Changes in Access to Healthy Foods after Implementation of the WIC Food Package Revisions

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Abstract

Recent revisions to the food packages provided by the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) added healthy foods and required WIC-authorized stores to make these foods available. This study examined the availability, variety, and prices of healthy foods before and after implementation of the food package revisions in 252 convenience and nonchain grocery stores in Connecticut. The findings provide strong evidence that stores responded to the food package revisions by improving the availability and variety of healthy foods in both urban and suburban settings. Most of these improvements occurred in WIC-authorized convenience and grocery stores, especially those in low-income neighborhoods. Some positive changes in the availability of whole-grain products were also observed in non-WIC convenience and grocery stores. The policy change, which targets WIC participants, improved access to healthy foods for both WIC and non-WIC consumers.

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Executive Summary

Policy changes that target demand and supply of healthy foods could be one strategy to improve access to healthy food in at-risk communities. In December 2007, the USDA revised the WIC food packages to offer participants foods that better reflect the Dietary Guidelines for Americans. These revisions can increase demand for healthy foods from millions of WIC participants and also require WIC-authorized stores to stock these foods. The policy change targeting WIC participants has the potential to improve access to healthy foods for all customers in at-risk communities.

What Did the Study Find?

Implementation of the WIC food package revisions significantly increased the availability and variety of key healthy foods in WIC-authorized convenience and grocery stores in the state of Connecticut. When facing new government regulations to stock certain healthy foods, Connecticut convenience and grocery stores found ways to deliver healthy foods that were previously lacking in their stores and communities. Most improvements in the provision of fruit and vegetables, whole grain products and lower-fat milk occurred in WIC-authorized convenience and grocery stores. Some positive changes in the availability of whole grain products were also observed in non-WIC convenience and grocery stores, potentially due to better access to new WIC healthy foods in supply chains. If the experience in Connecticut is typical of other states, national food policy that incentivizes demand and requires changes in stores can improve the food environment in at-risk communities. This could occur at no additional cost to taxpayers as the WIC food package revisions were designed to be cost-neutral.

The WIC food package revisions had a greater impact on the availability and variety of healthy foods in low-income communities, which is particularly important given the limited transportation options and lack of supermarkets in many low-income neighborhoods. In comparison to WIC stores serving higher-income neighborhoods, WIC stores in lower-income areas had greater improvements in the availability and variety of fruit and vegetables and whole grain products. The same was true for increased shelf-space for lower-fat milk, which helped reduce the large gap by neighborhood income before the revisions. We found no neighborhood differences in prices of three of the most commonly available foods -- eggs, whole milk and canned vegetables. Prices of these products in convenience and grocery stores were unaffected by the WIC revisions.

Store size and SNAP and WIC-authorization status of convenience and grocery stores were positively related to better availability and variety of fruits and vegetables and whole grain products. Larger and WIC-authorized convenience and grocery stores also had more shelf-space for lower-fat milk. Although market competition from other small stores and fast food outlets had a limited effect on the availability, variety and pricing of healthy foods in convenience and grocery stores in our sample, increasing distance from supermarkets predicted greater availability and variety of fruit and vegetables and whole grain products. Given existing literature on the negative impact of convenience stores on

diet quality and obesity risk, this information may be useful to policymakers considering zoning restrictions on these stores as a strategy for improving the community food environment. In the absence of nearby supermarkets, this study found that convenience and non-chain grocery stores serve an important role as suppliers of healthy foods.

How Was the Study Conducted?

This study assessed predictors of access to healthy food, focusing on the impact of the WIC food package revisions on the availability of healthy foods in convenience and grocery stores in Connecticut. Using a standardized questionnaire to assess availability, variety, quality, and prices of WIC-approved foods, the study conducted a systematic inventory of all food stores in five diverse Connecticut towns. The assessment was conducted before and after the introduction of new WIC food packages in October 2009. The policy effect of the WIC food package revisions was measured by differential changes in multiple measures of the provision of healthy foods in252 WIC-authorized and non-WIC convenience and grocery stores. To account for non-random group assignment of the natural experiment setting, the study estimated multilevel random intercept models that isolated contributions of neighborhood, market, and store characteristics. The study further assessed if the WIC food package revisions had a differential impact in communities of various neighborhood income levels.

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Introduction

Prior research has shown that environments in which people make food decisions can affect their diet quality and health. Limited availability of healthy foods can contribute to increased risk for poor nutrition (Booth et al 2001), chronic illnesses like obesity (Larson et al 2009) and heart disease (Diez 2003). The food environment is influenced by multiple economic, social, retail and policy factors. Understanding each factor and their potential interaction is important for creating effective policy change that improves food environments in at-risk communities. In this study we considered several factors that could affect the food environment: (a) the WIC food package revisions as an example of a food policy change, (b) neighborhood attributes, (c) food market characteristics, and (d) store characteristics.

Overview of the WIC Food Package Revisions: One of the nation's largest food assistance programs, the Supplemental Nutrition Program for Women, Infants, and Children (WIC) provides supplemental healthy foods, nutrition education, and medical referrals to approximately 50% of infants, 25% of children less than 5 years of age, 29% of pregnant and 26% of postpartum women in the U.S. In 2009, 9.12 million women, infants, and children were enrolled in WIC nationwide, spending $4.6 billion dollars annually (USDA 2010). In 2007, following recommendations from the Institute of Medicine (IOM, 2005), the USDA issued regulations to revise and implement new WIC food packages by October 1, 2009. A major focus of the revisions was to align WIC benefits with the 2005 Dietary Guidelines for Americans and to offer low-income mothers, children and infants foods that reflect dietary recommendations and promote healthy weight (Oliveira and Frazao, 2009).

Noteworthy changes included additions of new whole grain products and cash-value vouchers for fruits and vegetables as well as reductions in the fat content of WIC approved dairy foods. The revisions also reduced quantities of eggs and cheese as well as eliminated juice from the infant food packages and reduced juice quantities for children and women. A number of incentives to support breastfeeding were included. For example, the new food package delays the introduction of complementary foods to infants from the child's 4^{th} to 6^{th} month; includes jarred baby meats for fully breastfed babies and jarred fruit and vegetables for all babies at 6 months (Oliveira and Frazao, 2009). These revisions will likely increase demand for healthy foods from millions of WIC participants, and lead WIC authorized stores to increase availability of these foods. As food stores are the main delivery system of WIC-approved foods (Oliveira and Frazao, 2009) and required to carry new healthy foods, revisions in the WIC food packages have the potential to improve access to healthy foods for all customers.

Neighborhood Income Effects: While most individuals in the U.S. have reasonable access to healthy food, those with poor access (approximately 2-8% of the U.S. population) are from low-income households, and tend to live in lower-income neighborhoods, marked by racial segregation or low population density (USDA, 2009). Areas with low median household income and minority predominance often have poor

access to healthy foods and higher neighborhood food prices (Horowitz, et al., 2004; Inagami, et al., 2006; Morland, et al., 2002; Sloane, et al., 2003), and, in comparison to suburban and higher income areas, less access to supermarkets and higher densities of fast food outlets and convenience stores (Larson, et al., 2009). Access to a variety of affordable healthy foods is especially problematic for low-income consumers lacking transportation to retailers outside their communities and forced to shop in small local markets (Morland, et al., 2002; Sloane, et al., 2003). Although lower-income families on average spend less on the same foods than high-income families by shopping in supermarkets and large groceries (Broda, et al., 2009, USDA, 2009), the lack of access to affordable healthy foods in many low-income communities is a significant problem.

Economies of scale, technological advancements and increasing market competition drive down prices in supermarkets relative to smaller stores. More recently, nontraditional stores such as mass merchandisers, supercenters, club warehouse and dollar stores have begun to offer even bigger discounts. Compared to traditional supermarkets their expenditure-weighted price discounts in 2004-2006 were on average 7.5 percent ranging from 3 to 28 percent across products (Leibtag, et al., October 2010). About 90% of the Supplemental Nutrition Assistance Program (SNAP) benefits are already spent in large grocery stores and supermarkets (USDA, 2009). Distance to stores does not appear to be a major barrier for low-income shoppers looking for affordable and preferred foods – on average SNAP recipients travel further than the nearest grocery store to purchase food (Ohls, 1999).

Market Competition: Consistent with economic theory, a number of studies have found that increased local market competition leads to lower food prices (Abe and Kawaguchi, 2010; Basker and Noel, 2009; Binkley and Connor, 1998; Cotterill, 1999; Marion, 1998; Stiegert and Sharkey, 2007). A survey of supermarket fresh produce buyers found that local competitive pricing was one of the most common pricing tactics in this volatile product category (McLaughlin, 2004). Still, only a few studies have considered how local competition across store types impacted food pricing and availability. For example, Binkley et al (1998) found supermarket prices to be lower in the face of competition from other supermarkets and warehouse stores, but unrelated to the concentration of small stores. Further, competition from fast food outlets led to lower supermarket prices for some goods (e.g., frozen foods, canned goods, baked goods) and higher prices for others (e.g., fresh produce, fresh meat).

Few studies have assessed how market competition influences the broader food environment and, in particular, small food stores. One study provided empirical support for a theory of market segmentation resulting in a natural oligopoly of high-quality supermarkets providing a broad range of high-quality products and a competitive market of small grocers providing low-price and low-quality products (Ellickson, 2006). However, we did not identify any studies that examined availability and prices of food categories in small food stores based on competition from other small stores, supermarkets or fast food outlets. Because small stores like convenience and non-chain grocery stores are a particularly important part of the food environment for residents of low-income communities who have limited access to transportation to supermarkets,

additional research is needed on the role of market competition in shaping food availability, prices and quality in these stores.

Store Characteristics: Store size and type may be important predictors of availability and prices of healthy foods. For example, store type differences across regions were shown to account for most of the regional and market variation in food prices in the U.S. (Leibtag, 2005, 2008). Controlling for store type and product availability eliminated all differences in food prices by household income (Leibtag, 2005, 2008). Variation in food costs to suppliers by store type influence food availability, quality and prices. Large supermarkets have economies of scale and can use more direct distribution channels. As the retail food market has consolidated in recent years, supermarkets have moved away from supplying fruits and vegetables from regional wholesalers to directly obtaining goods from large product shippers distributing bulk quantities of products (Cook, 2004). This shift may leave small stores with fewer regional direct wholesalers and higher expenses in offering fruit and vegetables (Kaufman, et al., 2000). Few available suppliers could make it harder for small stores to find specific product sizes and brands at affordable wholesale prices, including those specified in the WIC food packages (Oliveira and Frazao, April 2009).

