Evaluating the Impact of the Revised Special Supplemental Nutrition Program for Women, Infants, and Children Fruit Juice Allotment on Fruit Intake, Dietary Quality, and Energy/Nutrient Intakes among Children 1-4 Years of Age

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Abstract: *Objective*: The goals of this study were to assess the impact of recent changes in the WIC allotment on fruit intake, dietary quality/adequacy, energy/nutrient intakes, and potential impact of the complete removal of 100% fruit juice (FJ) from the package.

Methods: 24-hour recalls from children 1-4 years who were WIC participants or income-eligible nonparticipants in the NHANES 2007-2008 and 2011-2014 (before and after WIC package changes) were analyzed.

Results: There were no differences in the Healthy Eating Index-2015 total score; subcomponent scores for "greens and beans" and for "fatty acid ratio" were higher in 2011-2014 than in 2007-2008 in children participating in WIC; scores for "sodium" were higher in 2011-2014 than in 2007-2008 in children not participating in WIC but income-eligible. In WIC participants mean intakes of riboflavin, vitamins B12 and C, and zinc were significantly ($p<0.01$) lower, and intake of vitamin E was significantly ($p<0.01$) higher in 2011-2014 compared to 2007-2008. One significant difference in nutrient adequacy in children was that of a lower ($p<0.01$) percentage of inadequacy for WIC participants for vitamin E and a higher ($p<0.01$) percentage of inadequacy for WIC participants for vitamin A in 2011-2014 as compared to those in 2007-2008. The elimination of FJ from the WIC food packages resulted in a 38-50% lower total fruit intake and a 4-5% reduction in total HEI-2015 score.

Conclusion: Changes in the WIC program resulted in potential adverse effects on mean intakes of some nutrients but not on the nutrient adequacy or overall diet quality. Confirmatory studies are needed.

Keywords: WIC program, dietary intake, children, NHANES, fruit juice.

INTRODUCTION

Twenty-five percent of children 1-4 years of age (years) will receive the Supplemental Nutrition Program for Women, Infants, and Children (WIC) benefits at some point in their lives [1, 2]. WIC packages were recently revised to offer foods that better reflect current dietary recommendations and promote healthy weight in WIC participants [2]. Revised packages, which were based on monthly allowances for children 1-4 years included the addition of new foods, such as whole-grain cereals one-half of the 1021 gr of allowable breakfast cereal must be whole grain; the addition of $8 of fruit and vegetable cash-value vouchers; reductions in milk from 15,142 mL (16 quarts), 100% fruit juice (FJ) to 3,785 mL (128 fl oz), and to 1 dozen eggs. There was also a switch from whole milk to 2% milk for children 2 years or older and women [2].

Previous studies that assessed changes following WIC policy updates found that the availability and access [3-5] to healthier foods improved after implementation of these new requirements [2]. Other studies found that WIC revisions were associated with significant shifts from higher-to-lower-fat milk, increased intake of whole grains, fruits, and vegetables [6, 7], higher dietary quality [8] improved nutritional profiles of food purchases [9] for WIC participants compared with nonparticipants.

One of the major changes was the change in the maximum monthly allowance for FJ consumption in younger children. A reduction in the quantity of FJ in the WIC food packages was based in part on the assumption that the proposed change would help increase intake of whole fruits and vegetables while still containing food costs [1, 2]. This rationale is consistent with the Dietary Guidelines for Americans (DGA) [10], and Institute of Medicine (IOM) [11] the American Academy of Pediatrics (AAP) recommendations [12]. For children ages 1-3 years, intake of FJ should be limited to, at most, 118 mL daily and for children ages 4-6 years, FJ should be limited to 118-177 mL daily. Therefore, the WIC-proposed maximum monthly allowance of FJ was reduced from 8517 mL to 3785

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mL [1, 2], which amounts to approximately 118 mL of FJ per day/child.

FJ consumption by children has been an especially contentious topic in the literature regarding diet quality [13-15] and weight in children [13, 15]. Specific to FJ consumption among children, the weight of the evidence demonstrates that children are not consuming excessive amounts of FJ [13]. Further, FJ consumption in children has been associated with increased intakes of total fruit servings [13] and improved overall diet quality [14, 15]; finally, FJ consumption has been shown to provide important short-fall nutrients in the diets of children [13-17]. The overwhelming weight of the evidence suggests that consumption of FJ is not associated with obesity in children [16, 17] and contributes to diet quality and nutrient intake[16, 17]. Although these concerns with consumption of FJ is generally unsupported, may be appropriate concerns for some populations and it is appropriate to bring the WIC packages in line with the DGA recommendations, which does set public policy for all federal food distribution/feeding programs.

