The 2009 WIC Program Revisions: An Analysis of the Policy, Health Outcomes, and Costs

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ABSTRACT

Objective: This paper evaluates the effect of the 2009 revisions to the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) food packages intended to increase access and consumption of a varied, healthy diet.

Methods: This paper uses methodological triangulation to address whether the WIC program achieved its stated goals of improving access to healthy foods within the first year of implementing new food packages. I provide a synthesis of the current state of the field, a secondary analysis of a large nationally representative survey, and a limited review of economic evaluations of the WIC program.

Results: The revisions to the WIC food packages in part reflect a political movement to respond to the growing obesity epidemic in the United States. A series of Congressional hearings followed by reports from the Government Accountability Office and the Institute of Medicine provide the groundwork for a change in WIC program policy. The review of recent studies of the effect of the food package changes suggests that implementation was successful, as stores succeeded in adjusting inventories to comply with new regulations and participants are, in general, eating a healthier diet compared to before the revisions. I conducted a pre-post analysis of NHANES data comparing food item availability, food security, and BMI among WIC participants, and found that even within one year after implementation, WIC participants were on average more likely to have access to healthy foods (fruits, vegetables, low-fat milk) after the food package revisions, than before. Food security also improved for children after the policy change, though within this short time frame no reduction in obesity was observed. My literature review of economic evaluations found few published articles addressing WIC program costs as they pertain to participant health and health care utilization. However, a review of
government documents shows that researchers acknowledge the lack of cost outcomes, and provide guidelines for future research.

**Conclusion:** These findings demonstrate that the WIC program has responded to growing national concern about nutrition and health, and has successfully adapted the program to respond to the higher prevalence of obesity, particularly among children. The policy changes implemented in 2009 are largely successful in reaching one of its stated goals - increasing access to a more varied and healthier diet for participants. I provide specific recommendations for future research emphasizing the importance of multi-state analyses and the inclusion of program and health care costs.
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INTRODUCTION

The Special Supplemental Nutrition Program for Women and Children, also known as WIC, was established in 1972 as a pilot program to provide supplemental foods to poor pregnant women and small children who were at nutritional risk. Since its inception, participation in WIC has grown rapidly, and the scope of services offered through the program has also expanded. In addition to paying for select foods through a monthly voucher or special electronic benefit (EBT) card, WIC provides education to participants about nutrition, healthy dietary choices, and child development; it also provides support for breastfeeding, and serves as a medical referral center. WIC often becomes a gateway for participants to enter the health care system, by facilitating preventive services such as vaccinations, and providing resources for participants to seek appropriate medical care when necessary.

In the fall of 2009, the WIC program underwent the first revision to its food packages since 1980. The food package revisions changed the content of food provided to participants to include a more varied and healthier selection of food items. For the first time, the packages were required to include fruits, vegetables, and whole grains, and allowed for cultural dietary preferences among participants. The new food packages were designed to be in line with the American Academy of Pediatrics recommendations and the US Dietary Guidelines for healthy pregnancies and child growth and development.

This study triangulates methods to address this recent policy revision, I will first provide a historical context and describe the development of the policy that ultimately led to the food package revisions. Then, I will present a secondary analysis of National Health and Nutrition Examination Survey (NHANES) data created by the Centers for
Disease Control and Prevention. To my knowledge, this analysis is the first evaluation of the effect of the new food packages on a national sample of WIC participants. Finally, I review literature describing WIC program costs. These three methodological approaches allow me to provide a more complete and multi-dimensional description of the development of the WIC policy changes and the subsequent effect these changes had on WIC participants. Finally, this study will conclude with specific recommendations for future research.
THEORETICAL PERSPECTIVES

WIC Program: Historical Background

The Special Supplemental Nutrition Program for Women, Infants, and Children (also known as WIC), was created as a two-year pilot program in 1972 by an amendment to the Child Nutrition Act of 1966. This amendment was a response to a growing concern among the American public during the mid 1960s about the prevalence of malnutrition among low-income Americans. This public concern was stimulated by events such as the Poor People’s March on Washington and a television documentary titled “Hunger in America”. The White House Conference on Food, Nutrition, and Health convened in 1969 and concluded with recommendations to pay careful attention to the nutritional needs of low-income pregnant women and young children. In 1969, the US Department of Agriculture (USDA) established a food program called the Supplemental Food Program that would become the predecessor for WIC; this earlier incarnation provided food supplementation to low-income pregnant women, infants, and young children. It was soon determined, however, that, even taken together, the Supplemental Food Program and the existing Food Stamp Program were not meeting the nutritional needs of women and children.

On September 26, 1972 the WIC program was formally authorized as a pilot program modeled on a clinic and commissary voucher program developed at Johns Hopkins University in 1968. Although initially the program was not structured to include formal nutrition education or health care referrals, a clinical link was set in place by requiring that beneficiaries have a nutritional risk assessment performed by health care professionals. The USDA initially moved slowly to implement the program; the first WIC
site did not open until January 1974 in Pineville, Kentucky. However, by the end of 1974 WIC had sites in 45 states. In October 1975, WIC was permanently established as a federal nutrition assistance program by PL 94-105 to amend the National School Lunch Act and Child Nutrition Act of 1966. As written in the law, the purpose of the program is to “provide supplemental nutritious food as an adjunct to good health care during such critical times of growth and development in order to prevent the occurrence of health problems.” In the following years, adjustments were made to WIC in order to provide more clarity and standardization. In 1978, nutrition risk was defined, income eligibility standards were linked to standards used in the school lunch program, and the program was linked to clinical referral services including immunizations and family planning. In 1980, the USDA adjusted the contents of the food package so there would be a maximum of 6 grams of sugar per dry ounce for adult cereals. This was the last time the WIC food packages were revised until the changes finalized in 2009.