Store surveys comparing market food baskets show that prices are usually higher and healthy foods are less available in convenience versus grocery stores (Glanz, et al., 2007; Kaufman, et al., 1997; Liese, et al., 2007). Chain affiliation also predicts better food availability and lower prices of healthy foods (Chung and Myers, 1999). Grocery stores have higher availability and quality of produce than convenience stores (Glanz, et al., 2007), which is more strongly predictive of fruit and vegetable consumption than perceived price (Zenk, et al., 2005). Better food availability, prices and quality have led low-income customers to redeem most of their food assistance benefits in supermarkets (Cole, 1996), and low-price supercenters (USDA, 2009). However, convenience stores remain an important food source for the approximately 10% of the U.S. population who have no access to suitable transportation and live in neighborhoods with poor food retail access (5%) or low-income areas located further than one mile from a supermarket (4%) (USDA, 2009).

Study Objectives and Components: This study's goal was to evaluate multiple determinants of access to healthy foods. Using a pre-post natural experiment design enabled by the WIC food package revisions, we evaluated multiple domains of healthy food access in representative suburban and urban areas in Connecticut.

The study included five tasks:

1. Refine an existing store inventory instrument to focus on WIC-approved foods;
2. Collect and test data for differences in food environments across stores and neighborhoods;
3. Assess the role of food market competition in access to healthy food;
4. Evaluate the impact of the WIC food package revisions on the availability, variety, prices and quality of healthy foods;
5. Track WIC vendor participation in the state of Connecticut.

A supplement to this study was interviewing of managers and owners of convenience and grocery stores about their perceptions, beliefs and attitudes as well as the effects of the WIC revisions on these stores (Andreyeva, et al., 2011a). Structured in-person interviews were completed before and after the revisions implementation in a subsample of retailers assessed via store inventories.

Methods

Data

Sampling, Store Selection and Classification: Our sample included food stores operating in five Connecticut towns. To maximize the diversity of food environments surveyed within a limited study budget, we sampled towns from the 24 most populated towns in the state and included five towns of diverse residential income and food store density. Stores located within half-a-mile of each town's boundaries were also included. Residents of the five sampled towns included about 20% of WIC participants in Connecticut in 2008 (USDA, 2010).

We obtained a list of food retailers (stores, delis, fast food outlets and restaurants) from a commercial database provider InfoUSA, Inc. (InfoUSA, 2008). InfoUSA uses a proprietary modified 6-digit Standard Industrial Classification (SIC) code to classify establishments. We identified food stores using several selected SIC codes: Convenience Stores, Delicatessens, Food Markets, Food Products-Retail, Grocers-Retail, Health and Diet Foods, Fruits and Vegetables-Retail. Specialized stores like bakeries and meat markets were excluded due to limited range of foods. Pharmacies were excluded as they accept WIC benefits only for infant formula. Store locations were geocoded using ArcGIS 9.2 and Environmental Systems Research Institute (ESRI) Census 2000 TIGER/Line® data for designated towns and census tracts and InfoUSA latitude and longitude data for store coordinates (ESRI, 2000).

We extended a list of 371 food outlets identified through InfoUSA with 12 stores from WIC administrative records. At baseline in Spring 2009, we excluded 99 locations based on site visits: 35 were not found at InfoUSA-provided addresses, 19 were closed/out of business, 28 were delis/restaurants, 9 specialties, and 8 other businesses. During field work, we identified 29 more stores; all found in census tracts with median household income above $39,200 (considered as higher-income neighborhoods in our study). There was no difference by neighborhood income in the misclassification errors (e.g., delis with SIC classification as stores). The final sample included 313 stores; 10 stores (3%) were dropped from the analysis after refusing participation. In Spring 2010, we successfully assessed 289 of the baseline 303 stores. Between the two assessments, 13 stores closed, including 6 supermarkets due to the statewide closure of a supermarket chain. One store refused participation at follow-up.

Stores were classified in four categories according to the definitions used in the validated Nutrition Environment Measures Survey in Stores (NEMS-S) instrument (NEMS, 2007):

1. Convenience stores (stores with longer operating hours and offering a medium variety of canned goods, dairy products, and other groceries in limited amounts),
2. Food-marts (convenience stores associated with a gas station),
3. Grocery stores (non-chain markets like "mom and pop" grocery stores, bodegas and stores with a greater food variety than in convenience stores but less availability compared to supermarkets), and
4. Supermarkets (regional or national chain grocery stores).

Store WIC authorization status was based on store reports verified in administrative data from the state WIC agency. SNAP authorization status was store-reported.

Data Collection: We visited stores in March-June 2009 (pre-revision) and April-July 2010 (post-revision) with many 2009 visits completed in March (63%) and 2010 visits in May (56%). Assessments were conducted between 9am and 4pm on weekdays by two trained raters. Training for raters consisted of a 4-hour presentation and a 2-week field work period with a research staff member. During the field training both raters completed assessments independently and reviewed forms to improve performance. After the training, each rater completed half of the measures. For inter-rater reliability testing, two raters conducted all assessments independently in about 20% of stores chosen at random (e.g., first 2 stores out of 10 scheduled for daily assessment). Data from the rater with the highest number of completed items were used in analysis.

The study was exempt by the university institutional review board (IRB). Raters requested permission to do a store inventory upon entering the store premises. They introduced themselves, showed university identification, asked to talk to the store manager and, if the manager was not available, presented a letter describing the study and discussed it with a cashier. On occasion, raters had to come back to obtain permission from the manager if they were unavailable during the initial visit. The average time to obtain permission and complete the assessment by two raters varied from 17 (SD 9.2) minutes at food-marts to 24 (SD 11.6) minutes at convenience stores, 31 (SD 15) minutes at non-chain groceries and 47 (SD 14.2) minutes at supermarkets.

Measures

Store Instrument Development and Measures: We adapted a store inventory instrument from the validated NEMS-S measure (Glanz, et al., 2007) and focused it on WIC authorized foods as proxies for healthy foods (Appendix A). The instrument included products from the pre- and post-revision WIC food packages approved in the state of Connecticut: milk, eggs, cheese, baby foods, juice, cereal, bread, tortillas, rice, tofu, soy milk, canned fish, peanut butter, dry beans, and fresh, canned, frozen fruit and vegetables. Each food category had multiple products including 5 types of milk (skim, 1%, 2%, and whole cow's plain milk, and soy milk), most popular according to national consumption data (USDA, 2006) fresh fruits and vegetables (10 each), frozen fruits and vegetables (3 each), and canned fruit and vegetables (3 each). For rice, breads and cereals we considered whole grain and non-whole grain products including for comparison non-

authorized foods such as white rice, white flour bread and tortillas. Altogether, the instrument had 65 unique food items.

The store assessment started with general store characteristics such as verification of the store name and address, date and time of assessment, number of cash registers and aisles, and WIC and SNAP authorization status. Food assessment included product availability, price, quality, and variety. Each product was recorded as available if the store had it in stock during our inventory. Prices were recorded in dollars per unit for the least expensive brands or supermarket brands for most products and for reference brands of select items (e.g., WIC-approved brands of infant formula). Produce quality was assessed for all available ten fresh fruits and vegetables. The quality indicator was based on a one-to-five scale ranging from "A": Excellent Quality (no molded, wrinkled, shriveled, bruised, wilted items), "A-": Very Good Quality (few molded, bruised, etc.), "B": Good Quality (several/ less than a quarter molded, bruised, wrinkled), "B-": Fair Quality (a quarter to a third molded, wrinkled, bruised) to "C": Poor Quality (majority molded, wrinkled, bruised).

In convenience and non-chain grocery stores (i.e., non-supermarkets), raters assessed milk shelf-space and counted varieties of fruit and vegetables and whole grains. Measures of milk shelf-space were based on procedures in the NEMS-S and other food availability surveys (Cheadle, et al., 1991; Glanz, et al., 2007) to include a count of gallons and half-gallons of plain lower-fat (skim, 1%, 2%) and whole milk of any brand. Raters also evaluated varieties of fresh, frozen and canned fruit and vegetables eligible for purchase with WIC fruit and vegetable vouchers (excluding white potatoes, canned or frozen fruit and vegetables with added sugar, cream, and oils). They counted unique varieties of WIC approved fruit and vegetables. For example, two brands of frozen broccoli were counted as one frozen vegetable; Navel and Valencia oranges added one fresh fruit to the count. To familiarize raters to some cultural and ethnic fruit and vegetables, we provided an extended checklist of produce and showed pictures of many exotic fruit and vegetables.

As brand role is likely to play an important role in consumer selection of breads, rice and heavily-marketed cereals, we incorporated brand diversity in counting varieties of whole grain products. Raters counted across brands and types of brown rice but not package sizes. They used the same approach for whole wheat and whole grain breads, but included two counts: all sizes and all WIC-approved 16-ounce loaves. A count of whole grain tortillas included varieties and brands of whole wheat and corn soft tortillas. Whole grain cereals were counted using a checklist of eight most popular whole grain cereals based on 2007 national sales data from Nielsen Company (The Nielsen Company, 2008). Given an uncertain definition of whole grain cereals and frequent product reformulation, we considered it impractical to collect data on availability of all whole grain cereals. The eight cereals in our count represented 58% of 2007 national sales of cereals to all households and 46% of sales to households with children (The Nielsen Company, 2008).

Dependent Variables: We measured food availability as the percentage of stores that offered that food for purchase during our inventory. Composite variety measures were calculated for each store other than supermarkets and included a total count of varieties of

fresh, frozen, canned fruit and vegetables as well as a count of varieties of whole grain products (brown rice, whole grain cereal, whole wheat/ whole grain breads and whole grain tortillas). Milk shelf-space was measured as a ratio of available gallons of lower-fat milk to gallons of whole milk with half-gallons converted into gallons. A produce quality rating was calculated as the mean of available quality ratings for fresh fruit and vegetables. Finally, we developed a composite scale of healthy food supply, discussed elsewhere (Andreyeva, et al., 2011b).

Prices were converted to standard units, which varied by product. Prices of fresh produce available by piece or bunch were converted to prices per pound using conversion factor data from the USDA's National Nutrient Database for Standard Reference (USDA, 2007). We adjusted 2009 price data for inflation between March 2009 and May 2010 using U.S. city average consumer price index (CPI) for corresponding food categories (Bureau of Labor Statistics, 2008). Price comparisons across stores and neighborhoods are challenging due to significant differences in availability of foods. This prevented us from constructing a representative market basket of healthy foods that would be equally available across stores and neighborhoods. Instead, we compared inflation-adjusted prices of individual foods and used a composite price index for three most commonly available foods. The basket included products available in at least 90% of stores in both years: whole milk, eggs, and canned vegetables.