Few studies [3-6] have looked at the impact of the reduction of FJ availability in the WIC package especially any potential unintended diet/nutritional consequences that could occur as a result of this change to the diet and health of young children. The goal of this study was twofold: 1) to assess the impact of recent changes in the WIC program on fruit intake, dietary quality, and energy/nutrient intakes; and 2) to model the potential impact of complete removal of FJ from the WIC package, which has been proposed by some [18]. Data from the National Health and Nutrition Examination Surveys (NHANES) for 2007-2008 and 2011-2014 (before and after WIC package changes, respectively) were used for these analyses of children 1-4 years.

METHODS

Dietary data from NHANES 2007-2008, 2011-2012, and 2013-2014 were used; however, those with unreliable data determined by the United States Department of Agriculture (USDA) were excluded (n=336) and, as were those missing WIC status or ineligible for it (n=1,184). The analyses were performed on two groups of children 1-4 years: a) WIC participants and those who were income-eligible (poverty income ratio [PIR] $\leq$ 1.85) but nonparticipants at the time of the interview. A key comparison of interest was whether there were any changes in the intake when examining pre- and post-changes to the WIC program (to increase sample size, the data for NHANES 2011-2012 and 2011-2014 were combined for post-change examination).

Twenty-four hour dietary recalls for all foods and beverages were obtained from proxies for children in both groups [19]. Usual intakes (UI) of total energy, macronutrients (protein, total fat, saturated fatty acids [SFA], carbohydrates, and dietary fiber), vitamins (A, B6, B12, C, D, and E; thiamin; riboflavin; niacin; and folate) and minerals (calcium, phosphorus, magnesium, iron, zinc, sodium, and potassium) and select food groups (total fruit, whole fruit, and fruit servings from FJ from the Food Pattern Equivalents Databases [FPED]) [20] were estimated using the National Cancer Institute [NCI] method) [21]. The NCI macros (Mixtran and Distrib) were used to generate parameter effects after covariate adjustments and to estimate the distribution of UI. The one part NCI model was used for energy and nutrients since these substances are consumed on most days by most subjects; the two part model (probability and amount) was used for food groups given these are consumed episodically. Covariates for these analyses were the day of the week of the 24-hr recall [coded as weekend (Friday-Sunday) or weekday (Monday-Thursday)] and sequence of dietary recall (first or second); variance estimates were obtained using the two days of intake with one-day sampling weights. Nutrient adequacy was determined as percentage below the Estimated Average Requirement (EAR) using the cut-point method; the percentage above the Adequate Intake (AI), when appropriate was also determined [22, 23]. Usual diet quality was also assessed using the Healthy Eating Index (HEI)-2015 with total and subcomponent scores using two days of diet quality estimates with NCI methods described above [24, 25]. SAS 9.2 and SUDAAN 11 were used for all analyses. NHANES survey weights, strata and primary sampling units (PSUs) were used in all analyses [26].

Finally, one set of modeling approaches were conducted where 100% of FJ (food codes 612X, 641X, 6720X, 6721X; all food codes listed in the Appendix) was replaced with water. Using the first day of dietary recall intake of total energy, macronutrients, energy-adjusted vitamins and minerals, total HEI-2015 score, and HEI-2015 subcomponents was also assessed with this modeled scenario.

Analyses were conducted within NHANES 2007-2008 and within NHANES 2011-2014, and then regression analyses were used to assess whether changes in the WIC program have influenced results by using NHANES cycle as an independent variable and assessing whether an interaction existed between cycle (2007-2008 and 2011-2014) and WIC participation with age and race/ethnicity as covariates. If the interaction term was significant, there was a difference due to changes in the WIC program. Statistical comparisons, primarily of WIC participation versus income-eligible nonparticipation, were conducted using z-scores. A significant p-value was set at p<0.01 (this conservative p-value was used given a large number of comparisons evaluated).

RESULTS

The sample size for children 1-4 years (n=1,701) was comprised of WIC participants (n=1,156) and WIC-eligible nonparticipants (n=545). There were no differences in intake of total fruit, fruit from FJ, or whole fruit cup equivalents between children in NHANES 2007-2008 and 2011-2014 in either group of children (Figure **1**).

