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Positive Influence of the Revised Special Supplemental Nutrition Program for Women, Infants, and Children Food Packages on Access to Healthy Foods

Tatiana Andreyeva, PhD; Joerg Luedicke, MS; Ann E. Middleton, MPH; Michael W. Long, MPH; Marlene B. Schwartz, PhD

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ABSTRACT

Background The Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) has important potential for preventing diet-related disease in low-income children. WIC food packages were recently revised to offer foods that better reflect dietary recommendations for Americans.

Objective This article reports on how implementation of the new healthier WIC food packages affected access of low-income populations to healthy foods (eg, whole grains, fruit and vegetables, and lower-fat milk).

Design A pre–post store inventory was completed using a standardized instrument to assess availability, variety, quality and prices of WIC-approved foods (65 food items). Stores were assessed before (spring 2009) and shortly after the new WIC package implementation (spring 2010).

Participants/setting All convenience stores and nonchain grocery stores located in five towns of Connecticut (N=252), including 33 WIC-authorized stores and 219 non-WIC stores.

Statistical analyses performed The healthy food supply score was constructed to summarize postrevision changes in availability, variety, prices of healthy foods, and produce quality. The effect of the WIC food package revisions was measured by differential changes in the scores for stores authorized to accept WIC benefits and stores not participating in WIC, including differences by neighborhood income. Multivariate multilevel regression models were estimated.

Results The 2009 introduction of the revised WIC food packages has significantly improved availability and variety of healthy foods in WIC-authorized and (to a smaller degree) non-WIC convenience and grocery stores. The increase in the composite score of healthy food supply varied from 16% in WIC convenience and grocery stores in higher-income neighborhoods to 39% in lower-income areas. Improved availability and variety of whole-grain products were responsible for most of the increase in the composite score of healthy food supply.

Conclusions Designed as cost-neutral changes, the WIC food package revisions have improved access to healthy foods for WIC participants and society at large.
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FOR MANY AMERICAN FAMILIES, POOR DIET QUALITY and related excess body weight are significant barriers to improving health and prolonging a disease-free life.[1] This is especially true for families of lower socioeconomic status who, compared with more affluent households, are less likely to eat healthy foods, and more likely to overconsume total fat and saturated fat.[2,3] Prior research has shown that the environments in which people make food decisions can affect their diet quality and health. Residents in communities with limited availability of healthy foods are at higher risk for poor nutrition,[4,5] chronic illnesses such as obesity,[6,7] and heart disease.[8,9] Low-income and minority populations are more likely to live in areas with limited supermarket access but numerous fast-food establishments and convenience stores.[10,11] Even when physical access to healthy foods is available, higher prices and poor product quality can pose significant barriers to improving nutrition and health in vulnerable populations.[12-14]

Economic incentives provided in the context of federal food and nutrition assistance programs could be one strategy to expand access to healthy foods in low-income communities. The Supplemental Nutrition Program for Women, Infants, and Children (WIC) provides healthy foods (via WIC food packages), nutrition education, and medical referrals to approxi-

mately 50% of all infants born in the United States and 25% of all American children younger than age 5 years, as well as 29% of pregnant women and 26% of postpartum women in the US population.[15] Because of its broad reach and targeted influence on young high-risk children, WIC has considerable potential for early intervention to prevent excessive weight gain in children of low-income families. Upon recommendations from the Institute of Medicine,[16] the US Department of Agriculture recently revised WIC food packages to offer foods that better reflect dietary recommendations and promote healthy weight in WIC participants.

The main changes included the provision of cash-value vouchers for fruits and vegetables, new whole-grain products, lower fat content of dairy foods, and reduced juice quantities. The revisions allow whole milk for children younger than age 2 years; women and older children can receive 2%, 1%, or skim milk. Participants receive whole-grain/whole-wheat bread and other whole-grain alternatives (eg, whole-grain tortillas and brown rice; this varies by state). At least 50% of WIC-approved cereals are now required to be whole grain. Cash-value vouchers for fruit and vegetables are provided for purchases of any eligible fresh, frozen, or canned fruit and vegetables (eg, white potatoes are not eligible). The revised packages also includes a number of incentives to support breastfeeding.[15] The revisions reflect the most significant WIC package change since the program's inception in 1972 and provide a unique natural experiment to assess the ability of food assistance policy to improve diet quality in children of low-income families.