Independent Variables: The set of store-level characteristics included store size -- measured by number of cash registers (1, 2, or 3 registers and above) -- and indicators of SNAP and WIC authorization status. A set of market characteristics contained measures of competition for food stores and fast food chains. Food store competition was assessed for each store except supermarkets using data on the density of other non-supermarket stores in the area. We calculated the kernel density of non-supermarket stores within half-a-mile radius of the store coordinates. The kernel density gives a greater weight to stores closer in space within the search radius; a store across the street has a greater impact on the score than a store half-a-mile away. Another market competition measure was distance to the nearest supermarket assessed for each non-supermarket store (in thousands of feet). To account for differences in customer traffic, we included population density measured as number of census tract residents within the store tract. We categorized census tracts with median household income under $39,200 (American Community Survey 2006-2008 estimates) as low-income neighborhoods and the rest as higher-income areas. Our income threshold was based on 2008-2009 income eligibility for WIC for a family of four people (Food and Nutrition Service, 2008). Town indicators were not included due to lack of independent town variation in healthy food access.

We also assessed competition for consumer food dollars from fast food chains and included measures of their density within half-a-mile radius of each convenience and grocery store. We selected the top 20 national fast food restaurants with the highest U.S. sales in 2009 (QSR Magazine, 2009). The restaurants, in order of sales, included McDonald's, Subway, Burger King, Starbucks, Wendy's, Taco Bell, Pizza Hut, Dunkin' Donuts, KFC, Sonic, Arby's, Jack in the Box, Domino's, Chick-fil-A, Panera Bread, Dairy Queen, Papa John's, Hardee's, Quizno's, and Popeye's. Collectively, they totaled

$117 billion in 2009 sales accounting for 85% of the top 50 chain restaurants sales. There were 459 outlets belonging to one of the top 20 fast food chains within half-mile boundaries of the study towns. We further added 74 establishments from local fast food chains. Using Arc GIS10 we constructed a separate kernel density of fast food chain outlets within a half-mile radius of each non-supermarket store. Of note, focusing on national and regional fast food chains leaves out other sources of prepared food, which in some low-income urban areas have been shown to be more prevalent than fast food restaurants (Lee, et al., 2010).

Missing Data Imputations: We applied a propensity score matching approach to impute missing data (Enders, 2010). Missing values were fairly infrequent ranging in prevalence from 0.3% to 9.4% with the median of 2.1% in 2009 and 2.8% in 2010. The imputation approach used information from the assessed stores with valid data and closest in background characteristics to those missing data. Similarity in certain characteristics of the matched stores makes them known as nearest neighbors. In the first step, for each food item missing data we estimated a Probit regression model with a binary dependent variable indicating whether information was missing. Using this model we predicted propensity scores for all stores conditional on the store type, size and location in a low- versus higher-income neighborhood. In the second step, we matched stores with missing values with their nearest neighbors with valid data (stores with similar propensity scores) and replaced the missing value with the value from the nearest neighbor.

Data Analysis

Descriptive Data Analysis: We computed descriptive statistics and conducted chi-square and *t*-tests in store comparisons by WIC status, year and neighborhood income. Descriptive analyses were conducted for convenience and non-chain grocery stores with observations in both years (N=259). We isolated supermarkets as a unique group not expected to change due to the WIC revisions (N=36 in 2009 and N=30 in 2010). The inter-rater reliability analyses were completed by calculating percent agreement and kappa statistics for stores with two independent assessments (Dilorio, 2005; Landis and Koch, 1977).

Growth Models of the WIC Policy Change: We used multilevel regression modeling techniques to account for data structure with multiple sources of variation. There are two reasons for employing a multilevel estimation approach (Hox, 2002). First, our data is hierarchically structured and observations are not independent of each other but clustered or "nested" within groups. At the lowest level of analysis (Level 1) we have 2009 and 2010 observations that are grouped within a store. Stores, referred as Level 2 in the data hierarchy, are grouped within neighborhoods or census tracts (Level 3). Stores located in the same neighborhood are more similar to each other and their error terms are correlated. Second, regression modeling is essential in light of the quasi-experimental nature of the WIC revisions. There was no random assignment of stores to the experiment (WIC) and control (non-WIC) groups, and WIC stores are likely different from non-WIC stores. For example, WIC stores more likely locate in low-income areas where WIC participants

live, and neighborhood characteristics affect food availability. A multivariate approach is needed to account for non-random group assignment.

Multilevel models are also known as mixed-effects models for their simultaneous estimation of fixed and random effects. In a 3-Level linear random intercept model we can formulate a regression equation on each level. The basic application is an intercept only model without covariates for which the Level 1 equation can be written as:

$$Y_{ijk} = \pi_{0jk} + e_{ijk} \qquad \text{(Equation 1)}$$

where Y_{ijk} is the dependent variable for an observation *i* in a store *j* in a census tract or neighborhood *k*, π_{0jk} is the mean of the 2009 and 2010 measurements for a given store *j* in a neighborhood *k*, and e_{ijk} is the normally distributed error term for an observation *i* in a store *j* in a neighborhood *k*. On the second level, we can allow the predicted means of the dependent variable to vary across stores:

$$\pi_{0jk} = \beta_{00k} + r_{0jk} \qquad \text{(Equation 2)}$$

where the predicted mean in each store π_{0jk} is regarded as the dependent variable so that another intercept β_{00k} can be estimated for all stores clustered in a neighborhood *k*. The term r_{0jk} denotes the error term for stores *j* in neighborhoods *k* and indicates the variation across stores. Finally, we formulate the third-level model and estimate the variation of the store level means across neighborhoods:

$$\beta_{00k} = \gamma_{000} + u_{00k} \qquad \text{(Equation 3)}$$

Here, γ_{000} is the highest-level intercept and the error term u_{00k} indicates variation of the store means across neighborhoods. By substituting the equation terms, we can formulate the model in a single mixed model equation:

$$Y_{ijk} = \gamma_{000} + r_{0jk} + u_{00k} + e_{ijk} \qquad \text{(Equation 4)}$$

This model estimates a fixed intercept and three random effects that can be interpreted as variance components. To estimate the unadjusted effect of the WIC food package revisions, we included two variables and their cross-level interaction effect in the baseline model: an indicator variable for the year of assessment was added on Level 1, an indicator for the store WIC authorization status on Level 2, and their interaction was added across levels. We can estimate the following equation on Level 1:

$$Y_{ijk} = \pi_{0jk} + \pi_{1jk}(year_{ijk}) + e_{ijk} \qquad \text{(Equation 5)}$$

where the coefficient of the time variable π_{1jk} is an estimated parameter of the difference in the dependent variable between the two measurement points for each store *j* in neighborhood *k*, and the intercept π_{0jk} becomes the predicted value of the dependent variable in a given store at Time 1 (2009).

On the second level, we can formulate two equations. First, we predict the baseline difference between WIC and non-WIC stores as follows:

$$\pi_{0jk} = \beta_{00k} + \beta_{01k}(WIC_{jk}) + r_{0jk} \quad \text{(Equation 6)}$$

Second, we predict the difference between two measurement points by WIC authorization status to assess the differential change over 2009-2010 for WIC and non-WIC stores:

$$\pi_{1jk} = \beta_{10k} + \beta_{11k}(WIC_{jk}) \quad \text{(Equation 7)}$$

Given that WIC authorization status is measured at the store level and the time variable is measured at the observation level, Equation 7 represents a cross-level interaction effect. The difference between 2009 and 2010 is directly modeled as the dependent variable on the next level predicted by WIC status. Finally, we formulate the Level 3 equation that provides the intercept to our model of the predicted mean of the dependent variable for all non-WIC stores at Time 1 (2009):

$$\beta_{00k} = \gamma_{000} + u_{00k} \quad \text{(Equation 8)}$$

We can formulate a single equation by substituting the equation terms:

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

(Equation 9)

This specification has seven estimation parameters: four fixed effects and three random effects. The fixed effects provide the point estimates of interest. The intercept can be interpreted as the predicted mean outcome for non-WIC stores at Time 1. The estimated parameter γ_{010} represents the difference between WIC and non-WIC stores at Time 1, γ_{100} can be interpreted as the difference between Time 1 and Time 2 for non-WIC stores and γ_{110} gives a point estimate of the change between Time 1 and Time 2 for WIC stores or the baseline rate of change. Hence, γ_{110} represents a point estimate of the effect of the WIC food package revisions.

After fitting the model to estimate an unadjusted effect, we included a third-level indicator for neighborhood income. We predicted the change for WIC stores in low- and higher-income neighborhoods yielding a three-way interaction spanning all levels of data, which could determine whether the revisions had a differential impact by neighborhood income. This model can be written as follows:

$$Y_{ijk} = \gamma_{000} + \gamma_{001}(inc\_hi_k) + \gamma_{010}(WIC_{jk}) + \gamma_{100}(year_{ijk}) + \gamma_{110}(WIC_{jk}) * (year_{ijk}) + \gamma_{111}(inc\_hi_k) * (WIC_{jk}) * (year_{ijk}) + r_{0jk} + u_{00k} + e_{ijk}$$

(Equation 10)

Finally, we included other covariates on all levels for control purposes. All models were estimated applying a Maximum Likelihood method (Full Maximum Likelihood, cf. (Hox, 2002)). Some of our dependent variables were not continuous and normally distributed. For example, we estimated multilevel Poisson regression models for two count measures of whole grain products and fruit and vegetable varieties. The same modeling logic as with multilevel linear models was applied for Poisson models.

All regressions were estimated for a sample of convenience and grocery stores with pre-post data and unchanged WIC-authorization status in 2009 and 2010. Stores that changed their groups from experiment (WIC) to control (non-WIC) and vice versa violated the natural experiment setting of the WIC food package revisions. This additional restriction excluded six stores of which five stores lost WIC-authorization between 2009 and 2010 and one was a new WIC vendor (N=252).

Cross-Sectional Models of Food Access: Using baseline 2009 data for 267 convenience and grocery stores we estimated a set of multilevel linear and count models to assess predictors of healthy food access. These cross-sectional models were two-level (store and neighborhood/census tract) and included the same covariates as in the growth models. Our cross-sectional approach aimed to estimate the role of various contributors to food access independent of the effect of the WIC food package revisions.