There were no differences in HEI-2015 total score between children in NHANES 2007-2008 and 2011-2014 regardless of whether participating in WIC or not participating in WIC but income-eligible. However, subcomponent scores for “greens and beans” and for “fatty acid ratio” were higher in 2011-2014 than in 2007-2008 in children participating in WIC; and scores for “sodium” were higher in 2011-2014 than in 2007-2008 in children not participating in WIC but income-eligible; all other subcomponent scores were similar (Table **1**).

There were no differences in total energy intake or intake of macronutrients before or after the changes in the WIC package in children regardless of WIC participation and not participating in WIC but income eligible (data not shown). In children participating in WIC, mean intakes of riboflavin (1.77 ± 0.04 vs. 1.99 ± 0.06 mg/d), vitamin B12 (4.20 ± 0.12 vs. 4.84 ± 0.17 mcg/d), vitamin C (93.3 ± 4.42 vs. 126 ± 10.79 mg/d) and zinc (7.71 ± 0.20 vs. 8.48 ± 0.22 mg/d) were significantly (p<0.01) lower, and intake of vitamin E (4.98 ± 0.18 vs. 4.19 ± 0.22 mg/d) was significantly (p<0.01) higher in 2011-2014 as compared to 2007-2008. There were no significant differences in intake of other micronutrients over time in income-eligible nonparticipating children (Table **2**).

The only significant difference in nutrient adequacy before or after the changes in the WIC package in children was that of a lower (p<0.01) percentage of inadequacy for WIC participants for vitamin E (60.60 ± 3.75 vs. 76.21 ± 4.60 %) and a higher (p<0.01) percentage of inadequacy for WIC participants for vitamin A (1.69 ± 0.55 vs. 0.06 ± 0.11 %) in 2011-2014 as compared to those in 2007-2008 (Table **3**).

A separate analysis was performed to assess the impact of the interaction of WIC participation and time. While it was shown that there were significant

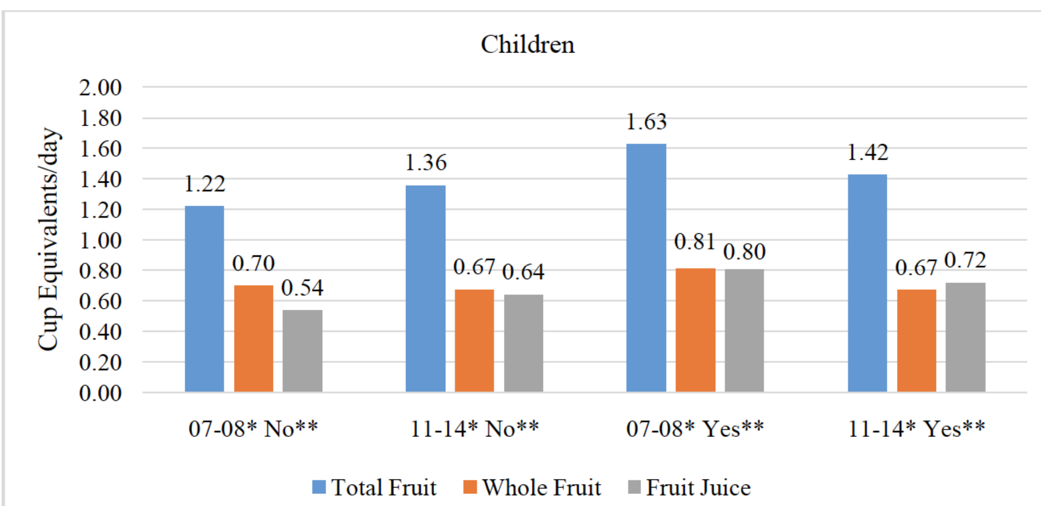

Figure 1: Total Fruit, Fruit from 100% Juice, and Whole Fruit Usual Intake Consumption.

*Data source: NHANES 2007-2008 and 2011-2014 (before and after changes in Women, Infants and Children feeding program); usual intake estimated using the National Cancer Institute method.

**No differences in any measure of fruit intake across NHANES cycles for WIC participants (Yes) or for income-eligible nonparticipants (No) as assessed by z-scores with p<0.01 deemed significant.