There is substantial policy interest in how the WIC package changes can influence access to healthy foods, diet quality, and health outcomes in low-income populations. Because WIC-authorized food stores are required to carry the new healthy WIC foods,[15] the food retail landscape can change for all customers. This study was designed to measure the influence of the revised WIC packages on the provision of healthy foods in convenience and grocery stores in the state of Connecticut. A systematic inventory of all food stores in five Connecticut towns was completed before and after the introduction of the revised WIC food packages in October 2009. The policy effect of the WIC food package revisions was measured by differential changes in the composite score of healthy food supply in stores authorized to accept WIC benefits and required to carry new WIC foods and stores not participating in WIC.

METHODS

Town Selection

The study sample frame included all food stores operating in five Connecticut towns. Sampling from the 24 most populated towns in Connecticut, five towns were selected to represent communities of diverse income and food store densities. Specifically, 24 towns were sorted by town median household income (based on US Census data for the year 2000) and grouped into 12 towns with the highest income and 12 towns with the lowest income. Within each income group, towns were further sorted by number of existing food stores (based on 2002 Economic Census data) and grouped into three subgroups among the lower-income towns and two subgroups among the higher-income towns (oversampling lower-income towns). From each of the five subgroups, we selected a town with the number of food stores closest to its subgroup mean. Jointly, the five sampled towns represented nearly 20% of WIC participants in the state.[17] In addition, food stores were included if they were located within 0.5 miles of the selected town's boundaries. A list of Connecticut food retailers was obtained from InfoUSA, Inc, a commercial database provider. (InfoUSA Database of US Businesses; 2008.)

Store Selection and Classification

The following selected Standard Industrial Classification codes were used to identify food stores: Convenience Stores, Delicatessens, Food Markets, Food Products-Retail, Grocers-Retail, Health and Diet Foods, and Fruits and Vegetables-Retail. Pharmacies and specialty stores were not included due to their limited range of foods. Store locations within the sampled boundaries were geocoded using ArcGIS version 9.2 (2000, Environmental Systems Research Institute) and Environmental Systems Research Institute Census 2000 TIGER/Line data for designated towns and census tracts using InfoUSA latitude and longitude coordinates for store locations.

The study identified 313 stores as meeting inclusion criteria at baseline, of which 10 retailers (3%) refused participation. From a total of baseline 303 stores, the 2009 sample included 135 convenience stores (ie, stores selling a medium variety of grocery items in limited amounts), 81 food marts (ie, convenience stores at gas stations), 51 grocery stores (ie, nonchain stores such as bodegas and mom-and-pop stores), and 36 supermarkets (ie, chain grocery stores). Two hundred eighty-nine stores participated in the follow-up in 2010 (13 stores closed, one refusal) with the same store type distribution as in 2009.

Although all types of stores were visited in the sampled towns, this analysis of the WIC revision effects focused on stores other than supermarkets, such as nonchain grocery and convenience stores (including food marts). Supermarkets were excluded from our analysis because healthy foods were available in these stores before the policy change. Stores that changed their WIC authorization status between the two assessments were also excluded (n=7), giving a final analytic sample of 252 stores. About 15% of convenience and grocery stores accepted WIC benefits. Store-reported WIC authorization status was verified using administrative records provided by the Connecticut State WIC agency.