Store Participation in WIC: To inform the debate on whether stores drop from the WIC program as a result of the package revisions, we tracked changes in WIC store participation in Connecticut between May 2008 and October 2010. We used 30 months of data from the state WIC agency on stores authorized to accept WIC benefits. The monthly list provided the store name, contact information (address and phone number), and local WIC agency. All phone numbers were checked for accuracy and used in merging of authorized stores across months. Each store was classified as a pharmacy, supermarket chain, or grocery/convenience/food mart. Stores that prepare and dispense drugs and medicines were grouped into 'Pharmacy' based on the store name (e.g., CVS). Supermarket chains were identified by regional and national chain names and by selecting stores with more than one establishment under the same name. The remaining stores were grouped into non-chain grocery stores, convenience stores, and food marts. Changes in participation were assessed monthly for the total number of stores and separately for each group.

Results

Sample Description: In 2009, we assessed 135 convenience stores, 81 food-marts, 51 grocery stores, and 36 supermarkets; with the same type distribution in 2010 (**Table 1**). About two-thirds of stores were authorized to accept SNAP benefits although their percentage varied from 35-40% in food-marts to 100% in supermarkets. WIC authorization was less common, with about 15% of non-supermarket stores and 81% of supermarkets accepting WIC benefits in 2009. Only 7% of stores in higher-income areas

were WIC authorized versus 26% in low-income areas. There was large variation in store type across different towns (**Table 2**). For example, supermarkets represented 20% of all stores in the sample's wealthiest town but only about 5% of stores in the poorest town. There were large differences by store type in low- and higher-income areas. For example, 36% of all stores in wealthier neighborhoods were food-marts that carry very limited varieties of foods. In contrast, in low-income areas 11% of stores were classified as food-marts. As shown in earlier studies (Larson, et al., 2009), the share of supermarkets was higher in wealthier neighborhoods (14 vs. 8% in 2009).

Reliability Analysis: Inter-rater reliability data were collected in 16% (48/303) of the stores in 2009 and 26% (75/289) of the stores in 2010. Agreement on product availability was consistently high in both years, ranging from 80-100% in 2009 (Mean=96%) and 88-100% in 2010 (Mean=97%) with kappa statistics in the range of 0.64-1.00 (**Table 3**). In 2009, only a few products had percent agreement on availability as low as 80-90%, including canned salmon (80%) and cheese, dry lentils, and cereals (88-89%). To calculate fruit and vegetable quality reliability, the five-point quality score was collapsed to three levels (1, 2=level 1, 3=level 2, 4, 5=level 3). Inter-rater reliability of fruit and vegetable quality rating was lower relative to percentage agreement on food availability, especially in 2010. In 2009, percent agreement on quality ratings ranged from 60-100% (Mean=80%) with about half of assessed fruit and vegetables in the range of 60-80% (**Table 4**). In 2010, agreement on produce quality was lower, ranging from 30-86% (Mean=59%). Kappa statistics could not be calculated if the particular fruit or vegetable was not offered in a sufficient number of stores. Most fruits and vegetables scored in the upper range of the scale leading to low and sometimes negative kappa statistics when agreement was high but variation was low (e.g., 2009 oranges ratings agreed 71% of the time, but the kappa was 0.08).

Descriptive Analysis for Convenience and Grocery Stores

Food Availability: Baseline food availability in convenience and grocery stores was the lowest for soy products (<10%) and the best for whole milk, eggs, and canned vegetables (≥90%). Many of important healthy foods had limited availability: about half of non-supermarket stores did not carry any fresh fruit and vegetables and about 80% had no whole wheat/ whole grain bread and tortillas in 2009. Furthermore, while 69% of stores stocked white rice, only 17% offered brown rice (**Table 5**). Availability significantly improved for a few healthy foods in 2010, doubling for brown rice and almost doubling for whole wheat/whole grain bread. Few improvements in the total sample mask differential patterns for WIC and non-WIC convenience and grocery stores. For example, fresh fruit was available in about half of WIC and non-WIC stores in 2009; this remained unchanged in non-WIC stores at follow-up but rose to 100% in WIC stores (**Table 6**). The availability of fresh and frozen vegetables also increased significantly in WIC stores, with no change seen in non-WIC stores. The availability of whole wheat bread and brown rice went up in both WIC and non-WIC stores although the increase was several times larger in WIC stores. Improvements in non-WIC convenience and grocery stores that are not required to change following the WIC package revisions might reflect broader secular

changes in demand for whole grain products and/or improved access to suppliers carrying new products for their WIC stores.

Food Prices: Compared to 2009, a number of food products had lower inflation-adjusted prices in Connecticut convenience and grocery stores in 2010 (**Table 7**). For example, a gallon of whole milk went down from $4.13 to $3.92; a similar rate of reduction was seen in lower-fat milk. Of note, U.S. consumer price index (CPI) for milk during this period was 1.9% and the Northeast CPI for food consumed at home was 0.6% (Bureau of Labor Statistics, 2008). Other significantly cheaper products in 2010 were whole grain cereals, white-flour bread, oranges, orange juice, and jarred baby fruit/vegetables. In contrast, whole wheat bread, white rice, eggs and some vegetables were on average more expensive in 2010. Using the price index of three most commonly available foods (whole milk, eggs, and canned vegetables) we observed no change as whole milk prices went down while egg prices increased.

Comparisons by WIC status (**Table 8**) suggest that the total cost of three most commonly available foods increased on average by $0.04 in non-WIC stores but went down by $0.07 in WIC convenience and grocery stores. A larger reduction in the cost of whole milk in WIC vs. non-WIC stores explains the difference ($0.27 or 7% versus $0.19 or 5% respectively). Of note, similar changes with greater price reductions in WIC stores were seen for lower-fat milk, which suggests that the WIC food package revisions that reduced whole milk and increased lower-fat milk are unlikely to explain the observed milk price patterns in Connecticut convenience and grocery stores. Price change comparisons by WIC status for many healthy foods are difficult due to a very low number of WIC convenience and grocery stores offering these foods at baseline. For example, only 3 WIC stores had whole wheat/whole grain bread in 2009 and 27 stores in 2010.

Milk Shelf Space: The 2009 share of lower-fat milk in milk shelf-space was larger in non-WIC than WIC convenience and grocery stores (46.9% and 33.4%, $p<0.01$). As expected, lower-fat milk share increased significantly to 41.5% in WIC convenience and grocery stores in 2010 ($p=0.05$). The reduction to 44.4% in non-WIC stores was not significant (**Table 9**).

Variety Count: Following the WIC food package revisions, both non-WIC and WIC convenience and grocery stores had significant increases in available varieties of some whole grain products (**Table 9**). For example, non-WIC stores had more varieties of whole grain cereals, brown rice and whole wheat/corn tortillas in 2010 even though they had no program requirements to change their inventory. In total, their count of whole grain products increased from 3.0 to 3.8 ($p<0.05$). In comparison, WIC stores had a significant increase in the number of available varieties of brown rice (from 0.3 to 1.6, $p<0.001$), whole grain cereals (from 2.4 to 3.1, $p<0.05$), and whole wheat bread (from 0.4 to 0.9, $p<0.10$). Taking into account whole wheat/corn tortillas, the total whole grain count increased from 3.6 to 6.6 ($p<0.01$). As a result of the 2010 changes, the gap in available varieties of whole grain products between WIC and non-WIC convenience and grocery stores more than tripled from 0.8 to 2.9.

Improvements in available varieties of fruit and vegetables were smaller in WIC convenience and grocery stores and lacking in non-WIC stores (with an exception of canned unsweetened fruit). After the package revisions, WIC stores offered a significantly greater variety of fresh fruit (from 2.6 to 4.6, $p<0.10$) and canned unsweetened fruit (1.1. to 1.6, $p<0.05$), but had no changes in any vegetables and frozen fruit varieties. The count of fresh, frozen and canned fruit and vegetables in non-WIC convenience and grocery stores was on average 14.2 varieties in both 2009 and 2010. In comparison, WIC stores had on average 18.6 varieties at baseline and 22.1 varieties a year later. The high prevalence of food-marts among non-WIC stores could explain the difference in the baseline variety of fruit and vegetables between WIC and non-WIC stores (although not significant). Food-marts rarely carry fruit and vegetables and could bias results for all non-WIC convenience and grocery stores.

Produce Quality: Significant differences in the percentage of inter-rater agreement on produce quality between 2009 and 2010 and low agreement on quality in 2010 do not allow us to directly compare changes in produce quality over two years. Our raw quality ratings suggest that fruit and vegetable average quality declined in 2010. However, variation in perceptions of produce quality among different raters collecting data in 2009 and 2010 (despite exposure to the same training) likely explains the observed effect. One confirmation of this hypothesis is a reduction in the average quality of produce in supermarkets, including those located in higher-income areas. These stores have consistently high quality of produce (data not shown), so the observed effect is questionable. To address the problem, we z-standardized produce ratings with a mean of 10 and a standard deviation of 1 in both years. Comparisons for WIC and non-WIC convenience and grocery stores revealed no difference for either fresh fruit or vegetables: 2009 standardized mean for fruit (vegetables in parentheses) was 9.85 (9.83) in WIC stores vs. 9.67 (9.71) in non-WIC stores. There was no change in standardized quality ratings between 2009 and 2010 in either WIC or non-WIC convenience and grocery stores.

Cross-Sectional Models of Food Access in Convenience and Grocery Stores

Food Prices: We found few significant predictors of the price index of three most commonly available foods in convenience and grocery stores (**Table 10**). The price index was positively related to higher population density in the store census tract, which suggests that demand is higher at each price level in more populated neighborhoods. Better customer traffic allows stores to charge somewhat higher prices. We found no price difference between stores located in low- and higher-income neighborhoods, which is different from some earlier studies (Block and Kouba, 2006; Chung and Myers, 1999; Hendrickson, et al., 2006; Kaufman, et al., 1997; Kunreuther, 1973).

Milk Shelf Space: In contrast to price models, there were many significant associations between lower-fat milk share and store, market and neighborhood characteristics. Larger stores had a significantly higher share of lower-fat milk in milk shelf-space, by about 14.3 percentage points in stores with two cash registers ($p<0.001$) and by 16.4 percentage

points in stores with at least three cash registers ($p<0.10$), as compared to stores with one cash register (**Table 11**). There was no difference in milk shelf-space by WIC status, but SNAP authorized stores had about 7 percentage points lower share ($p<0.05$). As expected, lower-fat milk was available in relatively larger quantities in stores located in higher-income neighborhoods, by about 14.1 percentage points after including all covariates ($p<0.01$). Of note, the variance components analysis suggests that milk shelf space had a sizable variation by neighborhood income. Food market competition measures did not correlate with milk shelf-space with one exception of marginally significant density of other food stores (-0.54 percentage points, $p<0.10$).