Table 1: Total HEI-2015 and Subcomponent Scores of Children (2-4 Years) Who Were WIC Participants and Income-Eligible Nonparticipants

Variable	Usual Intake of WIC Participants (n= 1,156)						Usual Intake of WIC-Eligible Nonparticipants (n= 545)					
	2007-2008	SD	2011-2014	SD	Difference	P value	2007-2008	SD	2011-2014	SD	Difference	P value
HEI-2015 component 1 (total vegetables)	2.05	0.09	2.02	0.08	-0.02	0.8611	2.17	0.09	1.93	0.15	-0.25	0.1663
HEI-2015 component 2 (greens and beans)	0.67	0.09	1.07	0.09	0.40	**0.0023**	0.71	0.15	0.91	0.18	0.20	0.3915
HEI-2015 component 3 (total fruit)	3.74	0.10	3.61	0.08	-0.13	0.3147	3.27	0.14	3.46	0.15	0.19	0.3594
HEI-2015 component 4 (whole fruit)	3.05	0.13	2.95	0.11	-0.11	0.5219	2.87	0.24	2.91	0.18	0.05	0.8728
HEI-2015 component 5 (whole grains)	2.04	0.19	2.60	0.17	0.55	*0.0306*	1.92	0.32	2.60	0.20	0.68	0.0695
HEI-2015 component 6 (dairy)	8.76	0.24	8.30	0.15	-0.46	0.1033	8.08	0.32	8.05	0.28	-0.03	0.9482
HEI-2015 component 7 (total protein foods)	3.28	0.09	3.39	0.09	0.11	0.3972	3.55	0.12	3.15	0.18	-0.40	0.0671
HEI-2015 component 8 (seafood and plant protein)	1.20	0.11	1.42	0.12	0.22	0.1822	1.24	0.25	1.37	0.17	0.12	0.6826
HEI-2015 component 9 (fatty acid ratio)	2.24	0.17	3.18	0.18	0.94	**0.0002**	2.77	0.26	3.04	0.26	0.27	0.4600
HEI-2015 component 10 (sodium)	6.04	0.24	6.12	0.14	0.08	0.7720	4.91	0.28	6.32	0.30	1.42	**0.0005**
HEI-2015 component 11 (refined grain)	7.00	0.26	6.60	0.16	-0.40	0.1948	6.01	0.31	6.38	0.22	0.37	0.3235
HEI-2015 component 12 (saturated fat)	4.49	0.16	5.03	0.23	0.54	0.0514	4.77	0.47	5.36	0.36	0.59	0.3184
HEI-2015 component 13 (added sugar)	7.38	0.21	7.63	0.18	0.25	0.3695	6.23	0.24	6.67	0.25	0.44	0.2055
HEI-2015 total score	51.78	0.78	53.78	0.46	2.00	*0.0276*	48.38	0.98	51.94	1.06	3.56	*0.0135*

Data source: NHANES 2007-2008 and 2011-2014 (before and after changes in Women, Infants and Children feeding program); Healthy Eating Index (HEI) – 2015 was assessed using usual intake with HEI calculated for both days of dietary intake with differences assessed using z-scores with $p<0.01$ deemed significant.

Table 2: Usual Intake of Energy and Micronutrient Intake in Children Who Were WIC Participants and Income-Eligible Nonparticipants

Variable	Usual Intake of WIC Participants (n= 1,156)						Usual Intake of WIC Eligible Non Participants (n= 545)					
	2007-2008	SD	2011-2014	SD	Difference	P value	2007-2008	SD	2011-2014	SD	Difference	P value
Calcium (mg)	1080	34.63	989	28.56	-91	*0.0426*	898	53.11	929	49.65	31	0.6723
Folate, DFE (mcg)	408	12.21	388	12.53	-20	0.2575	403	16.83	375	13.29	-29	0.1828
Iron (mg)	11.1	0.32	10.9	0.31	-0.2	0.6000	10.8	0.35	10.4	0.39	-0.3	0.5238
Magnesium (mg)	192	4.50	193	3.88	1	0.8708	182	6.14	185	6.93	3	0.7077
Niacin (mg)	14.5	0.36	14.4	0.35	-0.1	0.8393	14.7	0.51	14.7	0.53	-0.1	0.9452
Phosphorus (mg)	1073	26.65	1060	21.84	-13	0.7084	1027	48.67	1023	39.56	-4	0.9478
Potassium (mg)	2055	50.31	1993	39.63	-62	0.3363	1838	69.98	1887	72.17	49	0.6237
Riboflavin (vitamin B2) (mg)	1.99	0.06	1.77	0.04	-0.22	**0.0008**	1.84	0.08	1.70	0.06	-0.13	0.1984
Sodium (mg)	2157	66.47	2050	41.23	-107	0.1706	2325	85.00	2060	67.85	-265	*0.0148*
Thiamin (vitamin B1) (mg)	1.21	0.03	1.16	0.02	-0.04	0.2628	1.22	0.04	1.16	0.04	-0.05	0.3519
Total folate (mcg)	289	7.51	280	7.86	-10	0.3816	286	10.93	268	8.25	-18	0.1994
Vitamin A, RAE (mcg)	596	21.23	557	13.88	-38	0.1335	573	34.28	511	22.20	-62	0.1292
Vitamin B12 (mcg)	4.84	0.17	4.20	0.12	-0.64	**0.0017**	4.33	0.29	4.14	0.19	-0.19	0.5825
Vitamin B6 (mg)	1.39	0.04	1.36	0.03	-0.04	0.4887	1.29	0.06	1.30	0.05	0.02	0.8477
Vitamin C (mg)	126	10.79	93.3	4.42	-33.1	**0.0045**	87.8	10.54	77.7	4.18	-10.1	0.3730
Vitamin D (D2 + D3) (mcg)	7.75	0.39	7.21	0.24	-0.54	0.2395	5.89	0.50	6.54	0.36	0.65	0.2929
Vitamin E as alpha-tocopherol (mg)	4.19	0.22	4.98	0.18	0.79	**0.0050**	4.45	0.29	5.01	0.21	0.57	0.1112
Zinc (mg)	8.48	0.22	7.71	0.20	-0.77	**0.0093**	7.78	0.34	7.74	0.26	-0.04	0.9198