**WIC Program: Structure and Eligibility**

WIC is a discretionary program funded by cash grants from the USDA appropriated yearly to WIC State agencies. Congress appropriated $6.522 billion for WIC in FY 2013. The program relies on a multi-tiered administrative model that integrates Federal, state, and local agencies to administer and deliver services to participants. Currently there are 90 WIC State agencies, including Washington DC, U.S. territories, and Indian Tribal Organizations. The Federal agency is responsible for providing the majority of WIC funds. As a discretionary spending program, WIC provides services to those who meet eligibility requirements up to the maximum yearly budget.
provided by the federal government. State matching is not required; however States can use their own funds to supplement the federal grant. In addition to providing funds, at the Federal level, the Food and Nutrition Services department within the USDA and its associated regional offices provide program administration and support services, set nutritional risk eligibility standards, issue regulations, and monitor compliance with these regulations.

State agencies coordinate program operations and have the option to adjust program design within pre-determined bounds. States can adjust income eligibility requirements and can specify certain brands or price requirements for foods purchased with WIC funds. This flexibility can help contain overall program costs, and allow more participation in the program. The 90 WIC state agencies contract with more than 10,000 local WIC agencies that provide services to WIC participants.

Local agencies are mostly state and county health departments, but can also be public or private service agencies; they may be located in clinics, hospitals, community centers, mobile vans, and schools. Services that are required to be provided in WIC centers include nutrition risk assessment, breastfeeding promotion, health care referrals when necessary, and access to the appropriate Food Package. Food Packages are provided by sending participants the appropriate WIC vouchers or an EBT card so that they may purchase the food at local WIC-approved stores.

Eligibility criteria for the WIC program include categorical, income, and residency requirements. The categorical groups are infants (age 0 to 1 year), children (up to the child’s fifth birthday), and three categories of eligible women: pregnant (during pregnancy, up to 6 weeks after delivery), postpartum (up to 6 months after the birth of the child or end of pregnancy), breastfeeding (up to the infant’s first birthday). Income requirements can vary by states, but applicants must have income at or below the
income level set by the State agency to which they are applying. Income standard must be between 100 percent to 185 percent of the Federal poverty income guidelines. Applicants who also participate or have family members who participate in other federal welfare programs (e.g. Food Stamps, “welfare,” formerly Aid to Families with Dependent Children, and since 1996 the more restrictive Temporary Assistance for Needy Families, Medicaid, or free or subsidized school lunch programs) are deemed to meet income eligibility criteria automatically. Residential criteria require the applicant to show proof of residency in the state or territory in which they are applying for WIC services. Applicants do not have to meet duration or length-of-residency requirements in order to meet the WIC residency requirement.

Participant Characteristics. The most recent WIC report, released in 2013, says that in April 2012, 9.7 million women, infants, and children were enrolled in WIC. Enrollment occurs within a six or twelve month period and enrollment figures are measured on a monthly basis. Half (53.4%) of enrollees were children, about a quarter (23.0%) were infants, and the rest were women, most of whom were pregnant (10.1% of all participants). Most pregnant women enrolled in WIC during their first trimester (56.9%), and only 7.8% enrolled in the third trimester.

Racial and ethnic characteristics of WIC beneficiaries are collected separately to fulfill Office of Management and Budget requirements, and “Hispanic or Latino” is not offered as a racial identification choice, although multiple race identifications are permitted. Hispanic origin is queried in a separate indicator of ethnicity. In 2012, 58.2% of all participants reported their race as White, 19.8% reported as African American Only, and 3.9% reported either as Asian, Native Hawaiian, or Other Pacific Islander Only, the remaining 8% identified as another racial group or mixed race. Forty-one percent (41.5%) of participants reported Hispanic/Latino ethnicity.
Household income was not reported by 8.3 percent of WIC participants in 2012. However, among the vast majority of those who reported, the average annual income of WIC participant families in April 2012 was $16,842. Among participant groups, families of breastfeeding women reported the highest income at $17,958, and postpartum women had the lowest income at $12,962. WIC participants come from households significantly poorer than the average US household. In 2012, 73.1% of WIC participants had incomes below the Federal Poverty Level (100% FPL), while only 15% of the general population that had incomes below this level.

**Food Packages.** As described above, WIC participants receive several program services intended to provide supplemental food, health education, and health care referrals. The food packages were one of the services established at the program’s inception. With the exception of the sugar limit set in 1980, almost no modifications had been made to the original food packages offered to WIC participants since 1972 until the recent revision that went into effect in 2009. Prior to this revision, the food packages included food products that contain “nutrients known to be lacking in the diets of populations at nutritional risk,” and it was specified in the law that these foods contain “high-quality protein, iron, calcium, vitamin A, and vitamin C”\(^5\). The foods included in the packages were iron-fortified infant formula, iron-fortified infant and adult cereal, vitamin C-enriched fruit and/or vegetable juice, eggs, milk, cheese, and peanut butter. Breastfeeding women were eligible to also receive carrots and canned tuna\(^3\). Packages were determined by categorical groupings, as outlined in Table 1.
As the table above shows, the original food packages lacked fresh produce for all participants, except that a small monthly allowance of carrots was available to some breastfeeding women. In 1992, a separate program called the Farmer’s Market Nutrition program was established by the WIC Farmers’ Market Nutrition Act of 1992 (PL 102-314). This small program is associated with the WIC program but functions separately and is not available in all States or Territories that offer WIC. Before the WIC food packages were revised in 2009, the Farmer’s Market program was the only program that could provide access to fresh fruits and vegetables to some eligible WIC participants. The 2009 revisions ultimately led to the inclusion of fresh fruits and vegetables, along with other changes to the food packages. Below, I describe the political momentum changes of the 1990s and early 2000s that led to these changes in the content of the food packages.

**Political Momentum Leading to Policy Change**

From its inception, WIC has benefitted from strong bipartisan congressional support that has allowed the program to continue to grow over the last thirty years. In 1976 the federal appropriations for WIC was $106 million and the program served approximately 344,000 women and children\textsuperscript{11,12}. The program received expanded funding over the next decades allowing the program to grow rapidly, although its budget may not have grown as rapidly as did its number of participants. By 1994, the program received $3.2 billion in federal grants, almost a 12-fold increase in constant dollars, and had approximately 7 million participants, a twenty-fold increase\textsuperscript{12}. This period of rapid growth witnessed disproportionate expansion in Western states like California, growing from 13\% of total WIC participants in 1988 to 24\% ten years later. This geographic
growth and the diversification of the general population resulted in a change in overall WIC demographics. This was particularly evident in the proportion of Hispanic participants which grew from 21% in 1988 to 32% in 1998\textsuperscript{13}.

