	4	4	4	4	4
Use of WIC benefits, %	86	35	82	39	0		0	
Use of SNAP benefits, %	45	50	52	50	35	48	34	47
Use of non-food EBT, %	5	22	5	22	3	18	3	16
Store-level socio-demographic controls								
Household income, \$	56,042	15,964	55,952	15,927	57,918	17,660	57,941	17,514
College graduates, %	16	6	16	6	16	6	16	6
Households in poverty %	9	6	9	6	8	6	8	6
Non-Hispanic white, %	83	13	83	13	82	14	82	14
Non-Hispanic black, %	4	5	4	5	4	5	4	5
Unemployed, %	8	3	8	3	8	3	8	3
Massachusetts, %	76	42	76	42	67	47	67	47
N (observations)	17,844		18,415		6627		6527	
N (households)	2137				1303			

**Table 2**

Food and beverage purchase changes after WIC revisions. Purchases of low-income households, 2009–2010.

	WIC Households			Comparison Households				
	Exp(b)	95% CI	Pre	Post	Exp(b)	95% CI	Pre	Post
<i>Ounces purchased per household per month</i>								
Total food & beverages								
Healthy items	1.019*	1.001, 1.037	859	870	0.973	0.941, 1.006	590	577
Neutral items	0.987	0.956, 1.019	144	143	0.975	0.924, 1.028	137	134
Moderation items	0.845***	0.829, 0.861	957	836	0.952**	0.920, 0.986	768	737
Food								
Healthy items	1.039***	1.021, 1.057	466	489	0.961*	0.930, 0.992	355	337
Neutral items	0.988	0.961, 1.016	70	71	0.926***	0.889, 0.966	57	52
Moderation items	0.982*	0.966, 0.999	404	402	0.935***	0.906, 0.966	329	303
Beverages								
Healthy items	0.997	0.971, 1.025	416	414	0.990	0.938, 1.046	187	182
Neutral items	0.993	0.944, 1.045	78	78	1.020	0.940, 1.107	66	67
Moderation items	0.753***	0.733, 0.774	617	470	0.970	0.928, 1.015	366	349
<i>Expenditure per household per month, \$</i>								
Total food & beverages								
Healthy items	0.988	0.972, 1.005	83	82	0.966*	0.935, 0.998	66	65
Neutral items	0.782***	0.742, 0.823	32	25	0.857***	0.816, 0.901	18	16
Moderation items	0.914***	0.899, 0.930	99	91	0.924***	0.895, 0.954	88	82
Food								
Healthy items	1.031**	1.012, 1.049	67	70	0.965*	0.933, 0.999	54	51
Neutral items	0.974	0.941, 1.007	15	14	0.862***	0.825, 0.901	11	10
Moderation items	0.953***	0.937, 0.970	82	80	0.917***	0.887, 0.947	67	60
Beverages								
Healthy items	0.830***	0.809, 0.851	18	15	0.973	0.924, 1.025	6	6
Neutral items	0.646***	0.594, 0.704	18	12	0.854**	0.764, 0.954	5	4
Moderation items	0.766***	0.745, 0.787	20	16	0.975	0.929, 1.022	12	12

Note: Full model results are available from the authors upon request. Presented are exponentiated coefficients (exp(b)) and 95% confidence intervals for the binary variable indicating the time periods for the WIC panel: pre (Jan–Sept 2009) and post (Jan–Sept 2010) and for the comparison panel: pre (Apr–Sept 2009) and post (Apr–Sept 2010) from separate GEE regression models for longitudinal data with a logarithmic link function (Poisson family); all models included control variables (SNAP, non-food EBT, number of transactions, socio-demographic store area controls).