Data source: NHANES 2007-2008 and 2011-2014 (before and after changes in Women, Infants and Children feeding program); usual intake estimated using the National Cancer Institute method.
Differences assessed by z-scores with p<0.01 deemed significant.

Table 3: Percentage of the Population Below the Estimated Average Requirement (EAR) in Children Who Were WIC Participants and Income-Eligible Nonparticipants

Variable	% Below EAR of WIC Participants (n= 1,156)						% Below EAR of WIC Income-Eligible Nonparticipants (n= 545)					
	2007-2008	SD	2011-2014	SD	Difference	P value	2007-2008	SD	2011-2014	SD	Difference	P value
Calcium (mg)	5.06	1.36	10.21	2.24	5.15	*0.0494*	18.49	4.19	16.32	3.27	-2.17	0.6831
Folate, DFE (mcg)	0.29	0.20	0.36	0.22	0.07	0.8205	0.37	0.76	0.20	0.34	-0.16	0.8435
Iron (mg)	1.37	0.33	1.80	0.38	0.43	0.3860	0.73	0.59	1.25	0.78	0.52	0.5919
Magnesium (mg)	0.55	0.35	0.13	0.11	-0.42	0.2583	1.16	0.98	0.81	0.60	-0.35	0.7604
Niacin (mg)	0.15	0.16	0.40	0.21	0.24	0.3497	0.06	0.23	0.01	0.08	-0.06	0.8194
Phosphorus (mg)	0.16	0.17	0.02	0.03	-0.14	0.4207	0.11	0.16	0.07	0.07	-0.04	0.8234
Riboflavin (vitamin B2) (mg)	0.00	0.01	0.01	0.01	0.01	0.3759	0.01	0.03	0.00	0.00	0.00	0.8721
Thiamin (vitamin B1) (mg)	0.01	0.03	0.17	0.10	0.17	0.1205	0.25	0.48	0.00	0.06	-0.24	0.6160
Vitamin A, RAE (mcg)	0.06	0.11	1.69	0.55	1.63	**0.0039**	1.46	1.71	0.68	0.86	-0.78	0.6818
Vitamin B12 (mcg)	0.00	0.00	0.04	0.04	0.04	0.4266	0.00	0.02	0.00	0.01	0.00	1.0000
Vitamin B6 (mg)	0.07	0.10	0.01	0.03	-0.06	0.5334	0.08	0.16	0.00	0.01	-0.08	0.6280
Vitamin C (mg)	0.79	0.43	0.15	0.12	-0.64	0.1539	2.23	2.19	0.86	0.77	-1.38	0.5538
Vitamin D (D2 + D3) (mcg)	79.65	4.40	82.33	2.18	2.68	0.5850	92.79	3.77	89.14	3.85	-3.65	0.4987
Vitamin E as alpha-tocopherol (mg)	76.21	4.60	60.60	3.75	-15.61	**0.0085**	78.37	6.73	62.97	6.30	-15.40	0.0947
Zinc (mg)	0.11	0.12	0.10	0.12	-0.01	0.9552	0.12	0.21	0.15	0.24	0.03	0.9317

Data source: NHANES 2007-2008 and 2011-2014 (before and after changes in Women, Infants and Children [WIC] feeding program); usual intake estimated using the National Cancer Institute method; percentage of the population below the EAR was determined with the probability method.
Differences assessed by z-scores with $p<0.01$ deemed significant.