Variety Count: Poisson models for fruit and vegetable variety predicted a positive association with store size (**Table 12**). In comparison with smallest stores with one cash register, stores with two cash registers had about three times more varieties (IRR=2.736, $p<0.001$) and stores with at least three cash registers had seven times as many varieties of fruit and vegetables (IRR=7.212, $p<0.001$). WIC and SNAP authorization status were both independently related to greater variety of fruit and vegetables, by around 13.3% (IRR=1.133, $p<0.05$) and 76.3% (IRR=1.763, $p<0.001$) respectively. Stores in wealthier neighborhoods had 31.2% (IRR=0.688, $p<0.10$) lower variety of fruit and vegetables. The only market competition measure related to more fruit and vegetable variety was distance to the nearest supermarket (IRR=1.076, $p<0.001$). Similar results were found for the whole grain variety (**Table 13**), with the exception of SNAP status. Store size, WIC authorization status, neighborhood income, and distance to the nearest supermarket were again significant predictors of greater variety of whole grain products in Connecticut convenience and grocery stores. One new measure with predictive power was population density that suggested a greater variety of whole grain products in more densely-populated areas (IRR=1.117, $p<0.05$).

Growth Models of the WIC Revisions Effects

Food Prices: There was no baseline difference in food prices for three most commonly available foods (whole milk, eggs, and canned vegetables) between WIC and non-WIC stores. For this basket we detected a reduction of about \$0.05 ($p<0.05$) in 2010 prices. This change was observed before and after adjusting for covariates, neighborhood and WIC revisions (**Table 14**). As discussed above, this effect is driven by significantly lower prices of whole milk. It is unknown why milk prices in Connecticut convenience and grocery stores went down between 2009 and 2010. This could reflect reductions in demand among WIC customers (due to the package revisions) and/or non-WIC customers (due to a trend to reduce fat intake) or other unobserved factors that influenced the milk market. There was no effect of the WIC package revisions on prices of three most commonly available foods.

Milk Shelf-Space: Estimation results for the share of lower-fat milk revealed no baseline difference between WIC and non-WIC convenience and grocery stores (**Table 15**). This significantly changed after the WIC food package revisions: non-WIC stores had a slightly lower share (by 2.42 percentage points, $p<0.10$) while WIC stores notably

increased the share of lower-fat milk in 2010. Specifically, the unadjusted effect was an increase of 9.39 percentage points for all WIC stores, which grew to 13.46 percentage points for WIC stores located in low-income neighborhoods in the models accounting for neighborhood income and a smaller 12.13 percentage points increase for these stores after including covariates. The significant interaction of income, WIC and time (-14.56 percentage points, $p<0.05$) indicates the amount by which this increase was smaller for WIC stores located in higher-income areas. This suggests no change with respect to milk shelf space in WIC stores in higher income areas and a reduction in the baseline gap in milk shelf-space by neighborhood income. Differences in milk shelf-space by neighborhood income were substantial: 21.67 percentage points higher in high-income areas before covariate adjustment and 11.09 percentage points after including controls. Store size and density of fast food chains were positively related to a higher share of lower-fat milk while the opposite was true for SNAP authorization status and density of convenience and grocery stores.

Variety Count: Fruit and vegetable variety in WIC convenience and grocery stores was significantly higher than in non-WIC stores, by 74% ($p<0.01$) before adjusting for covariates (**Table 16**). After the WIC package revisions, fruit and vegetable varieties in WIC stores increased by 23.8% ($p<0.01$) in lower-income neighborhoods whereas non-WIC stores saw a reduction of 5.4% ($p<0.10$). The effect for WIC stores located in higher-income areas was essentially zero (IRR of 1.238* IRR of 0.774 = 0.96, indicating a decrease of 4% within these stores). Larger store size, SNAP authorization status and a further distance from the closest supermarket predicted greater variety of fruit and vegetables in Connecticut convenience and grocery stores.

Available varieties of whole grain products (**Table 17**) were higher in WIC compared to non-WIC convenience and grocery stores (by 56.5%, $p<0.05$). They increased further after the WIC package revisions, by 42.6% ($p<0.01$) for all WIC stores. After adjusting for neighborhood income and other covariates, the effect was a 61.6%-increase ($p<0.001$) for WIC stores located in low-income neighborhoods, but no significant change for WIC stores in higher-income areas. Spillovers from WIC to non-WIC stores might explain the increased variety of whole grain products in non-WIC convenience and grocery stores in 2010, by 24.6% ($p<0.001$). As with fruit and vegetable varieties, store size, SNAP authorization status and distance to the nearest supermarket were significantly related to greater available varieties of whole grain products in Connecticut convenience and grocery stores.

Analysis of Supermarkets: As supermarkets were not expected to change following the WIC food package revisions and offered large varieties of healthy foods at baseline, we focused their analysis on price and produce quality comparisons by neighborhood income and overtime. As we expected, produce quality was somewhat worse in supermarkets in lower-income neighborhoods in both years, but the only significant difference was for fresh fruit in 2010 (9.34 vs. 10.2, $p<0.05$). Limited statistical power due to a small sample size of supermarkets may explain a lack of significant results. We observed no significant difference in supermarket prices of three most commonly available foods by neighborhood income. In contrast to price changes in convenience and grocery stores,

milk prices did not decrease in supermarkets. The only significant change was a price reduction for canned vegetables, which did not affect the price index of three most commonly available foods.

Store Participation in WIC: The number of stores authorized to accept WIC benefits in the state of Connecticut went down from 605 in May-September 2008 to 538 in June-October 2010 (**Table 18**). The reduction was driven by dropouts among convenience, non-chain grocery stores and food-marts; their participation during this period declined by 16% versus 8% for supermarkets and 5% for pharmacies. The biggest reductions in the total number of WIC-authorized stores occurred in October 2008 (N=25), October 2009 (N=14), and April 2010 (N=20). The latter reflected a temporary drop due to one chain closure with many stores resuming work and WIC participation under another chain ownership. Significant changes in October participation reflect the authorization cycle that uses October 1 as the timeline for renewals and new authorizations in Connecticut. Most of the reduction in WIC store participation occurred before the WIC package implementation in October 2009, including 36 stores in the fourth quarter of 2008, of which 30 were convenience and grocery stores. In comparison, the number of participating stores between October 2009 and October 2010 declined by 11 stores (1 convenience store and 12 pharmacies dropped and 2 supermarkets were added). Given this pattern of change in store participation, it does not appear that Connecticut convenience and non-chain grocery stores stopped participating in the WIC program as a result of the WIC food package revisions.

Discussion

The implementation of the revised WIC food packages significantly increased the availability and variety of key healthy foods in WIC convenience and grocery stores in Connecticut. Utilizing a natural experiment design to observe WIC and non-WIC stores before and after the revisions implementation, this study showed strong evidence of the positive impact of the WIC food package revisions on healthy food availability and variety in urban and suburban settings. When facing new demand from WIC customers and new government regulations to stock certain healthy foods, Connecticut convenience and grocery stores found ways to deliver healthy foods that were previously lacking in their stores and communities. If the experience in Connecticut is typical of other states, national food policy that incentivizes demand and requires changes in stores can improve the food environment for all customers in at-risk communities. This could occur at no additional cost to taxpayers as the WIC food package revisions were designed to be cost-neutral.

While most significant changes occurred in WIC-authorized convenience and grocery stores, non-WIC stores also showed improvements in the availability and variety of whole grain products. Such improvements could be due to better access to new WIC healthy foods in supply chains. Wholesalers serving small stores usually work with both WIC and non-WIC stores so that the latter group also gets access to new foods that wholesalers carry for WIC stores. Alternatively, secular changes in customer demand for

healthier foods could encourage all food stores to provide those foods. As both WIC and non-WIC customers get exposed to new healthy foods in WIC stores, they may start asking for them in non-WIC stores as well. Increased provision of healthy foods, especially whole grain products, may also suggest that there was unmet demand before the WIC package revisions. However, based on interviews with managers and owners of convenience and grocery stores, it appears that stores can find ways to provide food if there is customer demand (Andreyeva, et al., 2011a).

The WIC food package revisions had a greater impact on the availability and variety of healthy foods in low-income communities, which is particularly important given the limited transportation options and lack of supermarkets in many low-income communities. Improvements in the availability and variety of fruit and vegetables and whole grain products were significantly larger in WIC stores located in lower-income neighborhoods as compared to WIC stores serving higher-income areas. The same was true for increased shelf-space for lower-fat milk, which helped reduce the large gap observed by neighborhood income before the WIC revisions. It is interesting that while observing poorer availability of lower-fat milk in low-income areas, we saw the opposite effect for available varieties of whole grain products and fruit and vegetables. It is possible that a considerable prevalence of food-marts (convenience stores at gas stations) in higher-income neighborhoods explains these results. Food-marts always have milk but a very limited inventory of other foods, especially fruit and vegetables.

We found no neighborhood-attributable differences in prices of three most commonly available foods in convenience and grocery stores, which is different from some earlier studies (Block and Kouba, 2006; Chung and Myers, 1999). A limited range of food products and exclusion of supermarkets from price comparisons could explain the difference in findings. In fact, only higher population density made a detectable difference in prices of most commonly available foods. It is notable that the WIC food package revisions had no effect on price changes for several most commonly available foods that underwent significant changes in the new packages (reduced amounts of eggs and whole milk and authorization of canned vegetables).

In addition to the significant beneficial effect of the WIC food package revisions on the availability and variety of major healthy foods, we have identified several consistent predictors of healthy food availability and variety in Connecticut convenience and grocery stores. Store size was always related to greater varieties of major healthy foods and shelf-space of lower-fat milk. SNAP- and WIC-authorization of convenience and grocery stores generally suggested similar patterns (besides milk for SNAP), in part because WIC requires authorized stores to carry a minimum amount of certain healthy foods. This result also reflects the fact that many food-marts do not accept SNAP or WIC benefits. Due to their location, these stores most likely rely more heavily than other convenience stores on sales of cigarettes, lotteries, and snack foods to customers stopping for gas. From a policy prospective, we may think of encouraging convenience and grocery stores to participate in SNAP and especially WIC that sets nutritional standards on food packages. Program participation of these stores could increase access to healthy food in the communities they serve.