Data Collection

Stores were visited in March through June 2009 (prerevision) and April through June 2010 (postrevision) during work hours between 9 AM and 4 PM on weekdays. Trained raters conducted store inventories using a standardized inventory tool. It followed the assessment methodology of the Nutrition Environment Measures Survey in Stores (NEMS-S) measure that was shown to have a high degree of inter-rater and test–retest reliability.[18] In contrast to NEMS-S, which includes popular food groups, this study focused on WIC-approved foods as proxies for healthy foods. The instrument included all foods from NEMS-S that were WIC-approved (eg, cow's milk, fresh fruit and vegetables, juice, bread, and cereal), but substituted non-WIC foods from NEMS-S (eg, beef, frozen dinners, chips, baked goods, hot dogs, and soda) with WIC foods unavailable in NEMS-S (eg, baby foods, tofu, soy milk, rice, eggs, peanut

butter, dry beans, cheese, canned fish, and canned and frozen fruit and vegetables). In total, food assessment included 65 food items and measured product availability, price, and variety; quality was also assessed for produce that included 10 fruits and 10 vegetables (a copy of the instrument provided upon request). The study was exempt by the university institutional review board as a human subjects study.

STATISTICAL METHODS

Healthy Food Supply Score

The dependent variable of this analysis is a composite score of the healthy food supply in each store. It summarizes data on availability, variety, quality, and prices of healthy foods in one composite measure; results for changes in availability, variety and prices are reported elsewhere.[19] To reflect the main changes in the WIC food packages, the following products were included in the score: cow's milk; soy milk; tofu; fresh, canned, and frozen fruit and vegetables; canned sardines and salmon; whole-grain bread and tortillas; brown rice; and whole-grain cereals (Table 1). The score incorporated several dimensions of the food provision, such as food availability and variety, pricing (milk only) and produce quality. Given the study focus on access to healthy foods (rather than affordability), the score was weighed heavily to reflect food availability and variety (89% of the maximum score).

Scoring was based on the relative significance of foods in healthy diet (as perceived by the authors) and characteristics of the store inventories. The score was largely weighted toward whole grains and fruit and vegetables whose consumption is below recommended levels for many Americans.[16] Fresh fruit and vegetables were weighed greater than frozen and canned fruit and vegetables because lack of produce, not canned vegetables, is a common problem in convenience stores. The thresholds for variety counts and produce quality were based on the data characteristics in our sample. For example, the median count of canned vegetable varieties was five, so stores offering more than five types of canned vegetables received an extra point. Overall, the score could vary from 0 to 31 points with a maximum 13 points for fruit and vegetables (fresh=3.5 points, frozen=2 points, canned=1 point; fruit and vegetables separately), 10 points for whole-grain products (eg, cereals=2 points, bread=3 points, tortillas=2 points, and rice=2 points), milk=4 points, canned sardines/salmon=2 points, and tofu and soy milk=2 points.

Independent Variables

Store-level characteristics included store size measured by number of cash registers (three indicator variables for having one, two, or three or more cash registers). Store authorization to accept the Supplemental Nutrition Assistance Program and WIC benefits was measured by two indicator variables. To assess the food environment surrounding each store, measures of food store and fast-food chain competition were included. For each store in the study, store competition was measured as the distance-weighted density of nonsupermarket stores within a half-mile radius of the store coordinates, measured before and after the program change. The distance-weighted number of stores per square mile, or kernel density, was calculated using a quadratic kernel function in the ArcGIS 9.2 Spatial Analyst software. Kernel density is used to analyze the retail food environment because it provides an intuitive, continuous summary measure of spatial access to food stores that gives a higher weight to stores located closer to the point of interest within the search radius. The difference from a simple density measure is in assigning different weights to each location in the search radius that depends on its proximity to the location of interest. It addresses Tobler's First Law of Geography that "everything is related to everything else, but near things are more related than distant things."[20,21] For example, a store across the street had a greater influence on the kernel density than a store half a mile away.

Similarly, the kernel density of fast-food chain outlets within the same half-mile radius of each store coordinate was constructed. The kernel density was used for fast-food outlets for the same reason as for stores, to give a greater weight to the number of outlets located relatively close to the store for which the measure was assessed. The focus was on the top 20 national fast-food restaurants with the highest US sales in 2009[22] and local fast-food chains (n=533). Supermarket proximity was estimated for each nonsupermarket store (ie, convenience or grocery store) as its distance in thousands of feet to the closest supermarket. Population density per store measured customer traffic as number of census tract residents living in the store census tract. Median household income in a census tract (American Community Survey 2006-2008 estimates) defined neighborhood income in the store location. The cutoff ($39,200) was based on 2008-2009 income eligibility for WIC for a family of four people.[23] Stores located in neighborhoods with median household income >$39,200 were coded as stores operating in higher-income communities.