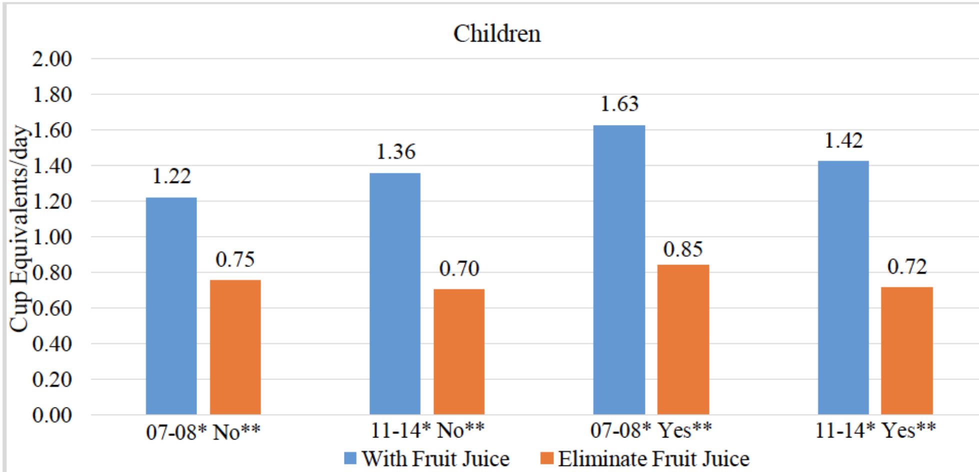

Figure 2: Impact on Usual Intake of Total Fruit With and Without 100% Fruit Juice Removed.

*Data source: NHANES 2007-2008 and 2011-2014 (before and after changes in Women, Infants and Children feeding program); usual intake was estimated using the National Cancer Institute method before and after removing intake of 100% fruit juice.

**Removal of 100% fruit juice resulted in a reduction of 38-50% of total fruit intake.

differences in certain variables from 2007-2008 and 2011-2014, the results in these tables assess whether there were differences based on WIC participation over time (e.g., did changes in WIC program have an impact independent of the effect of time?). In children, there were no significant (p<0.01) differences due to changes in the WIC program independent of time (data not shown).

The elimination of FJ from the WIC food packages resulted in a dramatic drop in total fruit intake; total fruit intake was 38-50% lower (Figure **2**). Removal of FJ resulted in only a 4-5% reduction in the total HEI-2015 score (Figure **3**) and had only a modest impact on total energy intake (3.8-6.4% reductions).

No effects on protein, total fat, or SFA intakes due to the removal of FJ were seen; reductions in carbohydrates (7.1-12.0% reductions) and dietary fiber (3.0-4.9% reductions) were observed. Elimination of FJ in WIC participants resulted in reductions of about 5% or more in calcium (5.8-9.2%), magnesium (5.8-7.8%), potassium (10.9-11.4%), vitamin B6 (4.8-5.1%), and vitamin C (44.8-59.8%) (Data not shown).

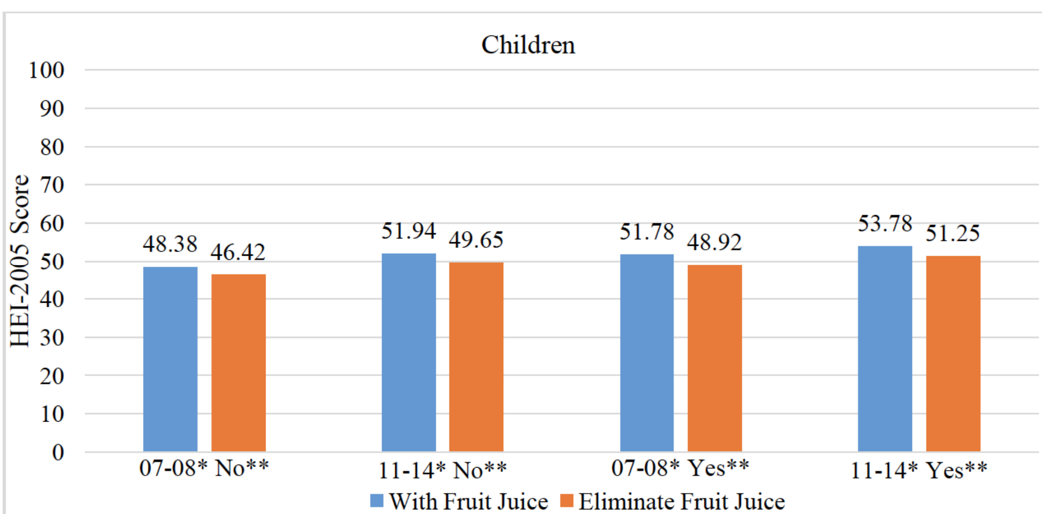

Figure 3: Impact on Total HEI-2005 Score With and Without 100% Fruit Juice Removed.