Although market competition from other small stores and fast food chain outlets had a limited effect on the availability and pricing of healthy foods in convenience and grocery stores in our sample, increasing distance from supermarkets predicted greater availability and variety of fruit and vegetables and whole grain products. Given existing literature on the negative impact of convenience stores on diet quality and obesity risk, this information may be useful to policymakers considering zoning restrictions on these stores as a strategy for improving the community food environment. In the absence of nearby supermarkets, this study found that convenience and non-chain grocery stores serve an important role as suppliers of healthy foods.

Study Strengths and Limitations: Our study has a number of unique strengths, including collection of multiple observations on a large number of food stores for many healthy foods; analysis of multiple dimensions of food access such food availability, variety, pricing, and quality; and use of a natural experiment setting of the WIC food package revisions. In combination with in-depth interviews of stores (Andreyeva, et al., 2011a), this study provides a comprehensive assessment of the supply side effects of the WIC food package revisions.

Out study is not without limitations. First, we assessed food availability, variety, pricing and quality and their changes after the WIC revisions in one state, Connecticut. States differed in the revisions implementation (e.g., minimum stocking requirements, authorized foods), which could influence the results. Market characteristics and their role in food access might also vary across states. For example, we did not assess rural areas that may have unique problems in the revisions implementation and/or the role of other access predictors. Second, food availability is only one of many determinants of food choices and diet quality. We evaluated multiple measures of access to healthy foods, but did not assess customer food choices. No conclusions can be made on whether and how changes in the availability of healthy foods affected dietary outcomes of WIC participants and low-income populations in general. Third, we used approximate measures of market competition due to lack of sales data for food stores. Further, we did not assess changes in availability of unhealthy foods, which are part of the food environment.

Directions for Future Research: This study provides an in-depth assessment of the supply-side impacts of the WIC food package revisions, but does not address the impact on food demand among WIC and non-WIC customers. Future studies should assess whether the WIC food package revisions led to changes in consumer purchases, improvements in nutritional quality of diet, weight and health outcomes. Further monitoring of the impact of the WIC revisions implementation is important to ensure that the initial beneficial effects outlined in this study are sustained in the long term.

Conclusion: Our results suggest that policies aimed at increasing demand for healthy foods can improve the availability and variety of healthy foods in at-risk communities. Recent revisions to the WIC food packages significantly increased the availability and variety of fruits and vegetables, whole grain products and lower-fat milk in WIC-authorized convenience and grocery stores, especially in low-income neighborhoods.

Through new demand for healthy foods from WIC participants and new stocking requirements in WIC stores, the WIC food package revisions led to beneficial changes with healthy food availability within six to eight months of implementation. The policy change that targeted WIC participants has factually improved the food environment for all customers and potentially at no additional cost to taxpayers.

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Table 1: Types of Stores and WIC/SNAP Authorization Status

Type of Store	2009			2010		
	N	% WIC authorized	% SNAP authorized	N	% WIC authorized	% SNAP authorized
Convenience store	135	21.5	63.7	129	21.7	72.1
Food mart/ gas station	81	4.9	34.6	80	6.3	42.5
Grocery store	51	11.8	62.8	50	14.0	66.0
Supermarket	36	80.6	100.0	30	73.3	100.0
Total	**303**	**22.4**	**60.1**	**289**	**21.5**	**65.7**

Source: Authors' calculations

Table 2: Sample Distribution by Town and Store Type

Town	N	Convenience Store	Food mart/gas station	Grocery Store	Supermarket
2009			***Percentages***		
Bristol	38	34.2	47.4	0.0	18.4
Danbury	49	36.7	22.5	26.5	14.3
Manchester	37	37.8	43.2	2.7	16.2
New Haven	135	61.5	14.1	19.3	5.2
West Hartford	44	15.9	38.6	25.0	20.5
Total	**303**	**44.6**	**26.7**	**16.8**	**11.9**
2010					
Bristol	36	33.3	50.0	0.0	16.7
Danbury	48	35.4	22.9	27.1	14.6
Manchester	33	39.4	45.5	3.0	12.1
New Haven	130	62.3	14.6	19.2	3.9
West Hartford	42	14.3	40.5	26.2	19.1
Total	**289**	**44.6**	**27.7**	**17.3**	**10.4**

Source: Authors' calculations

Table 3: Inter-rater Reliability for Food Availability Assessment

	2009		2010	
Type of Food	**% Agreement**	**Kappa**	**% Agreement**	**Kappa**
Fruit (average)	**97**	**0.91**	**97**	**0.93**
Apples	100	1.00	100	1.00
Grapes	100	1.00	100	1.00
Oranges	100	1.00	100	1.00
Pineapple	100	1.00	100	1.00
Frozen Blueberries	100	1.00	100	1.00
Canned Pineapple	100	1.00	97	0.94
Tropicana Orange Juice - 1 gallon (2010)	100	1.00	99	0.97
Juicy Juice, Plastic Bottle, 64 fl oz	98	0.88	96	0.91
Canned Peaches	97	0.89	95	0.80
Bananas	97	0.93	93	0.80
Cantaloupe	97	0.91	100	1.00
Peaches	97	0.90	98	0.93
Strawberries	97	0.89	100	1.00
Watermelon	97	0.87	98	0.92
Lemons	94	0.87	93	0.87
Juicy Juice, Canned (2009)	93	0.86	--	--
Tropicana Orange Juice - 1/2 gallon	91	0.79	97	0.94
Frozen Peaches	90	0.74	100	1.00
Frozen Strawberries	90	0.74	94	0.85
Canned Peaches2 (2010)	--	--	98	0.93
Canned Pineapple2 (2010)	--	--	95	0.88
Other, less expensive 64 fl oz bottle	--	--	90	0.79
Vegetables (average)	**99**	**0.96**	**97**	**0.94**
Green Cabbage	100	1.00	98	0.95
Whole Carrots	100	1.00	95	0.90
Celery	100	1.00	98	0.95
Cucumber	100	1.00	100	1.00
Yellow Onions	100	1.00	95	0.87
Frozen Broccoli	100	1.00	100	1.00
Frozen Green Beans	100	1.00	96	0.90
Frozen Sweet Corn	100	1.00	100	1.00
Canned Corn	100	1.00	99	0.97
Canned Green Beans	98	0.93	100	1.00
Canned Peas	98	0.88	99	0.97
Broccoli	97	0.91	100	1.00
Baby Carrots	97	0.90	98	0.95
Lettuce	97	0.93	100	1.00
Peppers	97	0.94	98	0.95
Tomatoes	97	0.90	98	0.92
Canned Corn2 (2010)	--	--	94	0.88
Canned Green Beans2 (2010)	--	--	97	0.94
Canned Peas2 (2010)	--	--	88	0.76
Milk (average)	**98**	**0.95**	**100**	**0.98**
Whole Milk	100	**	100	1.00
Soy Milk	100	1.00	100	1.00
Skim Milk	98	0.95	100	1.00
Reduced Fat Milk	98	0.95	100	1.00

Low-fat Milk	96	0.91	99	0.96
Soy Milk2 (2010)	--	--	99	0.94
Protein (average)	**94**	**0.81**	**96**	**0.90**
American Cheese	100	1.00	98	0.97
Eggs - large white	100	1.00	99	0.88
Sardines, any size, any brand	98	0.88	98	0.96
Peanut Butter, Smooth	97	0.65	100	1.00
Peanut Butter, Chunky	97	0.94	95	0.90
Dry Beans*	97	0.66	100	1.00
Barley, whole (2009)	97	0.79	--	--
Tuna 6oz. (2009)	95	0.90	--	--
Tuna 5oz.	95	0.90	92	0.79
Barley, pearled (2009)	91	0.72	--	--
Cheese – low-fat	90	0.66	100	1.00
Dry Lentils*	89	0.68	91	0.79
Cheese - regular	88	0.76	94	0.86
Salmon1 (2010)	--	--	91	0.81
Salmon2 (2010)	--	--	95	0.80
Grains	**96**	**0.88**	**95**	**0.87**
Bread				
Arnold German Dark Wheat (2009)	100	1.00	--	--
Arnold Bakery Light (2009)	100	1.00	--	--
Pepperidge Farm Light (2009)	100	1.00	--	--
Weight Watchers 16oz. (2009)	100	1.00	--	--
Arnold Whole Wheat (2009)	95	0.64	--	--
Arnold, other (2009)	95	0.73	--	--
Wonder Bread - White (2009)	93	0.86	--	--
Other, Less expensive white bread (2010)	--	--	95	0.89
Whole Grain 16oz (2010)	--	--	97	0.94
Whole Grain 24oz (2010)	--	--	97	0.92
Wonder Bread - White (20oz) (2010)	--	--	94	0.87
Tortillas				
Any WG tortillas available (y/n) (2009)	100	1.00	--	--
White Flour Tortillas	96	0.92	100	1.00
White Corn Tortillas	**	**	100	1.00
Whole Wheat Tortillas	**	**	97	0.92
Rice				
Brown Rice - Uncle Ben's	95	0.88	100	1.00
White Rice - Uncle Ben's	88	0.74	93	0.86
Brown Rice - Other least exp. (2010)	--	--	98	0.97
White Rice - Other least exp. (2010)	--	--	97	0.84
Cereal				
Whole grain cereal				
Kashi Go Lean Crunch	98	0.90	94	0.74
Post Raisin Bran	98	0.90	89	0.60
Post Honey Bunches of Oats	95	0.86	97	0.89
GM Honey Nut Cheerios	95	0.89	92	0.84
Plain Cheerios	95	0.90	97	0.92
Oatmeal unflavored (2009)	95	0.90	--	--
Non-whole grain cereal - Rice Krispies	93	0.83	97	0.94
Quaker Life	91	1.00	92	0.72
Kellogg’s Raisin Bran	88	0.70	88	0.70
Frosted Mini Wheats (2010)	--	--	97	0.93
Corn Flakes (2010)	--	--	94	0.87

Formula/Baby Food	**96**	**0.91**	**98**	**0.95**
Gerber Soy Plus 2	100	1.00	97	0.92
Beachnut Fruit/Vegetables	100	1.00	97	0.92
Gerber Good Start Gentle Plus (powder)	97	0.94	100	1.00
Gerber Soy Plus	97	0.93	97	0.94
Gerber Fruit/Vegetables	97	0.93	97	0.92
Gerber Good Start Gentle Plus (liquid)	94	0.89	100	1.00
Gerber Good Start Soy Plus (liquid)	94	0.88	100	1.00
Gerber Meat	94	0.87	100	1.00
Plain infant cereal (Gerber)	94	0.82	94	0.89
Beachnut Meat	91	0.80	97	0.94
Plain infant cereal (Beachnut)	--	--	100	100
Average Across All Items	96	0.90	97	0.92
Min	80	0.64	88	0.60
Max	100	1.00	100	1.00