With the diversification of the participant population, the program began to receive criticism that the food provided by the program did not provide culturally appropriate foods\textsuperscript{14}. Other complaints about the food packages throughout the 1980s included the lack of fresh produce, over reliance on high-calorie foods like whole milk, cheeses, and fruit juices, and the lack of breastfeeding promotion. Gradually, increasing interest in nutrition and the growing prevalence of obesity contributed to a political environment favorable to revising the WIC food packages in order to address these concerns.

Concerns about the content of the food packages, however, had begun soon after the program was fully implemented in 1974. In 1978, PL 95-627 required the Secretary of Agriculture to assure that the fat, sugar, and salt content of the foods provided by WIC “were appropriate,” however the law did not define appropriate levels of these ingredients. Two years later, the USDA set a cap on the sugar content of cereals at 6 gram per ounce in response to concern from health advocates about the effect of a high sugar diet particularly on dental health\textsuperscript{15}.

The concern over the low rates of breastfeeding among WIC participants resulted in the USDA enhancing their breastfeeding promotion strategies in several different ways\textsuperscript{16}. Early on, the USDA responded to the low breastfeeding rates by including increased promotion of breastfeeding in The Child Nutrition and WIC Reauthorization Act of 1989 (PL 101-147). Later, a Congressional Hearing specifically to discuss breastfeeding was held in May 1992 at which Catherine Bertini, the Assistant Secretary for Food and Consumer Services at the USDA, testified about the largest proposed
funding increase by any President to date for the WIC program ($223 million) and delineated how the USDA was to make breastfeeding a priority. Assistant Secretary Bertini described forthcoming changes to the WIC food packages for breastfeeding women including enhanced benefits for exclusively breastfeeding mothers, additional grants to promote breastfeeding, and increasing education and support\textsuperscript{17}.

In 1992, WIC rolled out a new food package (Package VII) for mothers who breastfeed that included the first vegetable option for participants: fresh, frozen, or canned carrots. This new package demonstrated an acknowledgment by the USDA and WIC that the program needed to take more action to promote breastfeeding. Studies conducted in the late 1980s and early 1990s found that WIC participants had lower breastfeeding rates than did women in the nation as a whole, with only half of all WIC mothers initiating breastfeeding at the hospital\textsuperscript{18}.

While WIC was enhancing breastfeeding promotion, the program’s cost became a central issue. As a discretionary spending program, WIC can only provide services to eligible participants with funds the USDA provides. To provide services to more participants, WIC looked for ways to reduce costs. Infant formula purchases were by far the largest food-purchasing expense within the program; therefore, in an attempt to lower costs WIC used the large purchasing power it had with infant formula manufacturers to negotiate rebates. In 1986, Tennessee was the first state to successfully receive infant formula rebates and in the WIC Reauthorization Act of 1989, all WIC agencies were required to do the same\textsuperscript{19}. The infant formula rebate program continues to provide substantial savings for the WIC program.

Two years after this cost-containment measure began, pursuant to a congressional request, the Government Accountability Office (GAO) conducted a review of the breastfeeding promotion measures done by WIC. The GAO report found that the
USDA and state WIC programs had noticeably improved their breastfeeding promotional efforts since 1989 and noted that there had been an increase in breastfeeding among WIC participants. However, it reported that the GAO could not confirm whether this increase was directly caused by increased promotion and education by WIC. Additionally, it noted that the infant formula rebate program was successfully lowering the total cost of food expenditures for the program and that the new breastfeeding promotional efforts were not found to reduce program costs, as some had proposed (via reduction of infant formula purchases) because of the additional benefits provided in the new enhanced food package (supplemental infant formula, carrots, and tuna)\textsuperscript{20}.

Introduction of a larger variety of fresh produce was also made available to WIC participants at this time when the WIC Farmer’s Market Nutrition Act of 1992 established the Farmer’s Market program to work alongside but independently from WIC (PL 102-314). Women and children who were eligible - and lived in the few states that offered this small program - received vouchers to purchase uncooked produce directly from farmer’s markets. Few studies have analyzed the benefits of this program and the degree to which it improves access to fresh produce. However, a study in 1991 on the initial pilot program found that women were more likely to shop at farmer’s markets if they were program participants\textsuperscript{3}. The Farmer’s Market program continues to be a small adjunct program not available in all US States or Territories.

Instead of expanding and integrating the Farmer’s Market program to all WIC sites, there was a growing call to change the existing WIC program to respond to the largest nutrition problem facing Americans: obesity. The concern over the growing prevalence of obesity became more pronounced throughout the 1990s and spurred elected officials, health professional organizations, and public health scholars to
consider ways in which the WIC program could potentially reduce the burden of overweight and obesity early in life. A CDC study published in 1998 found that approximately 10% of children enrolled in WIC were overweight, an increase of 20 percent from 1983. Some scholars began to call attention to the low nutritional content of the food packages and the overrepresentation of high-fat foods in the packages as well as the lack of culturally diverse food items available to participants. Concerns also arose about the definition of “nutrition risk” to determine program eligibility, and whether the non-specific criteria could be contributing to fraud and abuse of the program.

Although “nutrition risk” was defined by law in 1978 there was considerable ambiguity in the language used to describe the term:

A) detrimental or abnormal nutritional conditions detectable by biochemical or anthropometric measurements,
B) other documented nutritionally related medical conditions,
C) dietary deficiencies that impair or endanger health, or
D) conditions that predispose persons to inadequate nutritional patterns or nutritionally related medical conditions, including, but not limited to, alcoholism and drug addiction. (PL 95-627 Sec.17(b)(8))

Therefore, during the late 1990s there was again support to provide greater specificity for eligibility, now with the added focus on food nutrition and obesity prevention. In 1996, the Institute of Medicine (IOM) released a study that reported inconsistencies in nutrition risk criteria among State agencies and prompted Congress to hold hearings to discuss potential changes to the program. A joint National Association of WIC Directors (NAWD)/FNS workgroup called the Risk Identification and Selection Collaborative (RISC) was formed to review each of the criteria addressed by IOM. On March 17, 1998 the
Subcommittee on Early Childhood, Youth and Families held a hearing in Washington to discuss child nutrition and focused on the WIC program. Continued dialogue about the program prompted a change in WIC policy in 1999 to develop standardized nutrition risk criteria. Prior to the new rule’s implementation, each State agency was tasked to develop its own nutrition risk criteria, which resulted in the broad inconsistencies noted by the GAO. The rule from the USDA in 1999 changed this by requiring WIC State agencies to use consistently defined nutrition risk criteria selected from a list of nearly 100 risk factors, including hemoglobin and hematocrit levels, weight, and height.