\*  $p < 0.05$ .\*\*  $p < 0.01$ .\*\*\*  $p < 0.001$ .



however, dominated by purchases of moderation foods (\$82 vs. \$67 for healthy foods); reflecting a higher per-ounce cost of moderation foods such as meats, frozen dinners, desserts. Post-WIC revisions, the volume of healthy food purchased by WIC households went up by 3.9% and expenditures by 3.1%, increasing the share of healthy foods in the overall food basket. The new WIC subsidies for fruit, vegetables and whole grains were responsible for these improvements (see Appendix 4). Reductions in moderation foods were small in volume (1.8%), but larger in expenditure (4.7%), driven mostly by cheese (reduced WIC allowances) and substitution of refined grains with whole grains. In contrast, comparison subjects reduced purchases of healthy foods in 2010 (by 3.5%).

The biggest post-revision improvements in purchases of WIC-participating households were observed for moderation beverages, which declined by 24.7% in volume and 23.4% in expenditures (Table 2). This is consistent with the changes in the WIC food packages that introduced restrictions on milk fat content and replaced whole milk (a moderation item) with low-fat/skim milk (a healthy item) for WIC-participating women and children. As low-fat milk purchases replaced whole milk, the share of less healthy beverages declined from 56% to 49%. This improvement would likely have been even more substantial if reductions in allowances of 100% juice (a healthy item) did not counteract the growth of healthy beverage purchases. No similar improvements were seen for beverage purchases of comparison households.

Interaction tests to understand if the WIC revisions had differential effects on certain WIC households identified a number of significant trends (Table 3). Households shopping in Massachusetts had a larger increase in healthy and neutral beverage volume and a greater decrease in moderation beverage volume, relative to Connecticut trends. This is

likely driven by stricter milk fat restrictions in 2010, not allowing 2% milk (a moderation item) as in Connecticut, but only 1%/skim milk. There was no effect of shopping in stores in lower socio-economic neighborhoods. WIC households also participating in SNAP did not decrease beverage volume purchased (all health types) at the level of WIC households not participating in SNAP. Larger food budgets among SNAP households may insulate them from the effects of the WIC revisions. Households with infants purchased more neutral food volume following WIC revisions and did not reduce moderation beverage volume to the same levels as households without infants.

## 6. Discussion

There are three key findings of our investigation. First, we show that healthy products comprise the largest share of food (but not beverage) purchases among WIC-participating households. Half of the food volume purchased by WIC households was healthy products, while healthy beverages accounted for only 37% of beverage volume before and 43% after the WIC revisions. While there is substantial room for improvement, especially for beverages, it appears that WIC favorably affects the nutritional quality of participant purchases. For example, only 30% of beverage purchases among comparison low-income households were healthy items. This could be an underestimate of WIC's effect due to a history of recent WIC participation in the comparison group. Low-income households that were never exposed to WIC and its nutrition education would probably have a less healthy profile of food purchases and a greater difference with WIC-participating households than the comparison subjects in this study.

**Table 3**

Changes in food and beverage volume purchased after WIC revisions, interaction analysis. Purchases of low-income households, 2009–2010.