-- not asked in data collection wave, or an 'optional' variable
* Missing data and distribution cause kappa problems
** too few rating categories
Source: Authors' calculations

Table 4: Inter-rater Reliability for Produce Quality

Produce	2009		2010	
	% Agreement	Kappa	% Agreement	Kappa
Fruit				
Watermelon	100	--	40	-0.36
Peaches	100	1.00	86	0.70
Cantaloupe	86	0.00	30	-0.25
Pineapple	83	0.00	78	0.55
Strawberries	80	0.00	33	-0.20
Apples	76	0.14	52	0.18
Grapes	75	0.00	69	0.14
Oranges	71	0.08	59	0.37
Lemons	69	0.16	52	0.28
Bananas	65	-0.02	58	0.31
Vegetable				
Celery	100	--	73	0.18
Whole Carrots	100	1.00	69	0.48
Baby Carrots	86	0.00	55	0.07
Broccoli	86	0.00	60	-0.18
Green Cabbage	78	-0.06	69	0.29
Tomatoes	76	0.50	63	0.37
Yellow Onions	75	0.45	57	0.28
Lettuce	65	0.31	55	0.26
Cucumber	64	0.15	62	0.42
Peppers	60	0.21	63	0.43
Average	**80**	**0.22**	**59**	**0.21**
Min	60	-0.06	30	-0.36
Max	100	1.00	86	0.70

Source: Authors' calculations

Table 5: Food Availability in Convenience and Grocery Stores

Food	2009 N=259	2010 N=259	Diff. in %	
	Percentages			
Whole milk	93	93	0	
Eggs	90	89	-1	
Canned plain vegetables	90	91	1	
Lower-fat milk	77	78	1	
Canned tuna/salmon/sardines	76	75	-1	
White flour bread	75	78	4	
Non-whole grain cereal	73	80	10	*
Peanut butter	72	77	7	
White rice	69	76	10	*
Whole grain cereal	68	73	7	
Orange juice	64	54	-16	**
Cheese	61	65	7	
Canned unsweetened fruit	58	65	12	*
Fresh fruit	54	59	9	
Dry beans/lentils	53	55	4	
Fresh vegetables	47	49	4	
Jarred baby foods	29	28	-3	
Infant formula	25	31	24	
Frozen vegetables	24	30	25	
Whole wheat/whole grain bread	22	40	82	***
Whole wheat/corn tortillas	19	26	37	**
Brown rice	17	35	106	***
Frozen fruit	12	14	17	
White flour tortillas	10	14	40	
Soy milk	9	11	22	
Tofu	7	8	14	

Note: *p<0.10, **p<0.05, ***p<0.01 for difference between 2009 and 2010.
Source: Authors' calculations

Table 6: Food Availability in Convenience and Grocery Stores by WIC Authorization Status

Food	Non-WIC stores			WIC authorized stores		
	2009 N=220	**2010** N=225		**2009** N=39	**2010** N-34	
			Percentages			
Whole milk	92	92		100	100	
Eggs	88	87		100	100	
Canned plain vegetables	88	89		100	100	
Lower-fat milk	75	75		90	100	
Canned tuna/salmon/sardines	72	71		97	100	
White flour bread	71	75		95	97	
Non-whole grain cereal	69	76	*	97	100	
Peanut butter	67	74		97	97	
White rice	66	72		90	100	
Orange juice	65	52	***	64	71	***
Whole grain cereal	62	69		97	100	
Cheese	55	60		97	100	
Canned unsweetened fruit	54	62	*	79	88	
Fresh fruit	54	53		51	100	***
Dry beans/lentils	45	48		97	100	
Fresh vegetables	43	44		67	85	*
Whole wheat/whole grain bread	24	34	**	8	79	***
Frozen vegetables	23	27		28	50	*
Jarred baby foods	22	18		69	94	***
Brown rice	16	26	**	21	94	***
Whole wheat/corn tortillas	15	22	**	38	53	
Infant formula	13	20	**	92	100	*
Frozen fruit	11	13		15	21	
Soy milk	10	12		3	9	
White flour tortillas	9	12		15	26	
Tofu	8	9		3	5	

Note: *p<0.10, **p<0.05, ***p<0.01 for difference between 2009 and 2010.
Source: Authors' calculations.

Table 7: Food Prices in Convenience and Grocery Stores

Product	2009^ N	2009^ Mean, $	2010 N	2010 Mean, $
Whole milk, gallon	231	4.13	227	3.92***
Eggs, dozen	226	2.07	226	2.26***
Canned vegetables, 15oz	217	1.48	216	1.52
Canned corn, 15oz	192	1.47	200	1.55**
White flour bread, 16oz	191	2.41	200	1.94***
Non-whole grain cereal, 16oz	185	5.45	205	5.44
Lower-fat milk, gallon	183	3.83	185	3.69**
Peanut butter, 18oz	183	3.50	198	3.55
White rice, 16oz	175	1.78	197	2.04***
Whole grain cereal, 16oz	163	5.73	188	5.19***
Dry beans/lentils, 1lb	135	1.43	142	1.57***
Canned pineapple, 15oz	130	1.75	141	1.85
Onions, 1lb	102	1.06	102	1.39***
American cheese, 1lb	99	4.81	96	4.86
Tomatoes, 1lb	96	1.93	99	2.11*
Bananas, 1lb	92	1.42	110	1.55
Apples, 1lb	78	1.88	99	1.86
Lettuce, 1lb	75	1.41	84	1.53*
Oranges, 1lb	68	2.30	93	2.02**
Baby jarred fruit/vegetables, 4oz	67	1.01	71	0.93*
Orange juice, gallon	64	5.61	84	4.45***
Infant formula powder, 12oz	57	15.30	74	15.65
Whole wheat/whole grain bread, 16oz	54	2.44	103	2.60**
Canned sardines, 3.75oz	48	1.50	52	1.52
Whole wheat/corn tortillas, 16oz	48	1.24	68	1.47
Brown rice, 16oz	43	2.19	90	2.21
Frozen corn, 16oz	34	2.13	41	2.41
White flour tortillas, 16oz	25	2.50	34	2.85
Tofu, 16oz	18	2.27	21	2.34
Soy milk, 64oz	14	4.12	27	3.40*
Frozen strawberries, 16oz	12	4.22	15	4.08

Note: *p<0.10, **p<0.05, ***p<0.01 for difference between 2009 and 2010.

^2009 prices are adjusted for inflation using US city average CPI for corresponding food categories
Source: Authors' calculations

Table 8: Food Prices in Convenience and Grocery Stores by WIC Authorization Status

	Non-WIC stores					WIC authorized stores				
	2009^		2010			2009^		2010		
	N	Mean, $	N	Mean, $		N	Mean, $	N	Mean, $	
Whole milk, gallon	193	4.08	194	3.89	***	38	4.34	33	4.07	***
Eggs, dozen	187	2.08	192	2.29	***	39	2.00	34	2.10	
Canned vegetables, 15oz	179	1.52	183	1.54		38	1.29	33	1.39	
Canned corn, 15oz	159	1.50	169	1.58	*	33	1.31	31	1.42	
White flour bread, 16oz	155	2.44	167	1.99	***	36	2.26	33	1.61	***
Non-whole grain cereal, 16oz	147	5.55	171	5.58		38	5.07	34	4.75	**
Lower-fat milk, gallon	148	3.73	153	3.62	*	35	4.22	32	4.03	*
Peanut butter, 18oz	145	3.68	165	3.70		38	2.82	33	2.81	
White rice, 16oz	140	1.78	163	2.09	***	35	1.81	34	1.82	
Whole grain cereal, 16oz	128	5.94	154	5.31	***	35	4.93	34	4.63	*
Dry beans/lentils, 1lb	97	1.47	108	1.62	**	38	1.33	34	1.43	
Canned pineapple, 15oz	101	1.79	116	1.86		29	1.61	25	1.82	
Onions, 1lb	79	1.05	79	1.36	***	23	1.10	23	1.51	***
American cheese, 1lb	66	4.82	67	4.94		33	4.79	29	4.69	
Tomatoes, 1lb	77	1.84	80	2.10	**	19	2.30	19	2.14	
Bananas, 1lb	79	1.52	88	1.54		13	0.87	22	1.57	***
Apples, 1lb	69	1.93	69	1.88		9	1.46	30	1.81	*
Lettuce, 1lb	62	1.41	64	1.51		13	1.39	20	1.59	*
Oranges, 1lb	62	2.34	69	2.07		6	1.91	24	1.86	
Baby jarred fruit/vegetables, 4oz	42	1.10	39	0.99		25	0.87	32	0.86	
Orange juice, gallon	50	5.51	64	4.42	***	14	5.94	20	4.51	***
Infant formula powder, 12oz	21	14.78	40	15.62		36	15.60	34	15.69	
Whole wheat/whole grain bread, 16oz	51	2.44	76	2.59		3	2.38	27	2.64	
Canned sardines, 3.75oz	35	1.54	31	1.60		13	1.40	21	1.39	
Whole wheat/corn tortillas, 16oz	33	1.29	50	1.62		15	1.12	18	1.06	
Brown rice, 16oz	35	2.20	58	2.19		8	2.17	32	2.24	
Frozen corn, 16oz	29	2.22	33	2.49		5	1.61	8	2.08	**
White flour tortillas, 16oz	19	2.73	26	3.03		6	1.76	8	2.27	
Tofu, 16oz	17	2.27	20	2.28		1	2.29	1	3.42	
Soy milk, 64oz	13	4.11	24	3.44		1	4.21	3	3.09	

Note: *p<0.10, **p<0.05, ***p<0.01 for difference between 2009 and 2010.
Source: Authors' calculations

Table 9: Variety of Healthy Foods in Convenience and Grocery Stores by WIC Authorization Status

Food	Non-WIC stores			WIC authorized stores		
	2009 N=220	**2010** N=225		**2009** N=39	**2010** N=34	
Milk shelf-space						
Share of lower-fat milk	46.9	44.4		33.4	41.5	*
Variety count						
Total whole grain products	3.0	3.8	**	3.6	6.6	***
Whole grain cereal	1.6	2.0	**	2.4	3.1	**
Whole wheat/whole grain bread	0.9	1.0		0.4	0.9	*
Brown rice	0.3	0.4	*	0.3	1.6	***
Whole wheat/corn tortillas	0.2	0.4	***	0.6	1.0	
Total fruits and vegetables	14.2	14.2		18.6	22.1	
Canned plain vegetables	5.2	4.7		8.2	7.5	
Fresh vegetables	4.0	3.8		4.7	5.1	
Fresh fruit	2.5	2.8		2.6	4.6	*
Frozen vegetables	1.3	1.4		1.3	2.4	
Canned unsweetened fruit	0.7	0.9	**	1.1	1.6	**
Frozen fruit	0.5	0.6		0.7	0.9	