DATA ANALYSIS

Descriptive statistics and pre–post comparisons in WIC and non-WIC stores and low- and higher-income neighborhoods were computed with χ^2 and t tests. Inter-rater reliability was assessed by calculating percent agreement and κ statistics for stores with two independent assessments.[24,25] Inter-rater reliability data were collected in 16% of stores in 2009 and 26% of stores in 2010. Agreement on product availability was consistently high in both years, ranging from 80% to 100% in 2009 (mean=96%) and 88% to 100% in 2010 (mean=97%) with κ statistics in the range of 0.64 to 1.00. Of 137 items such as food availability, prices, and variety used in the 2009 score construction, 45 items had missing values in several stores. Missing values were fairly infrequent, ranging from 0.3% to 9.4% (median=2.1%). In 2010, 41 items had missing data in several stores ranging from 0.5% to 8% (median=2.8%). Missing values for these items were imputed using valid data from stores that were closest in their propensity of missing information, known as nearest neighbors, given equivalent background characteristics.[26] The first step included estimating a Probit regression model with a binary dependent variable indicating if information was missing. This model was used to predict propensity scores for all stores conditional on the store type, size, and location in a low- vs higher-income neighborhood. In the second step, stores with missing values were matched with their nearest neighbors with valid data (ie, stores with similar propensity scores). Each missing value was replaced with the value from the nearest neighbor.

Table 1. Scoring key for healthy food supply score used to summarize data on availability, variety, quality, and prices of healthy foods

Food	Food inventory characteristic	Points assigned
Cow's milk	Skim milk in stock	0.5
	1% milk in stock	0.5
	2% milk in stock	0.5
	Higher price of whole milk vs any of lower-fat milk	1
	Gallons ratio of lower-fat vs whole milk <0.5	0.5
	Gallons ratio of lower-fat vs whole milk ≥0.5-1.5	1
	Gallons ratio of lower-fat vs whole milk >1.5	1.5
Soy milk	≥1 variety in stock	1
Tofu	≥1 variety in stock	1
Fresh fruit	1-4 varieties in stock	1
	5-9 varieties in stock	2
	≥10 varieties	3
	Average quality[a] <0.5	—[b]
	Average quality[a] ≥0.75	0.5
Fresh vegetables	1-4 varieties in stock	1
	5-9 varieties in stock	2
	≥10 varieties in stock	3
	Average quality[a] <0.5	—[b]
	Average quality[a] ≥0.75	0.5
Frozen fruit	1-2 varieties in stock	1
	≥3 varieties in stock	2
Frozen vegetables	1-2 varieties in stock	1
	≥3 varieties in stock	2
Canned fruit	1 variety in stock	0.5
	≥2 varieties in stock	1
Canned vegetables	1-5 varieties in stock	0.5
	≥6 varieties in stock	1
Canned fish	≥1 salmon variety in stock	1
	≥1 sardines variety in stock	1
Whole-grain/wheat bread	1 variety in stock	1.5
	≥2 varieties in stock	3
Whole-wheat/corn tortillas	1 variety in stock	1
	≥2 varieties in stock	2
Brown rice	1 variety in stock	1
	≥2 varieties in stock	2
Whole-grain cereal	1 variety in stock	1
	2-3 varieties in stock	2
	≥4 varieties in stock	3

[a]Produce quality rated at A, A−, or B is assigned 1; C or D is assigned 0.
[b]Reduce availability score by half to account for poor quality of produce.