*Data source: NHANES 2007-2008 and 2011-2014 (before and after changes in Women, Infants and Children feeding program); Healthy Eating Index (HEI) – 2015 was assessed using day one dietary recall data with and without 100% fruit juice removed from recalls.

**Removal of 100% fruit juice resulted in a reduction of HEI of about 4-5%.

DISCUSSION

The USDA–WIC program has been in existence since 1975. It was designed to support the health and nutrition of children up to 5 years and low-income pregnant women [27]. In December 2007, the interim rule revised the WIC benefits package to more closely align with IOM dietary recommendations [11] and the AAP recommendations [12]. Effective October 2009, the changes to WIC included: addition of more whole grains, fruits (particularly whole fruits), and vegetables; a switch toward lower fat milk; and a decrease in allotment of FJ from 8,517 to 3,785 mL per month (from 288 to128 fl oz per day).

Few studies have examined the influence of the revised WIC food allotment on food availability, accessibility, and affordability [3-6]. However, few studies assessed [6-8] dietary intake among WIC participants after the revised WIC package changes were made. The present study provides an updated comparison of the decreased FJ allotment on usual nutrient intake/adequacy and diet quality between WIC participants and income-eligible nonparticipants. This study contributes to the evidence base for future revisions of the FJ allotment in the WIC food package and potential nutritional consequences if FJ was totally removed in future WIC packages. A recent article [18] supports the recommendation to reduce/replace FJ allowances in the WIC program and reallocate those funds in cash-value vouchers to increase whole-fruit consumption.

In the current study, there were no differences in total fruit, fruit from FJ, or whole fruit cup equivalents (cup eq) between children in NHANES 2007-2008 and 2011-2014 in the WIC participants or WIC-eligible nonparticipants. Usual Intake of only five nutrients (vitamins B2, B12, and C and zinc were lower and vitamin E was higher) were significant for WIC participants when comparing UI in 2011-2014 to UI in 2007-2008. Regarding nutrient adequacy, the percentage of WIC participants below the EAR was significantly higher for vitamin A and lower for vitamin E. Additionally, there were no significant ($p<0.01$) differences in variables evaluated due to changes in the WIC program independent of time.

Data from this study showed minor significant changes in diet quality, nutrient intakes, and dietary adequacy between WIC participants and WIC-eligible nonparticipants in 2007-2008 compared to 2011-2014 (before and after WIC package changes). Total diet quality scores increased ($p<0.05$) for both WIC participants and WIC-eligible nonparticipants after the WIC package revisions. Using the HEI-2015, WIC participants (children) had significantly higher usual intake of greens and beans (difference 0.94 points) in 2011-2014 compared to 2007-2008. For WIC participants, the increase in the greens and beans score and the decrease in the fatty acid ratio may in part explain the higher HEI-2015 score in 2011-2014 compared to 2007-2008. The increase in the greens and beans score is similar to that of a previously published article on revised WIC food package and children's diet quality [8]. The increase in the HEI-2015 score for WIC-eligible nonparticipants is in part due to an increase in the sodium score likely due to the non-significant decrease in sodium intake (-26mg/d).

In an effort to better understand the nutrient differences, an analysis (data not shown) was performed looking at differences in intake of certain food groups as defined in the FPED (e.g., vegetables, grains, meats, oils, nuts/seeds) [23]. In addition, given their fortification profiles, we also assessed the intake of ready-to-eat cereal using the definitions in What We Eat in America food category for lower and higher sugar ready-to-eat cereal [28]. WIC participants in 2011-2014 compared to 2007-2008 had higher intakes of lower sugar ready-to-eat cereal and legumes, which may explain the decrease in vitamin B2 and possibly have contributed to differences in intake of vitamins B12, C, and E and zinc. There was an increase in oils but not nuts and seeds among the WIC participants, which may further explain the vitamin E differences. The data also showed a lower meat intake among WIC participants which may explain B12 and zinc differences in 2007-2008 compared to 2011-2014. There were no significant changes in total fruit, whole fruit, or FJ regardless of WIC status. However, removal of FJ resulted in a reduction of HEI-2015 of about 4-5%, suggesting that removal of FJ would have significant impacts on diet quality and nutrient intakes of children.