Note: *p<0.10, **p<0.05, ***p<0.01 for difference between 2009 and 2010.
Source: Authors' calculations

Table 10: Price Index in Convenience and Grocery Stores, 2009 Linear Models

	Model 1	Model 2	Model 3	Model 4	Model 5
Store size (# of cash registers, ref.: 1 register)					
2 registers	-0.015	-0.021	-0.019	-0.019	-0.039
3 or more registers	-0.027	-0.037	-0.022	-0.022	-0.042
WIC authorization status (1=yes)		-0.077	-0.088	-0.089	-0.058
SNAP authorization status (1=yes)		0.024	0.012	0.012	0.014
Median household income > $39,200			-0.043	-0.042	-0.081
Distance to nearest supermarket (in 1000ft)				-0.001	-0.006
Density of convenience and grocery stores					0.000
Density of fast food chains					0.007+
Population density (in 1000)					0.068**
Constant	2.787***	2.787***	2.821***	2.824***	2.733***
Std Dev between districts	0.038	0.032	0.024	0.026	0.000
Std Dev between stores	0.318	0.318	0.318	0.318	0.311
Number of observations	192	192	192	192	192

+ p<0.1, * p<0.05, ** p<0.01, *** p<0.001
Source: Authors' calculations

Table 11: Lower-Fat Milk Share in Milk Shelf-Space in Convenience and Grocery Stores, 2009
Linear Models

	Model 1	Model 2	Model 3	Model 4	Model 5
Store size (# of cash registers, ref.: 1 register)					
2 registers	15.233***	15.318***	15.544***	15.518***	14.305***
3 or more registers	17.856+	21.385*	18.041*	18.043*	16.383+
WIC authorization status (1=yes)		1.547	3.103	3.107	4.277
SNAP authorization status (1=yes)		-9.568**	-7.309*	-7.318*	-6.994*
Median household income > $39,200			20.253***	20.177***	14.141**
Distance to nearest supermarket (in 1000ft)				0.054	-0.064
Density of convenience and grocery stores					-0.544+
Density of fast food chains					0.454
Population density (in 1000)					1.416
Constant	44.904***	49.529***	34.027***	33.889***	39.327***
Std Dev between districts	16.399	15.179	12.653	12.641	10.824
Std Dev between stores	21.744	21.731	21.592	21.595	21.872
Number of observations	252	252	252	252	252

+ p<0.1, * p<0.05, ** p<0.01, *** p<0.001
Source: Authors' calculations

Table 12: Count of Fruit and Vegetable Varieties in Convenience and Grocery Stores, 2009 Poisson Models

	Model 1	Model 2	Model 3	Model 4	Model 5
Store size (# of cash registers, ref.: 1 register)					
2 registers	2.552***	2.646***	2.641***	2.712***	2.736***
3 or more registers	8.856***	6.973***	7.038***	7.201***	7.212***
WIC authorization status (1=yes)		1.140*	1.135*	1.143*	1.133*
SNAP authorization status (1=yes)		1.753***	1.742***	1.768***	1.763***
Median household income > $39,200			0.749+	0.650*	0.688+
Distance to nearest supermarket (in 1000ft)				1.078***	1.076***
Density of convenience and grocery stores					0.999
Density of fast food chains					0.996
Population density (in 1000)					0.936
Std Dev between districts	0.703	0.651	0.641	0.678	0.678
Number of observations	267	267	267	267	267

IRR reported as coefficients

+ p<0.1, * p<0.05, ** p<0.01, *** p<0.001
Source: Authors' calculations

Table 13: Count of Whole Grain Varieties in Convenience and Grocery Stores, 2009 Poisson Models

	Model 1	Model 2	Model 3	Model 4	Model 5
Store size (# of cash registers, ref.: 1 register)					
2 registers	2.909***	3.022***	3.014***	2.996***	2.906***
3 or more registers	7.072***	6.840***	7.009***	7.089***	6.865***
WIC authorization status (1=yes)		1.440**	1.420**	1.412**	1.485**
SNAP authorization status (1=yes)		1.151	1.132	1.133	1.139
Median household income > $39,200			0.821	0.745+	0.670*
Distance to nearest supermarket (in 1000ft)				1.054**	1.052*
Density of convenience and grocery stores					0.996
Density of fast food chains					1.016+
Population density (in 1000)					1.117*
Std Dev between districts	0.535	0.540	0.530	0.507	0.452
Number of observations	267	267	267	267	267

IRR reported as coefficients

+ p<0.1, * p<0.05, ** p<0.01, *** p<0.001
Source: Authors' calculations

Table 14: Price Index in Convenience and Grocery Stores, 2009-2010 Growth Linear Models

	Model 1	**Model 2**	**Model 3**	**Model 4**
WIC authorization status (1=yes)	-0.054	-0.058	-0.055	-0.032
Time of measurement (1=2010)	-0.064**	-0.064**	-0.061*	-0.053*
WIC x Time	0.023	0.021	0.021	0.017
Median household income > $39,200		-0.013	-0.013	-0.027
Income x WIC x Time		0.006	-0.003	0.018
Store size (# of cash registers, ref.: 1 register)				
2 registers			0.04	0.027
3 or more registers			-0.039	-0.06
SNAP authorization status (1=yes)				-0.028
Distance to nearest supermarket (in 1000ft)				-0.005
Density of convenience and grocery stores				0.003
Density of fast food chains				0.004
Population density (in 1000)				0.059**
Constant	2.798***	2.806***	2.799***	2.698***
Std Dev between districts	0.084	0.084	0.080	0.054
Std Dev between stores	0.202	0.202	0.203	0.201
Std Dev within stores	0.197	0.197	0.197	0.198
Number of observations	356	356	356	356

+ p<0.1, * p<0.05, ** p<0.01, *** p<0.001
Source: Authors' calculations

Table 15: Lower-Fat Milk Share in Milk Shelf-Space in Convenience and Grocery Stores, 2009-2010 Growth Linear Models

	Model 1	**Model 2**	**Model 3**	**Model 4**
WIC authorization status (1=yes)	-1.922	0.73	1.239	5.192
Time of measurement (1=2010)	-2.736*	-2.731*	-2.541+	-2.416+
WIC x Time	9.388**	13.353***	13.462***	12.130**
Median household income > $39,200		21.675***	21.246***	11.093*
Income x WIC x Time		-14.555*	-16.580*	-14.496*
Store size (# of cash registers, ref.: 1 register)				
2 registers			8.349**	7.466**
3 or more registers			9.826	8.645
SNAP authorization status (1=yes)				-6.120*
Distance to nearest supermarket (in 1000ft)				0.022
Density of convenience and grocery stores				-0.749*
Density of fast food chains				0.616*
Population density (in 1000)				2.180
Constant	48.437***	32.951***	31.320***	42.098***
Std Dev between districts	15.380	12.53	12.399	9.617
Std Dev between stores	18.633	18.527	17.895	17.967
Std Dev within stores	13.612	13.485	13.530	13.480
Number of observations	473	473	473	473

+ p<0.1, * p<0.05, ** p<0.01, *** p<0.001
Source: Authors' calculations

Table 16: Count of Fruit and Vegetable Varieties in Convenience and Grocery Stores, 2009-2010 Growth Poisson Models

	Model 1	Model 2	Model 3	Model 4
			IRR	
WIC authorization status (1=yes)	1.740**	1.589*	1.590*	1.331
Time of measurement (1=2010)	0.998	0.998	1.007	0.946+
WIC x Time	1.110+	1.150*	1.170*	1.238**
Median household income > $39,200		0.672*	0.667*	0.710+
Income x WIC x Time		0.88	0.833	0.774*
Store size (# of cash registers, ref.: 1 register)				
2 registers			1.201**	1.270***
3 or more registers			1.260+	1.400**
SNAP authorization status (1=yes)				1.410***
Distance to nearest supermarket (in 1000ft)				1.036***
Density of convenience and grocery stores				1.007
Density of fast food chains				0.984
Population density (in 1000)				1.025
Constant	8.447***	11.080***	10.681***	7.422***
Std Dev between districts	0.404	0.365	0.360	0.403
Std Dev between stores	0.929	0.929	0.897	0.816
Number of observations	504	504	504	504

+ p<0.1, * p<0.05, ** p<0.01, *** p<0.001
Source: Authors' calculations

Table 17: Count of Whole Grain Varieties in Convenience and Grocery Stores, 2009-2010 Growth Poisson Models

	Model 1	Model 2	Model 3	Model 4
			IRR	
WIC authorization status (1=yes)	1.565*	1.466*	1.487*	1.435*
Time of measurement (1=2010)	1.259***	1.259***	1.330***	1.246***
WIC x Time	1.426**	1.598**	1.592**	1.616***
Median household income > $39,200		0.794	0.756*	0.675*
Income x WIC x Time		0.69	0.594*	0.599*
Store size (# of cash registers, ref: 1 register)				
2 registers			1.977***	1.937***
3 or more registers			4.257***	3.948***
SNAP authorization status (1=yes)				1.208*
Distance to nearest supermarket (in 1000ft)				1.032*
Density of convenience and grocery stores				0.994
Density of fast food chains				1.008
Population density (in 1000)				1.104+
Constant	2.067***	2.412***	2.097***	1.635*
Std Dev between districts	0.328	0.310	0.316	0.269
Std Dev between stores	0.764	0.768	0.601	0.590
Number of observations	504	504	504	504

+ p<0.1, * p<0.05, ** p<0.01, *** p<0.001
Source: Authors' calculations

Table 18: WIC Vendor Participation in Connecticut 2008-2010

	5/2008-9/2008	10/2008-2/2009	3/2009-7/2009	8/2009-12/2010	1/2010-5/2010	6/2010-10/2010
			Number of Stores			
(1) Pharmacy	112	110	111	111	110	107
(2) Supermarket chain	213	208	205	198	192	196
(3) Grocery, convenience stores and food marts	280	252	239	236	237	235
Total Stores	**605**	**570**	**555**	**545**	**539**	**538**

Source: Authors' calculations