Table 2. Descriptive statistics of dependent and independent variables assessed before (2009) and after (2010) revisions to the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) in Connecticut (N=252)

	Year 2009		Year 2010	
Variable	Mean±standard deviation	Range	Mean±standard deviation	Range
Dependent variable				
Healthy food score for all convenience and grocery stores	8.40±5.18	0.50-30.50	9.35±5.49	1.00-28.50
Independent variables				
Time constant (no variation between 2009 and 2010)				
Store accepting WIC benefits, yes/no	0.13±0.34	0-1	—	—
Higher-income area of store location (census tract median household income >$39,200), yes/no	0.60±0.49	0-1		—
Kernel density[a] of fast food chain outlets within 1/2-mile radius of store, number of stores	5.63±6.35	0-27.32	—	—
Number of residents in census tract of store location (in thousands)	1.39±1.08	—	—	
Time varying (assessed in 2009 and 2010)				
Store size (1 cash register), yes/no	0.80±0.40	0-1	0.82±0.39	0-1
Store size (2 cash registers), yes/no	0.17±0.38	0-1	0.15±0.36	0-1
Store size (≥3 cash registers), yes/no	0.03±0.16	0-1	0.03±0.16	0-1
Store accepting SNAP benefits, yes/no	0.54±0.50	0-1	0.60±0.49	0-1
Distance from store location to nearest supermarket, 1,000 ft	3.24±2.46	0.12-16.84	4.37±3.43	0.12-16.84
Kernel density[a] of convenience and grocery stores within 1/2-mile radius of store location, number of chain outlets	12.21±7.84	3.48-36.79	11.70±7.35	3.47-33.80

[a]Kernel density is a weighted number of locations (stores or fast-food chain outlets) based on their proximity to the store for which the measure is assessed.

Multilevel regression modeling techniques were used[27] to model the effect of the WIC package revisions. At the lowest level of analysis, 2009 and 2010 observations were grouped within a store and stores further grouped within neighborhoods. The effect of the WIC revisions was estimated by using a three-level linear random intercept model. The model used to estimate the raw (without covariate adjustments) effect can be written as:

$$Y_{ijk} = \gamma_{000} + \gamma_{010}(WIC_{jk}) + \gamma_{100}(Year_{ijk}) + \gamma_{110}(WIC_{jk}) * (Year_{ijk}) + r_{0jk} + u_{00k} + e_{ijk}$$

in which Y_{ijk} denotes the food score at time i in store j in neighborhood k, γ_{000} represents the intercept (the predicted sample mean for non-WIC stores in 2009), γ_{010} is a parameter estimate for the baseline difference between WIC and non-WIC stores (WIC status),γ_{100} is an estimate of the difference between the two measurement points (Year), and γ_{110} is an estimate of the cross-level interaction of the store WIC status and year of measurement, the main parameter of interest. Differential effects in higher- and lower-income neighborhoods were also estimated via a three-way interaction effect between neighborhood income, store WIC status, and year measurements. There was no significant town variation, so the town effect was not included in modeling. Other covariates were added for control purposes. All models were fitted using Stata Statistical Software version 11.1. (2009, StataCorp).

RESULTS

Table 2 provides descriptive statistics of the dependent and independent variables assessed before (2009) and after the WIC revisions (2010). Most stores were small (one cash register in 80% of stores), accepted Supplemental Nutrition Assistance Program benefits (54% to 60%) and operated in higher-income neighborhoods (60%). The average distance to the closest supermarket was 3,240 feet in 2009 and increased to 4,370 ft in 2010 after several supermarkets closed in the area.

Table 3. Component changes in the healthy food supply score in convenience and grocery stores in Connecticut

	Non-WIC[a] Convenience and Grocery Stores (n=219)			WIC-Authorized Convenience and Grocery Stores (n=33)		
	Unadjusted Average Score			Unadjusted Average Score		
Food component	Year 2009	Year 2010	*P* value[b]	Year 2009	Year 2010	*P* value[b]
Fruit/vegetables (fresh, frozen, canned)	3.22	3.14	0.79	4.29	5.00	0.34
Whole-grain products	2.17	2.80	0.001	2.88	5.56	0.00
Lower-fat milk	2.26	2.17	0.56	1.86	2.11	0.31
Canned fish	0.33	0.33	0.94	0.88	1.24	0.08
Tofu/soy milk	0.18	0.21	0.59	0.06	0.12	0.52
Healthy food supply score	8.16	8.65	0.33	9.97	14.03	0.001

[a]WIC=Special Supplemental Nutrition Program for Women, Infants, and Children.
[b]Difference between mean score components in 2009 and 2010.