Redefining the nutrition risk criteria, however, did not address the growing problem of obesity among WIC participants. Studies at this time found that WIC participants had higher rates of obesity than did non-participants, and although the USDA noted that these trends were likely associated with the higher rates of obesity among the low-income minorities overrepresented in the program, no substantive changes were initiated within WIC to address the problem. The academic community continued to call on the USDA to act on both the nutritional quality and cultural diversity of the food packages, and in 2000 the National Association of WIC Directors (NAWD, now titled National WIC Association) formally called on the USDA to revise its food packages.

In the NAWD report, the association recommended revising the food packages so that they are consistent with dietary recommendations made in the "Dietary Guidelines for Americans." They requested that WIC include fresh fruits and vegetables in the food package, provide lower-fat milk, and allow for a greater variety of nutritious and culturally appropriate food choices. This revision would likely increase the scope and required funding of the program. There were other groups who believed that WIC should not continue to grow as it had been and instead limit its services to those in
greatest need. One of these groups was the conservative think tank, American Enterprise Institute, which published its own study of the WIC program in 2001. In this report the Institute claimed that most of the health outcomes attributed to WIC come from studies that were at that point nearly twenty years old and suffered from selection bias, because there were no randomized studies to provide data to differential the eligible low-income women and children who participate in the program and those who do not. The concern that WIC studies were outdated and at high risk for selection bias was echoed by other scholars and Congress members. However, at this time the priority for the USDA and WIC was to address the issue of nutritional value offered in the food packages, and it was not until 2011, ten years after the AEI first published their methodological concerns, that the IOM published its own report addressing the issue of selection bias and proposed strategies for future WIC research.

Following the recommendations made by NAWD in 2000, the GAO published a report titled “WIC faces challenges in providing nutrition services.” Here, the GAO recommend evaluation of WIC’s nutrition services, and provided 16 specific improvement strategies including standardizing the professional staffing requirements, providing staff educational development, and allowing food packages to be more flexible to suit the needs of participants. In response to this report, the Food and Nutrition Services (FNS) published yet another report of the WIC program in which it provides an extensive history of the program, and describes several issues of concern including low breastfeeding rates, content of food packages, and cost containment. The report concludes that the WIC program serves as an important gateway for many low-income Americans into the health care system and therefore it is important to the Department that WIC be as effective in providing services as possible. It also notes that additional research is necessary to know which changes the program should make and reports that
both the USDA’s Economic Research Service and the Food and Nutrition Service were at that time, the late 1990s and early 2000s, conducting several research projects to help shed light on potential strategies. Over the next three years, the information from these government-commissioned studies, other independent analyses, and a Congressional Hearing titled “Food for Thought: How to Improve Child Nutrition Programs” provided the momentum necessary to move forward with policy change. In 2004, the WIC program was reauthorized without any changes to the food packages. It was also in 2004 when, at the congressional hearing, the Undersecretary of the USDA Eric Bost, announced that the IOM had been requested to analyze the food packages and make recommendations on potential change.

Table 2 about here

In its landmark report, “WIC Food Packages: Time for a Change,” the IOM provides strategies by which WIC can revise the contents of the food packages so that they are in line with the Dietary Guidelines for Americans (over age 2), while allowing flexibility to provide foods that are culturally appropriate for the diverse population WIC serves, all while remaining cost-neutral, as specified by the USDA. After the publication of this report, other advocacy and health professional groups supported the proposed changes, including the American Academy of Pediatrics and the American Heart Association. The following year the USDA proposed a set of revised rules that largely reflected the recommendations of the IOM report, and opened the proposals for public comments. In 2007 these proposals were implemented as an interim rule to take effect no later than August 2009. The remainder of this analysis is devoted to determining whether the implementation of the 2009 revision to the WIC food packages was
successful. Specifically, I ask whether the changes achieved the stated goals of improving health outcomes and health behaviors, as well as asking whether we have evidence of the cost benefit of the program before and after the revisions.

**METHODS**

To provide a comprehensive analysis of the WIC policy revisions and the subsequent effect of these changes, this paper involves a triangulation of methodological approaches. First, I completed a literature review and analysis of the political “state of field” in order to describe the political context and influence of stakeholders that led to policy change. A second portion of the literature review focused on the success of the policy implementation, and is included in the “Findings” section of this paper. Second, using data from the NHANES database available through the Centers for Disease Control and Prevention, I performed a secondary cross-sectional analysis of interview and physical examination data before and after the WIC change. This data analysis describes the effect of food package changes on the health and dietary behaviors among a national sample of participants. Third, I completed a limited literature review of program cost evaluations. Analyzing the effect of the WIC policy changes through these three different methodological lenses provides a more complete picture of the context that ultimately lead to the policy change and a better understanding of the success of the implementation to date.

**Policy Analysis: State of the Field**

Given the intersection of public policy, nutrition, and health influencing WIC’s development, it was necessary to craft several search strategies in order to complete a
policy analysis of the WIC program, including searching both traditional academic literature and grey literature. For peer-reviewed literature, I primarily used the PAIS (Public Affairs Information Service) database for literature of public policy and social sciences. Additionally, I used the Google Scholar search engine which provided access to a greater variety of peer-reviewed literature than was otherwise accessible through medical databases like PubMed. In both of these search sites, I used the following key search terms to find literature about the development of the revised food package policy and its implementation: **WIC, 2009, policy**. To search literature describing the WIC program in general and the political climate leading up to the policy change, I used the following key search terms: **WIC, nutrition, USDA**.