	WIC households, state interaction models					
	Post-revision period		State		State * period	
	Exp(b)	95% CI	Exp(b)	95% CI	Exp(b)	95% CI
Food						
Healthy items	1.023	0.990, 1.058	0.862***	0.801, 0.928	1.021	0.983, 1.061
Neutral items	0.964	0.913, 1.018	0.799***	0.732, 0.872	1.035	0.972, 1.101
Moderation items	0.937***	0.907, 0.968	0.864***	0.806, 0.926	1.065**	1.026, 1.105
Beverages						
Healthy items	0.879***	0.835, 0.926	1.038	0.959, 1.123	1.173***	1.106, 1.245
Neutral items	0.912*	0.838, 0.993	0.824*	0.704, 0.965	1.121*	1.010, 1.243
Moderation items	0.819***	0.784, 0.856	0.864***	0.805, 0.927	0.891***	0.844, 0.940
WIC households, SNAP interaction models						
	Post-revision period		SNAP		SNAP * period	
	Exp(b)	95% CI	Exp(b)	95% CI	Exp(b)	95% CI
Food						
Healthy items	1.050***	1.025, 1.074	1.305***	1.272, 1.339	0.982	0.954, 1.011
Neutral items	0.981	0.944, 1.019	1.433***	1.377, 1.491	1.012	0.966, 1.060
Moderation items	0.973*	0.951, 0.996	1.366***	1.329, 1.403	1.016	0.987, 1.046
Beverages						
Healthy items	0.960*	0.927, 0.993	1.100***	1.064, 1.138	1.071***	1.028, 1.115
Neutral items	0.909**	0.846, 0.977	1.250***	1.160, 1.347	1.161***	1.065, 1.265
Moderation items	0.708***	0.683, 0.734	1.264***	1.224, 1.304	1.103***	1.056, 1.153
WIC households, infant models						
	Post-revision period		Infant		Infant * period	
	Exp(b)	95% CI	Exp(b)	95% CI	Exp(b)	95% CI
Food						
Healthy items	1.041***	1.022, 1.062	1.053***	1.030, 1.077	1.009	0.979, 1.041
Neutral items	1.006	0.979, 1.035	1.478***	1.428, 1.529	1.063*	1.015, 1.113
Moderation items	0.981*	0.963, 0.999	1.052***	1.030, 1.076	1.023	0.992, 1.055
Beverages						
Healthy items	1.015	0.986, 1.046	1.082***	1.052, 1.114	0.963	0.925, 1.002
Neutral items	1.061	0.994, 1.134	1.454***	1.363, 1.551	0.926	0.845, 1.014
Moderation items	0.731***	0.710, 0.752	0.978	0.951, 1.005	1.101***	1.053, 1.151

Note: Full model results are available from the authors upon request. Presented are exponentiated coefficients (exp(b)) and 95% confidence intervals for the binary variable indicating the time periods for the WIC panel: pre (Jan–Sept 2009) and post (Jan–Sept 2010).

\*  $p < 0.05$ .

\*\*  $p < 0.01$ .

\*\*\*  $p < 0.001$ .

Second, we show that the WIC revisions increased the proportion of healthy purchases, particularly for beverages, and the overall healthfulness of the product basket purchased by WIC households improved following the WIC revisions. Lack of similar changes for comparison low-income households suggests a causal impact of the WIC revisions. The observed improvements appear to align with the changes in the revised WIC packages, including reduced allowances of whole milk, cheese, juice and new allowances for fruit and vegetables and whole grain products. At the same time, participants did not start to purchase more of non-WIC moderation foods, such as sugar-sweetened beverages, sweet baked goods, added sugars, and meats.

Finally, for a large grocery chain in two New England states, we show a post-revision reduction in total food purchases among WIC-participating households, driven entirely by lower beverage purchases and purchases using WIC. Reduced allowances of infant formula, milk and juice in the new WIC packages appear to account for the observed decline in WIC-paid and total purchases. The effect on the grocery chain from reduced WIC purchases is unknown.

## 7. Limitations

Data were from two New England states that might differ from other states. Lack of household socio-demographic characteristics is another limitation, yet all households were WIC participants at some point and therefore low-income. The comparison group of former WIC participants could lead to underestimating differences with WIC households as they might have benefited from WIC nutrition education. Finally, the study assessed purchase behaviors at a single grocery chain, which did not include household purchases across all food stores and may not represent overall diets of WIC participants. Our study did not evaluate actual food intake and body weight outcomes. At the same time, there are a number of unique strengths, including detailed purchase data for over 2100 WIC-participating families in the pre-post revision period, which is linked to nutritional information on foods and beverages purchased and the method of payment used in each transaction. Importantly, our findings of the improved healthfulness of the product basket purchased by WIC participants are consistent with research on the dietary impact of the WIC revisions. Multiple studies to date, including national samples of preschool children, showed that dietary quality of WIC participants improved following implementation of the WIC revisions (Schultz et al., 2015; Tester et al., 2016; Spaulding et al., 2014; Whaley et al., 2012; Chiasson et al., 2013; Kong et al., 2014).