For both WIC and non-WIC stores, the healthy food supply score increased about 1 point, from 8.40 to 9.35 ($P<0.05$).

The score changes were different in WIC and non-WIC stores (Table 3). At baseline, WIC stores scored on average 9.97 points vs 8.16 points in non-WIC convenience and grocery stores ($P<0.05$), suggesting better provision of healthy foods. After implementation of the WIC revisions, the score increased to 14.03 ($P<0.001$) in WIC stores but stayed virtually flat at 8.65 points in non-WIC stores (nonsignificant). Improved availability and variety of whole-grain products (eg, whole-grain breads, tortillas, rice, and cereals) accounted for all of the composite score increase in non-WIC stores and most of the score increase in WIC stores.

Table 4 shows results from a set of multilevel regression models estimated for the healthy food supply score with 2 years of repeated observation data on 252 convenience and grocery stores. Model 1 presents the effect of the WIC food package revisions assessed before adding covariates and neighborhood income measures. The baseline difference between WIC and non-WIC stores was almost 2 points ($P<0.05$). The time variable (Year 2010) reflects an average increase in the score for non-WIC stores, which was 0.48 points ($P<0.01$). The effect of the WIC revisions was estimated as an interaction between an indicator for if a store accepted WIC benefits and the year of a postassessment survey (2010). It was a 3.58-point increase ($P<0.001$) in the healthy food supply score. This change amounts to 70% of the standard deviation of the 2009 score in WIC stores. In relative terms, the adjusted score increase of 3.58 points in WIC stores was a 33% improvement whereas a 0.48-point increase in non-WIC stores was 6% (estimated in logarithmic multivariate regressions).

Model 2 adds information on neighborhood income of the store location (nonsignificant). After accounting for neighborhood income, the increase in the healthy food score among WIC stores became more pronounced (coefficient=4.01; $P<0.001$). This is due to overrepresentation of WIC stores in low-income neighborhoods and the steeper score increase in those stores. After controlling for store size (Model 3), a three-level interaction between WIC, time variable and neighborhood income became statistically significant (coefficient=−2.41; $P<0.05$). This means that WIC stores located in low-income neighborhoods scored on average 2.41 points higher than WIC stores in higher-income neighborhoods. This point can also be illustrated in a comparison of unadjusted mean scores by neighborhood income (results not reported). Baseline scores were significantly lower in WIC stores in low-income than higher-income areas (9.21 vs 12.00; $P<0.01$). After the WIC revisions, these scores increased respectively to 13.8 and 14.7 points, significantly narrowing the gap but not eliminating it.

Including all covariates (Model 4) did not change the estimated effects of interest. The WIC revisions increased the healthy food supply score by 4.12 points ($P<0.001$) in WIC stores in lower-income neighborhoods (39% growth), by 1.68 points (calculated as the difference between the coefficients 4.12 and 2.44 in Table 4; $P=0.066$) in WIC stores in higher income neighborhoods (16% growth), and by 0.41 points ($P<0.05$) in non-WIC nonsupermarket stores (4% growth). The difference in change between WIC stores in higher and lower income neighborhoods (coefficient=2.44) remained significant at $P<0.05$.

DISCUSSION

In the state of Connecticut, the implementation of the revised WIC food packages led to a significant increase in the provision of healthy foods such as whole-grain products. This improvement was driven primarily by greater availability and variety of healthy food offerings in WIC-approved convenience and grocery stores, but also by some advances in non-WIC stores. The change occurred shortly after the new WIC policy took effect (6 to 7 months after implementation). This suggests that WIC stores have found ways to deliver new healthy foods when they were required to do so. If the experience in Connecticut is typical of other states, national food policy that promotes consumption of healthy foods, but also requires changes in stores, can help to improve local food environments for program participants and nonparticipants alike. This can occur at no additional cost to taxpayers as the WIC food package revisions were designed to be cost-neutral.