By definition, locating key grey literature resources was more challenging. However, thanks to the digitalization of government documents, much of the relevant literature is accessible through government websites. To find relevant articles and reports, I used a modified snowball method to include sentinel reports and reports cited in the peer-reviewed literature. For example, to find the Institute of Medicine’s landmark 2005 report **WIC Food Packages: Time for a Change** I searched the National Academy Press’ website; I retrieved congressional hearings through the U.S. Government Printing Office website, and official U.S. Government Accountability Office reports from the GAO website. I located individual documents were located by using key terms such as “WIC,” “nutrition,” and “food packages” at each of these websites.

**Secondary Cross-sectional Data Analysis**

The key question guiding this analysis of NHANES data is whether the revised food packages implemented in fall 2009 led to an immediate and measurable change in the diet, food purchasing behavior, food security, and health of WIC participants. To get
an indirect, aggregate look at this question I used data the CDC’s National Health and Nutrition Examination Survey (NHANES) database. NHANES is a series of surveys that examine a nationally representative sample of approximately 5,000 people each year. NHANES data are compiled and reported biannually and include de-identified demographic, socioeconomic, food consumption behavior, and health-related data.

The NHANES project also provides clinical and laboratory data on survey respondents, including anthropomorphic measures like weight and BMI. The CDC encourages the use of these data for further research and provides free access to datasets, questionnaire forms, documentation, and codebooks for all NHANES data on the NHANES website (http://www.cdc.gov/nchs/nhanes.htm).

For this paper, I used two survey sessions of the NHANES data (2007-2008 and 2009-2010) to examine the effect of the food package revisions in 2009 on the health and behavior of WIC participants. I conducted the statistical data analysis using R (version 3.1.0) by first importing and converting the original SAS data format into the R statistical package. I included datasets in which the key outcome variables relate to nutrition, food purchasing behavior, WIC enrollment, demographics, food security measures, and body measurements. These aforementioned variables constitute the inclusion criteria for the data analysis. The data file names from NHANES included in this analysis are

“Consumer Behavior” - Questionnaire
“Food Security” - Questionnaire
“Demographic Variables and Sample Weights” – Demographic
“Body Measures” - Examination
I merged these four datasets by study year (either 2007-2008 or 2009-2010) creating two large datasets, one for each period. I then eliminated columns of variables that would not be used in the final analysis and eliminated rows of survey respondents who did not answer “yes” to receiving WIC services in the last twelve months. By limiting the data in this way, I was able to retain only WIC participants in the data, in order to perform the pre-post analysis of the effect of the revised food packages.

I compared bivariate analyses by WIC status using chi-square tests and independent t-tests. Means for each variable of interest excluded missing data and included only self-reported WIC participants.

For further details regarding the NHANES database, including questionnaires, and the statistical data analysis please refer to Appendix 2 – Methods.

Limited Review of Cost Literature

The purpose of this limited review of cost literature is to provide a description of the current cost literature and where potential gaps in research lie. In order to find relevant documents for this search I search both grey literature and peer-reviewed academic publications. For peer-reviewed academic literature, I searched the PAIS database and Google Scholar search engine. To ensure the articles were cost reviews or cost analyses the search limitations for all three search databases were the inclusion of the words “WIC” and “Cost” in the abstract or title. Articles were excluded if the focus of the article was not participant health outcomes and instead infant formula rebate costs or the farmer’s market program.

For grey literature, I searched the U.S. GAO exclusively for cost evaluations of the WIC program, as it is this department that has been tasked by Congress to conduct
specific studies of WIC’s costs. Documents included in this review are those that provide national evaluations of program costs and benefits.

**FINDINGS**

**Policy Implementation**

At the time WIC authorized revisions to their food packages, there were increasingly more calls to action from public health scholars to respond to the childhood obesity epidemic in the United States. In 2010, Thomas Frieden, Director of the CDC, wrote an article in *Health Affairs* describing the pressing public health concerns caused by the childhood obesity epidemic, and delineated policy initiatives that may hold promise for reducing this health burden\(^35\). Frieden suggests key components that could reduce obesity among children include lowering the price of healthy foods, making healthy food more accessible by providing them in neighborhood stores, expanding access to farmer’s markets, and reducing access to less healthy foods. The WIC program aims to address aspects of all of those components. However, few studies have measured the degree to which the policy revision has led to changes in diet, food access, and health among participants.

The first published analyses of the WIC food package revisions were authored by researchers at the Rudd Center for Food Policy and Obesity at Yale University. Between 2011 and 2013, the Center published eight articles analyzing aspects of the implementation of the new WIC policy, with a focus on the effects on the local food economy\(^36-43\). These studies show that small corner stores in New England accepted the food package changes and quickly adapted to the new requirements, thus providing a
greater selection of healthy foods to their customers. Other studies from the Center show that participants responded to the new WIC packages by purchasing more whole grain products and less fruit juice, as was intended. The Center conducted studies in small corner stores and large supermarket chains, conducting vendor interviews, and various inventory analyses to show that the WIC program is increasing access to healthy foods and that the WIC-approved vendors who were required to adjust their inventory were able to do so with general success. However, the overarching limitation in the Center’s research is the geographic centralization of their work. The research overrepresents the North Eastern region of the United States, particularly Connecticut where the Center is based. The geographically limited distribution of studies reflects the location of the researchers and is not necessarily related to other variables of interest such as areas of greatest potential change in food accessibility or significant nutritional deficiency.