## 8. Conclusion

The revisions of the WIC food packages have improved the healthfulness of the product basket purchased by WIC participants. Healthier food purchases are likely to reflect healthier eating patterns and diet improvements. If sustained, these changes might have significant long-term effects on health care costs and productivity. Given the cost-neutral design of the WIC revisions, the current and future benefits to WIC participants could produce impressive return on investment for taxpayers. The “lessons learned” from the WIC food package revisions may be important to updating other federal food assistance programs. Understanding all of the intended and unintended consequences of the 2007 revisions will be essential in drafting the next round of the WIC food package revisions, expected within next several years.

## Conflict of interest

The authors declare no conflict of interest with this study.

## Funding disclosure

This manuscript was supported by a grant from the Institute for Research on Poverty (IRP) (547K514) RIDGE Center for the National Food

and Nutrition Assistance Research program. The content is solely the responsibility of the authors and does not necessarily represent the official views of the IRP, RIDGE or USDA.

## Transparency document

The [Transparency document](#) associated with this article can be found, in the online version.

## Acknowledgement

The authors express special thanks to the confidential grocery store chain for sharing their data. The authors appreciate helpful suggestions from the two anonymous reviewers, as well as Elizabeth Frazao and Andrea Carlson (USDA ERS).

## Appendix 1. Supplementary data

Supplementary data to this article can be found online at <http://dx.doi.org/10.1016/j.ypmed.2016.08.018>.

## References

- Altarum Institute, 2010. Obesity Prevention Mission Project Information: Evaluation of Women, Infants and Children (WIC) Vendor Changes in Response to the New WIC Food Package. Available from <http://www.altarum.org/research-initiatives-health-systems-health-care/improving-human-health-systems-mission-projects/childhood-obesity-project-info>.
- Andreyeva, T., Luedicke, J., 2013. Revisions to the WIC food packages and effects on purchases of whole grain products. *Am. J. Prev. Med.* 45 (4), 422–429.
- Andreyeva, T., Luedicke, J., 2014. Incentivizing fruit and vegetable purchases among participants in the Women, Infants, and Children Program. *Publ. Health Nutr.* 1–9 May 9.
- Andreyeva, T., Blumenthal, D.M., Schwartz, M.B., Long, M.W., Brownell, K.D., 2008. Availability and prices of foods across stores and neighborhoods: the case of New Haven, Connecticut. *Health Aff. (Millwood)* 27, 1381–1388.
- Andreyeva, T., Luedicke, J., Middleton, A.E., Long, M.W., Schwartz, M.B., 2012. Positive influence of the revised special supplemental nutrition program for women, infants, and children food packages on access to healthy foods. *J. Acad. Nutr. Diet.* 112, 850–858.