Table 4. Multilevel regression models for the healthy food supply score with 2 years of repeated observation data on 252 convenience and grocery stores in Connecticut

	Model 1	Model 2	Model 3	Model 4
Store accepting WIC[a] benefits (yes/no)	1.99*	2.04*	2.19**	1.99*
Year 2010 (yes/no)	0.48**	0.48**	0.57**	0.41*
Interaction of variables "Store accepting WIC benefits" and "Year 2010"	3.58***	4.01***	4.05***	4.12***
Higher-income area of store location (yes/no)	—	0.11	−0.17	−0.45
Interaction of variables "Store accepting WIC benefits," "Year 2010," and "Higher-income area of store location"	—	−1.61	−2.41*	−2.44*
Store size (2 cash registers) (yes/no)	—	—	3.08***	2.98***
Store size (≥3 cash registers) (yes/no)	—	—	8.34***	7.96***
Store accepting SNAP benefits (yes/no)	—	—	—	1.13**
Distance (in 1,000 ft) to nearest supermarket from store location	—	—	—	1.55***
Distance to nearest supermarket from store location, squared	—	—	—	−0.22**
Distance to nearest supermarket from store location, cubed	—	—	—	0.01**
Kernel density[b] of nonsupermarket stores within 1/2-mile radius of store location	—	—	—	−0.02
Kernel density[b] of fast-food places within 1/2-mile radius of store location	—	—	—	0.11*
No. of residents in census tract of store location (in thousands)	—	—	—	0.31
Constant	8.19***	8.12***	7.48***	3.67**
Standard deviation between districts	1.38	1.41	1.37	0.87
Standard deviation between stores	4.57	4.57	3.72	3.67
Standard deviation within stores	1.93	1.92	1.97	1.94
No. of neighborhoods	82	82	82	82
No. of stores	252	252	252	252
No. of observations	504	504	504	504
Log likelihood	−1,370	−1,369	−1,333	−1,319

[a]WIC=Special Supplemental Nutrition Program for Women, Infants, and Children.
[b]Kernel density is a weighted number of locations (stores or fast-food chain outlets) based on their proximity to the store for which the measure is assessed.
*$P<0.05$.
**$P<0.01$.
***$P<0.001$.

The beneficial changes of the WIC food package revisions were seen in both higher- and lower-income areas, but they were more pronounced in low-income communities. Before the WIC revisions, stores in low-income areas had significantly lower scores of healthy food supply than WIC stores from wealthier areas, but the gap in the scores narrowed notably as a result of the WIC package revisions. This is a welcome change that might help reduce disparities in food access across communities. Limited choices in neighborhood stores are more important for low-income residents without adequate transportation who must rely on the food available in local stores. In earlier research, availability of WIC stores with more healthy snacking options was found to mitigate disparities in the food environment surrounding lower- and higher-income schools.[28]

Although many of the assessed healthy foods (including fresh fruits and vegetables) had better availability following the WIC revisions, the most substantial gains were in the improved availability and variety of whole-grain products. It is of note that compared with other healthy foods, whole-grain products had particularly poor availability in convenience and grocery stores before the WIC revisions,[19] so improve-

ments in their access seem particularly important. If better access to whole-grain products translates into increased consumption, it may help address inadequacies in whole-grain intake in WIC target populations. For example, <5% of US adults consumed the recommended three or more servings of whole grains per day, based on the 1999-2004 National Health and Nutrition Examination Survey data.[29] Increasing whole-grain consumption has been associated with lower risk of excess weight gain and type 2 diabetes.[30,31]

Less notable changes for other healthy foods were likely due to multiple factors, including the baseline differences in food availability. For example, the majority of convenience and grocery stores carried lower-fat milk before the WIC revisions, which could explain modest improvement after the revisions. Similarly, fruit and vegetables had better availability than whole-grain products before the revisions. There were further increases in their availability after the WIC revisions, but their variety improvements were less significant than for whole-grain products.[19] Tofu and soy milk were not part of the mandatory minimum stocking requirements, so few smaller stores chose to carry these products.