Researchers also found that WIC participants were adjusting their dietary behavior and consuming the healthier food now available through WIC. Whaley and colleagues recorded statistically significant changes in the dietary habits of WIC participants in California to include healthier foods. Similarly, Chiasson, Findley, Sekhobo, Scheinmann, Edmunds, Faly, McLeod as well as Odoms-Young, Kong, Schiffer, Porter, Blumstein, Bess, Berbaum, Fitzgibbon measured positive dietary changes in participants in New York state and Chicago, respectively. The degree to which participants adjusted their dietary behavior in response to the changes in the WIC food packages varied across studies, and also varied by racial/ethnic groups, types of food, and ages. For a detailed review and critical appraisal of the literature please refer to Appendix 1 – Limited Systematic Review.
There is consensus in the literature that the WIC policy changes were successfully implemented and led to measureable improvements in access to healthy foods for WIC and non-WIC consumers, particularly in low-income neighborhoods. The evidence also shows a consistent trend of increased healthy food (vegetables, fruit, whole grains) consumption among WIC participants after the policy change. These initial results provide evidence that the WIC program is reaching its intended goals, though the magnitude of effect is varied. There are several important limitations in this evidence base.

I identified no study that used a representative multi-state or national sample of WIC participants to analyze the changes in health behavior, diet, food purchases, or health measures (like BMI). Although several studies investigate the effect of the WIC policy changes on store inventories and perceived successes and challenges of implementation, they are limited geographically and by store type. There is a high risk of selection bias among these studies partly because stores that were WIC-eligible before the food package revisions but were no longer WIC-eligible at the time of the post-interview or inventory review were excluded from the studies. A description of the experience of these store owners and the potential failure to meet new eligibility requirements would provide a more complete picture of the challenges faced in implementing this policy, or reveal potential confounding variables that differentiate stores associated with WIC and those that are not.

**Secondary Cross-sectional Data Analysis**

Overall, NHANES respondents who self-identified as WIC participants in 2007-2008 and 2009-2010 were comparable with respect to gender, US Citizenship, race and
ethnicity, and household income (Table 3). Mean age differed among WIC participants from the two survey cycles (13.5 vs. 25.1 years); this may indicate a greater proportion of children captured in the first survey compared to the second. Comparing WIC participants to non-WIC participants, there were large differences in household income, as can be expected because low-income is an eligibility requirement for enrollment in the program. Gender and citizenship were similar between the two groups, while proportions of racial groups among WIC participants and the general public differed greatly. Among WIC participants, Mexican Americans are overrepresented, comprising 40% of all WIC participants in both surveys compared to approximately 20% in the non-WIC cohort.

Table 3 goes about here (characteristics)

Pre-post bivariate analyses of WIC participants show statistically significant differences among all variables of interest. After the WIC food package revisions, WIC participants were on average more likely to have fruit, dark green vegetables, and low-fat milk available in their homes. Food item availability was coded on a scale from 1 to 5, 1 meaning always available, and 5 meaning never; therefore, a lower availability score represents greater food availability. Fruits and vegetables could be fresh, frozen, canned, or dried. Low-fat milk includes only 1%, skim, or fat-free milk, and does not include 2% milk. Soda includes sugary drinks such as any soft-drinks, fruit-flavored drinks, or fruit punch; this excludes diet drinks, 100% juice, and sports drinks. Salty snacks were defined as foods “such as chips or crackers” excluding nuts. All food types measured in the survey that were newly added to the WIC food packages (fruits, vegetables, and low-fat milk) were more likely to be available after the food package
revisions than before (Table 4). Foods that were less healthy were less likely to be available among WIC participants after 2009.

Mean body measurements (BMI and weight) among WIC participants increased slightly after 2009. BMI increased from a mean of 23.14 to 23.98, and weight increased by a mean of 5kg. The relative stability of mean BMI could be explained by the short time period between surveys in which little change in body mass would be expected to occur for WIC participants receiving new food packages. The larger difference in average weight is likely a reflection of the difference in average age between the two surveys. Children are likely overrepresented in 2007-2008 and the mean weight in this group is lower, as expected.

Food Security score is a composite (range = 1-4) of several questions in the survey, 18 if children live in the homes or 10 in homes without children, related to availability of food and need for emergency food assistance. Full food security, a score of 1, is defined as having no composite questions answered affirmatively. This score represents households with constant availability of adequate amounts of food for all persons living in the home. Very low food security, a score of 4, describes households with inadequate amounts of food, where family members may go without eating for a whole day, or frequently skip meals. Among WIC participants, after the 2009 food package revisions, the average household food security score increased (worsened) slightly, from 2.03 to 2.09, though it remained in the “marginal food security range.” Child food security scores fell (improved) by 0.18 score points, towards greater average food security. The slight worsening of household food security between 2007 and 2009 could
be associated with the economic recession that occurred in the United States in 2008; this recession may have led many families to seek emergency food sources or have lapses in food availability. However, because NHANES is a cross-sectional sample of the US population the changes for both household and child food security cannot be fully explored as individual family cohorts are not followed or compared.

**Limited Review of Cost Analyses**

Government publications rely heavily on a report presented to the USDA by Devaney, Bilheimer, and Schorein in October 1990\(^{50}\). The report concludes that for every dollar spent on WIC, Medicaid saves between $1.77 and $3.13\(^{50}\). This figure has been cited in congressional hearings\(^ {29,51}\) in support of the program and has been used in numerous scholarly publications as the evidence for the program’s cost effectiveness\(^ {52-55}\). Since that report was published, other government agencies reviewed various aspects of WIC program costs and benefits, including the GAO\(^ {56}\).

In a 1992 report, the GAO assessed the potential effect on Medicaid costs of expanding WIC to include all income-eligible pregnant women. The report reviewed 17 cost-benefit analyses of the WIC, including results from the 1990 Devaney report, and aggregated the data to determine the average cost-savings associated with WIC benefits in the first sixty days of life. Using estimated reductions in low birth weight rate and prorated Medicaid costs, the report states that serving all income-eligible pregnant women who were to give birth in 1990 would have cost about $111 million more than was spent by WIC that year, but could have returned more than $1.3 billion in avoided expenditures over the next 18 years\(^ {56}\). This review, therefore, supports the findings made by Devaney in 1990 about the cost-saving characterization of the program.
In 1998, the William F. Goodling Child Nutrition Reauthorization Act of 1998 (PL 105-336) asked the GAO to help Congress better understand the costs of delivering services through WIC. To fulfill this request the GAO published a series of four reports\textsuperscript{28,57-59}. One report reviewed literature from 1995 to 2000 that examined the effectiveness of the WIC program. Nineteen studies were included in the review, though only one study specifically addressed potential costs of new interventions. The report concludes, in part, by recommending that the USDA improve demonstration research by incorporating relevant cost information\textsuperscript{59}. According to the GAO website, where this report is now published, this recommendation was only partially implemented; the USDA agreed “in principle with the recommendation” but considering limited resources, the USDA would “endeavor to obtain the cost information whenever it is practical to do so”\textsuperscript{60}.