- Andreyeva, T., Luedicke, J., Tripp, A.S., Henderson, K.E., 2013. Effects of reduced juice allowances in food packages for the women, infants, and children program. *Pediatrics* 131 (5), 1–9.
- Andreyeva, T., Luedicke, J., Henderson, K.E., Schwartz, M.B., 2014. The positive effects of the revised milk and cheese allowances in the special supplemental nutrition program for women, infants and children. *J. Acad. Nutr. Diet.* 114 (4), 622–630.
- Block, D., Kouba, J., 2006. A comparison of the availability and affordability of a market basket in two communities in the Chicago area. *Public Health Nutr.* 9, 837–845.
- Booth, S.L., Sallis, J.F., Rittenbaugh, C., Hill, J.O., et al., 2001. Environmental and societal factors affect food choice and physical activity: rationale, influences, and leverage points. *Nutr. Rev.* 59, S21–S39.
- Bowman, S.A., Clemens, J.C., Friday, J.E., Thoeig, R.C., Moshfegh, A.J., 2014. Food Patterns Equivalents Database 2005–06: Methodology and User Guide. Food Surveys Research Group, Beltsville Human Nutrition Research Center, Agricultural Research Service, USDA, Beltsville, MD. Available at <http://www.ars.usda.gov/ba/bhnrc/fsrg>.
- Carlson, A., Frazão, E., 2012. Are Healthy Foods Really More Expensive? It Depends on How You Measure the Price, EIB-96. U.S. Department of Agriculture, Economic Research Service May.
- Chiasson, M.A., Findley, S.E., Sekhobo, J.P., et al., 2013. Changing WIC changes what children eat. *Obesity* 21, 1423–1429.
- Dubowitz, T., Heron, M., Bird, C.E., Lurie, N., et al., 2008. Neighborhood socioeconomic status and fruit and vegetable intake among whites, blacks, and Mexican Americans in the United States. *Am. J. Clin. Nutr.* 87, 1883–1891.
- Gladson. Nutrition database, 2011. Available from <http://www.gladson.com/SERVICES/NutritionDatabase/tabid/89/Default.aspx> obtained through TPA with USDA ERS.
- Hardin, J.W., Hilbe, J.M., 2003. Generalized Estimating Equations. Boca Raton, FL, Chapman & Hall/CRC.
- Havens, E.K., Martin, K.S., Yan, J., Dauser-Forrest, D., Ferris, A.M., 2012. Federal nutrition program changes and healthy food availability. *Am. J. Prev. Med.* 43 (4), 419–422.
- Hillier, A., McLaughlin, J., Cannuscio, C.C., Chilton, M., Krasny, S., Karpyn, A., 2012. The impact of WIC food package changes on access to healthful food in 2 low-income urban neighborhoods. *J. Nutr. Educ. Behav.* 44, 210–216.
- Information Resources Inc. Nutrition Data, 2014. <http://www.iriworldwide.com> obtained through TPA with USDA ERS.
- Institute of Medicine for the National Academies, 2005. WIC Food Packages: Time for a Change Washington, DC.
- Kong, A., Odoms-Young, A.M., Schiffer, L.A., 2014. The 18-month impact of Special Supplemental Nutrition Program for Women, Infants, and Children food revisions on diets of recipient families. *Am. J. Prev. Med.* 46 (6), 543–551.