Both WIC and non-WIC convenience and grocery stores increased availability of whole-grain products after the WIC revisions, with a larger improvement in WIC stores. One of the beneficial consequences of the WIC food package revisions for all stores was improved access to new WIC foods in supply chains. Wholesalers serving smaller stores usually work with both WIC and non-WIC stores, so the latter group could benefit from increased access to the new foods carried by wholesalers for WIC stores. Because both WIC and non-WIC customers are exposed to new healthy foods in WIC stores, they may start asking for these foods in non-WIC stores. Competition with neighboring stores would ensure that all stores provide foods for which there is demand. It is also possible that improved availability of whole-grain products in non-WIC stores may reflect ongoing trends unrelated to the WIC policy change. For example, stores could be reacting to social awareness of and demand for healthy foods such as whole-grain products. Extensive food marketing of "better for you" foods, including whole-grain product labeling, front package health claims, and other factors might be important as well.

There are several limitations of this study. The assessment of the WIC policy change was for the state of Connecticut. States differed in the implementation of the WIC package revisions (eg, minimum stocking requirements and authorized foods), which could influence the estimated effects. Second, although this study provides an in-depth assessment of the supply-side effect of the WIC food package revisions on food stores, it does not address the affect on food demand among WIC and non-WIC participants. No conclusions can be made about changes in dietary, weight, and health outcomes among WIC participants and low-income populations in general. Although the assessment tool was based on the NEMS-S instrument, this scoring approach has not been validated in other studies. The scoring was heavily focused on fruit and vegetables (42% weight) and whole-grain products (32% weight), so the change in one of these components could significantly affect the overall score. The score was based primarily on availability and variety of healthy foods (only milk prices were included in the score construction). The study focused on convenience and non-chain grocery stores as supermarkets carried all healthy foods before the WIC revisions (based on supermarket inventories, data not reported) and may have had limited potential to improve. Because supermarkets are almost always WIC-authorized, they would not contribute useful information in a stratified model assessing an interaction between time and WIC. Inclusion of supermarkets would have diluted the effect of the WIC revisions.

At the same time, the study has a number of unique strengths, including collection of repeated observations on a large number of food stores for major healthy food categories; a very high response rate (96%); analysis of multiple dimensions of the food environment, such as food availability, variety, prices, and produce quality (results for these outcomes were reported elsewhere)[19]; and use of a "natural experiment" setting for assessing the effect of changes in the WIC food packages.

CONCLUSIONS

These results suggest that policies designed to promote consumption of healthy foods should improve their availability in underserved communities. The recent revisions to the WIC food packages subsidized major healthy foods for women, children, and infants in low-income families. Within 6 to 8 months of the revisions implementation, the provision of healthy foods improved significantly in WIC and (to a smaller degree) non-WIC convenience and grocery stores, especially in low-income neighborhoods. If the experience in Connecticut is typical of other states, the federal policy change that targeted WIC participants has improved access to healthy foods for society at large.

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AUTHOR INFORMATION

T. Andreyeva is director of economic initiatives and a research scientist, J. Luedicke is a biostatistician, and M. B. Schwartz is deputy director and senior research scientist, all at Yale University Rudd Center for Food Policy and Obesity, New Haven, CT. A. E. Middleton is an evaluation consultant in private practice, Brooklyn, NY; at the time of the study, she was a research associate, Yale University Rudd Center for Food Policy and Obesity, New Haven, CT. M. W. Long is a doctoral student, Department of Society, Human Development, and Health, Harvard School of Public Health, Boston, MA.

Address correspondence to: Tatiana Andreyeva, PhD, Yale University Rudd Center for Food Policy and Obesity, 309 Edwards St, New Haven, CT 06520-8369. E-mail: tatiana.andreyeva@yale.edu

STATEMENT OF POTENTIAL CONFLICT OF INTEREST

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