I found little evidence to suggest that researchers are performing economic evaluations of the WIC program.

In PubMed and PAIS, I identified eleven articles meeting inclusion criteria. The PAIS database resulted in 7 books and no journal articles. PubMed returned 51 articles with “WIC” and “cost” in the title of the publications. The majority of these did not evaluate WIC cost outcomes, or were specifically focused on the effect of the infant formula rebate program or the farmer’s market program on program costs. The majority (81\%) of the articles I include in this review focus on the effect of WIC participation on infant health outcomes, largely birth weight and prematurity. All studies, save one, analyze the effect of WIC participation on downstream Medicaid costs, primarily extended hospitalization costs, emergent care, and medications required to care for underweight or premature infants\textsuperscript{53,55,61-69}. In addition to infant health outcomes, studies also measured changes in immunization rates\textsuperscript{70}, breastfeeding initiation\textsuperscript{62}, pediatric dental health\textsuperscript{63,64}, and maternal fertility\textsuperscript{61}.
Among these studies, the average time since publication is 14 years; I found no recent relevant systematic reviews of this literature. There is significant heterogeneity across studies in the outcomes used to measure Medicaid costs. Some describe Medicaid cost savings as relative differences in annual Medicaid expenditures per child\textsuperscript{55}, and others use prorated annual Medicaid costs and calculate Medicaid savings based on equivalent cost for measured reductions in certain health outcomes\textsuperscript{55,61,69}. Only three studies conduct secondary data analyses of cost outcomes for multiple states\textsuperscript{52,53,66}; all others conduct studies within a single state. Due to the heterogeneity of cost outcomes, it is not possible to create a succinct summary of the magnitude of Medicaid savings associated with WIC participation in this limited review.

Reports from the GAO and IOM provide guidelines to help improve the quality and expand the content of future studies. In 1992, the GAO described a framework to analyze costs and benefits of early intervention efforts by the WIC Program\textsuperscript{71}. The four-part framework involves identifying program outcomes, quantifying program outcomes, estimating and apportioning cost savings, and conducting sensitivity analyses. This framework can guide future WIC research, helping investigators use a systematic approach to assess costs of the program. Similarly, the IOM conducted a WIC research workshop in which different approaches to improving WIC research were discussed, including approaches to improve economic evaluations of the program\textsuperscript{27}. Although the panelists in this workshop, including Barbara Devaney, Sally Findley, and Paul Buescher—prominent WIC researchers—emphasized the need to assess cost-effectiveness or cost-savings of WIC by carefully identifying appropriate outcomes, they
do not provide a framework to do so. Instead, the workshop outlines specific research priorities including the foreseeable benefits and challenges of research topics such as the effect of WIC participation on long term outcomes related to health care utilization and participant health.

CONCLUDING THOUGHTS ABOUT WIC EFFECTIVENESS

Overall, the WIC food package revisions have been successfully implemented. My review of the state of the field suggests that this policy change was the culmination of nearly two decades of debate over and discussion of the evolving role of the WIC program, as it grew from primarily providing supplemental foods to women and children to providing a broad range of educational, nutritional, and health care services and support.

The secondary analysis of NHANES data show that even in a very short time period, WIC’s revised food packages can be said to have resulted in meaningful changes in the food availability and, potentially, the diets of WIC participants. The NHANES data show modest and statistically significant increases in availability of foods previously not included in the food package, including fruits, vegetables, and low-fat milk. A reduction in household availability of less healthy foods like soft drinks and salty snacks may reflect a national trend towards healthier foods, but among low-income household this finding is particularly important. The findings in this analysis demonstrate important trends that have not been presented elsewhere in the literature, the analysis is particularly important because these data are from a nationally-representative sample,
and not limited to a small geographic region, as is true of most other studies. However, this analysis should be interpreted within its limitations.

As a large national randomly sampled survey, NHANES does not represent each State and Local WIC agency equally. Instead, larger states with a bigger share of WIC participants, like Texas and California, are likely overrepresented. The two sessions of the NHANES data (2007-2008 and 2009-2010) used for this analysis were selected for their proximity to the WIC food package implementation in the fall of 2009, and the 2009-2010 survey is the most recent survey currently publicly available through the CDC. Therefore, I could not conduct a longer search for the effects of post-food package implementation. Since the data were collected immediately after the policy change, the magnitude of change reflected in the survey is likely to be lower than is the actual change, particularly change in participants’ weight and BMI. These changes may appear to be larger after a longer period of exposure to the new food packages. Additionally, it is possible that some data points in the second session represent responses from WIC participants in 2009 before the new packages were implemented nationwide in the fall of that year, further underestimating the effect size across all variables. Finally, in the future similar survey analyses would benefit not only from a longer study period by incorporating data from more recent surveys, but also adjusting for potential confounders such as age.

The limited literature review of economic evaluations found a relatively small number of studies that analyze WIC program costs beyond formula rebate programs or other cost-containment measures. The literature, in general, is outdated, with an average time since publication of approximately 14 years, and most studies are limited geographically to one state. This geographic limitation was also present in more recent studies of the effect of WIC food packages on either store inventory changes or dietary
changes among participants (Appendix 1 – Limited Systematic Review). Although smaller studies conducted in only one state are likely considerably less expensive to do, having data on WIC effects in multiple states for WIC is important. This is particularly true because WIC varies administratively at the state and local level; trends in one state may not be the same across other states.