A final analysis showed no indication that changes over time were associated with WIC program changes because the interaction of time and WIC participation was not significant (data not presented). Assuming that there were costs savings associated with the WIC changes, this appears to be a reasonable tradeoff in that, in general, diet quality and energy/nutrient intakes were not affected.

The 20l5 DGA recognized four nutrients of public health concern (dietary fiber, calcium, vitamin D, and potassium), and another five were identified as shortfall nutrients (vitamins A, C, and E; folate; and magnesium) [29]. In previous research [13, 14, 30], FJ consumption was associated with higher intakes of many of these shortfall nutrients, specifically vitamins A and C, potassium, dietary fiber, and magnesium.

Compared with nonconsumers, the overall nutritional profile of those consuming FJ had significantly higher intakes of energy, vitamins C and B6, potassium, riboflavin, magnesium, iron, and folate and significantly lower intakes of SFA, discretionary fat, and added sugars [13-15, 30, 31]. Consumption of FJ was also specifically associated with higher intake of whole fruit [13, 14, 32]. Most children do not consume the minimum recommended amount of 1 to 2 cup eq (age dependent) of fruit per day [33]. Forty-seven percent of total fruit intake of children comes from FJ [34], and it is a contributor to their total nutrient intake and overall diet quality [13-15, 30-32]. Infrequent intake of fruits during infancy has been associated with infrequent intake of fruits at 6 years [35].

One study [36] showed that replacing FJ with whole fruit resulted in only a limited impact on nutrient intake, with a tradeoff for dietary fiber with vitamin C and total sugars. Therefore, the data support the current AAP recommendation that FJ can be included in the diet and that incorporating FJ in the diet may be an important strategy to getting children closer to meeting the total fruit recommendation. However, health professionals need to monitor FJ consumption, particularly among younger children, to ensure that intakes are not excessive for recommended energy intake. Several reviews of FJ consumption on human health [16, 37] concluded that small amounts of FJ may be part of a healthy diet and current guidelines by the AAP [12] and DGA [10] are prudent and should be followed.

This study had a number of limitations. NHANES is a cross-sectional study; thus, cause-and-effect relationships cannot be determined. Another important limitation is the use of dietary recalls assessing intake in NHANES. Although 24 hour dietary recalls have been recognized as appropriate for providing data to estimate the population mean intakes [38] their limitations are well recognized and need to be considered when drawing conclusions [39]. Participants relied on memory to self-report dietary intakes of their children; therefore, data were subject to non-sampling errors, including under- or over-reporting of total energy intake [40, 41]. Parents reported 24-hour dietary recalls for their children in this study; parents often report accurately what children eat in the home [42] but may not know what their children consume outside the home [43], which could also result in reporting errors [44]. Specific to FJ consumption data, parents may not know whether the FJ consumed was FJ or a blended juice beverage; therefore, data may be subject to additional reporting errors. It is important to recognize that the results from this study do not reflect the effect of FJ consumption specifically, but rather the consumption of FJ within the context of the total diet. The results could reflect other foods consumed throughout the day among FJ consumers compared to nonconsumers. Changes in the WIC Program resulted in potential adverse effects on mean intakes of some nutrients but not on the nutrient adequacy or overall diet quality. More studies are needed to confirm these findings.

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AUTHOR CONTRIBUTIONS

VLF was responsible for the principal analysis of the data. TAN and CO'N also reviewed the data. TAN was responsible for drafting the initial manuscript. VLF and CO'N reviewed the manuscript and their revisions were incorporated for the final draft.

CONFLICTS OF INTEREST

Aside from the information above on funding support, the authors declare no other conflicts of interest.

ABBREVIATIONS

WIC	=	Women, Infant and Children
FJ	=	Fruit juice
NHANES	=	National Health and Nutrition Examination Survey
HEI	=	Healthy eating index
DGA	=	Dietary guidelines for Americans
IOM	=	Institute of Medicine
AAP	=	American Academy of Pediatrics
USDA	=	United States Department of Pediatrics
PIR	=	Poverty income ratio
UI	=	Usual intake
SFA	=	Saturated fatty acids
FPED	=	Food Pattern Equivalents Databases
NCI	=	National Cancer Institute
EAR	=	Estimated Average Requirement
AI	=	Adequate intake

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