- Langellier, B., Chaparro, P., Wang, M., Koleilat, M., Whaley, S., 2014. The new food package and breastfeeding outcomes among women, infants, and children participants in Los Angeles County. *Am. J. Public Health* 104, S112–S118.
- Lovasi, G.S., Hutson, M.A., Guerra, M., Neckerman, K.M., 2009. Built environments and obesity in disadvantaged populations. *Epidemiol. Rev.* 31, 7–20.
- May, A., Pan, L., Sherry, B., et al., 2013. Vital Signs: Obesity Among Low-Income, Preschool-Aged Children—United States, 2008–2011. *62 Morbidity and Mortality Weekly Report* 31.
- Nichols, A., 2012. Regression for Nonnegative Skewed Dependent Variables. BOS10 Stata Conference 2 Stata Users Group 2010. Available at [http://repec.org/bost10/nichols\\_boston2010.pdf](http://repec.org/bost10/nichols_boston2010.pdf).
- Ogden, C.L., Carroll, M.D., Kit, B.K., Flegal, K.M., 2014. Prevalence of childhood and adult obesity in the United States, 2011–2012. *JAMA* 311 (8), 806–814.
- Ogden, C.L., Carroll, M.D., Lawman, H.G., Fryar, C.D., Kruszon-Moran, D., Kit, B.K., Flegal, K.M., 2016. Trends in obesity prevalence among children and adolescents in the United States, 1988–1994 through 2013–2014. *JAMA* 315 (210), 2292–2299.
- Oliveira, V., Frazão, E., 2015. The WIC Program: Background, Trends, and Economic Issues, 2015 Edition. EIB-134. U.S. Department of Agriculture, Economic Research Service January.
- O'Malley, K., Luckett, B.G., Dunaway, L.F., Bodor, J.N., Rose, D., 2014. Use of a new availability index to evaluate the effect of policy changes to the special supplemental nutrition program for women, infants, and children (WIC) on the food environment in New Orleans. *Public Health Nutr.* 18 (1), 1–8.
- Powell, L.M., Slater, S., Mirtcheva, D., Bao, Y., Chaloupka, F.J., 2007. Food store availability and neighborhood characteristics in the United States. *Prev. Med.* 44, 189–195.
- Schultz, D.J., Byker Shanks, C., Houhtaling, B., 2015. The impact of the 2009 Special Supplemental Nutrition Program for Women, Infants, and Children food package revisions on participants: a systematic review. *J. Acad. Nutr. Diet.* 115 (11), 1832–1846.
- Sekhobo, J., Edmunds, L., Whaley, S., Koleilat, M., 2013. Obesity prevalence among low-income, preschool-aged children—New York City and Los Angeles County, 2003–2011. *Morb. Mortal. Wkly Rep.* 62(2).
- Small, M., McDermott, M., 2006. The presence of organizational resources in poor urban neighborhoods: an analysis of average and contextual effects. *Soc. Forces* 84, 28.
- Spaulding, C., Murano, P., Girmaji, A., Paulhill, K., Li, Y., 2014. Using the National Food and Nutrition Survey (NATFAN) to examine WIC participant food choices and intakes before and after changes in the food benefit. Contractor and Cooperator Report No. 82. U.S. Department of Agriculture, Economic Research Service.
- Tester, J.M., Leung, C.W., Crawford, P.B., 2016 May. Revised WIC food packages and children's diet quality. *Pediatrics* 137(50).
- U.S. Census Bureau, 2010. 2006–2010 American Community Survey. U.S. Census Bureau, Washington, DC.
- U.S. Department of Agriculture, 2014a. Special Supplemental Nutrition Program for Women, Infants and Children (WIC): Revisions in the WIC Food Packages; Final Rule. Federal Register Vol. 79(42), March 4. [http://www.fns.usda.gov/sites/default/files/03-04-14\\_WIC-Food-Packages-Final-Rule.pdf](http://www.fns.usda.gov/sites/default/files/03-04-14_WIC-Food-Packages-Final-Rule.pdf) Accessed January 5, 2016.
- U.S. Department of Agriculture, 2014b. Whole Grain Resource for the National School Lunch and School Breakfast Programs A Guide to Meeting the Whole Grain-Rich Criteria. Available at <http://www.fns.usda.gov/sites/default/files/WholeGrainResource.pdf>.
- U.S. Department of Agriculture, 2015. WIC program participation and costs FY <http://www.fns.usda.gov/pd/wic-program> (Accessed January 5, 2016).
- U.S. Department of Agriculture. What We Eat in America. Food Categories, 2001–2010. Available at [http://www.ars.usda.gov/SP2UserFiles/Place/80400530/pdf/0910/food\\_category\\_list.pdf](http://www.ars.usda.gov/SP2UserFiles/Place/80400530/pdf/0910/food_category_list.pdf).
- Vilsack, T., 2011. USDA accomplishments 2009–2011: United States Department of Agriculture.
- Whaley, S.E., Ritchie, L., Spector, P., Gomez, J., 2012. Revised WIC food package improves diets of WIC families. *J. Nutr. Educ. Behav.* 44 (3), 204–209.
- Wilde, P., Wolf, A., Fernandez, M., Collins, A., 2011. Evaluation of the Birth Month Breastfeeding Changes to the WIC Food Packages. U.S. Department of Agriculture, Food and Nutrition Service, Special Nutrition Programs WIC-12-BF.
- Wilde, P., Wolf, A., Fernandes, M., Collins, A., 2012. Food-package assignments and breastfeeding initiation before and after a change in the Special Supplemental Nutrition Program for Women, Infants, and Children. *Am. J. Clin. Nutr.* 96 (3), 560–566.
- Zenk, S.N., Odoms-Young, A., Powell, L.M., et al., 2012. Fruit and vegetable availability and selection: federal food package revisions, 2009. *Am. J. Prev. Med.* 43 (4), 423–428.