**Recommendations for future research.** The limitations of this research provide a guide to recommendations for future WIC research. First, studies should aim to encompass expanded study populations from broader geographically distributions to capture a more nationally representative sample of WIC participants. If a larger study is not possible, studies should provide justification for the limited geographic sampling and in the case where only smaller studies are feasible, attempt to study participants in areas that are diverse, racial/ethnically, and economically representative of the WIC population, and avoid sampling areas simply for researcher convenience. Second, future analyses should strive to collect data over longer lengths of time to provide information about the long-term effects of the program. Longer study periods are particularly important when measuring health outcomes, such as weight and BMI, health care utilization, and system costs. Finally, the inclusion of program costs should become a research priority. This will continue to be an important outcome for the WIC program, particularly as the health system continues to integrate services and provide more patient-centered care. WIC will likely grow in its capacity as a gateway to the health care system and as a referral center for participants. Additionally, with the expansion of Medicaid in many states, public service programs will continue to expand, and careful review of federal spending will continue to be of high priority. Research should include
cost outcomes to better assess the benefits of the WIC program and how to improve service delivery in the future.

The WIC policy revisions implemented in 2009 have the potential to benefit millions of low-income children and women. Through the policy changes, the USDA and WIC have addressed the unique dual challenge of hunger and obesity facing poor Americans today. As I have shown in this paper, these policy changes are a result of decades of political momentum leading to food package revisions, and through the secondary analysis of cross-sectional data and a review of recent literature I conducted, the first key years of implementation were a success. Going forward, WIC has the opportunity to help shape the health of the country by ensuring that the program fulfills its goals of increasing access to healthy foods, education, and health referrals to women, infants and children.
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### TABLES AND FIGURES

**Table 1. WIC Food Packages prior to 2009 Revisions by Participant Category**

<table>
<thead>
<tr>
<th>Food</th>
<th>I: Infants 0-3 months</th>
<th>II: Infants 4-12 months</th>
<th>III: Children/ women with special dietary needs</th>
<th>IV: Children 1-5 years</th>
<th>V: Pregnant and Breastfeeding Women</th>
<th>VI: Non-breastfeeding Postpartum women</th>
<th>VII: Breastfeeding women enhanced package</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infant formula</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Juice (fruit or vegetable)</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Infant cereal</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cereal (hot or cold)</td>
<td></td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Milk</td>
<td></td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cheese&lt;sup&gt;3&lt;/sup&gt;</td>
<td></td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peanut butter or dried beans/peas</td>
<td></td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tuna (canned)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Carrots&lt;sup&gt;4&lt;/sup&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
<td></td>
</tr>
</tbody>
</table>

<sup>1</sup> Table adapted from Oliveira, et al. (2002).

<sup>2</sup> Available to breastfeeding women whose infants do not receive formula from the WIC program.

<sup>3</sup> Cheese can be substituted for whole milk.

<sup>4</sup> Fresh, frozen, or canned.
Table 2. Political Timeline Leading to WIC Revision

<table>
<thead>
<tr>
<th>YEAR</th>
<th>EVENT or PUBLICATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1980</td>
<td>Last major revision to WIC food packages</td>
</tr>
<tr>
<td>1993</td>
<td>The Institute of Medicine (IOM) is appointed by the USDA to research the scientific basis for nutrition risk criteria used for WIC eligibility.</td>
</tr>
<tr>
<td>1994</td>
<td>Congressional Senate Hearing regarding HR 4554-103 which proposes to increase funding for WIC to $3.47 billion.</td>
</tr>
<tr>
<td>1996</td>
<td>IOM releases study reporting inconsistencies in nutrition risk criteria across states. This led to federal standardization of criteria effective April 1996.</td>
</tr>
<tr>
<td>1998</td>
<td>Congressional Hearing regarding WIC</td>
</tr>
<tr>
<td>1999</td>
<td>USDA publishes report titled “Review of the Nutritional Status of WIC Participants” analyzing nutrient intake of WIC participants</td>
</tr>
<tr>
<td>2000</td>
<td>National Association of WIC Directors (NAWD) releases independent research and policy statement recommending to change the WIC food package.</td>
</tr>
<tr>
<td>2001</td>
<td>Government Accountability Office (GAO) publishes report titled “WIC faces challenges in providing nutrition services.” Include recommendations to evaluate WIC’s nutrition services.</td>
</tr>
<tr>
<td>2002</td>
<td>Food and Nutrition Services (FNS) publishes an overview of the WIC program, titled “The WIC program: background, trends, and issues.” Report describes several “issues of concern” including low breastfeeding rates, content of food packages, and cost containment.</td>
</tr>
<tr>
<td>2003</td>
<td>Fox et al. publish article titled “WIC reauthorization: Opportunities for improving the nutritional status of women, infants, and children.” Propose changes to food packages and improvement of nutrition education for participants.</td>
</tr>
<tr>
<td>2003</td>
<td>Congressional House Hearing “Food for Thought: How to Improve Child Nutrition Programs”</td>
</tr>
<tr>
<td>2004</td>
<td>Child Nutrition and WIC Reauthorization Act of 2004 becomes law (PL 108-265)</td>
</tr>
<tr>
<td>2005</td>
<td>IOM publishes full report titled “WIC Food Packages: Time for a Change.”</td>
</tr>
<tr>
<td>2005</td>
<td>Fit WIC Report from USDA</td>
</tr>
<tr>
<td>2005</td>
<td>American Heart Association publishes endorsement of revisions to improve WIC food packages</td>
</tr>
<tr>
<td>2005</td>
<td>American Academy of Pediatrics publishes endorsement of WIC food packages revisions</td>
</tr>
<tr>
<td>2006</td>
<td>USDA publishes proposed rule to revise food packages which was open to public comment: “Special Supplemental Nutrition Program for Women, Infants and Children (WIC): Revisions in the WIC Food Packages”</td>
</tr>
<tr>
<td>2007</td>
<td>Interim rule to revise WIC food packages, the first comprehensive revision to the packages since 1980. Federal Register Vol. 72, No. 234 Effective February 4, 2008, no later than August 5, 2009</td>
</tr>
<tr>
<td>2014</td>
<td>Final Rule - effective May 5, 2014</td>
</tr>
</tbody>
</table>

SOURCE: Data collected by the author from various sources in the published and grey literature.
*Greyed areas represent legislation.*
### Table 3. Demographic Characteristics of NHANES Participants

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>2007-2008</th>
<th>2009-2010</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>WIC</td>
<td>Non-WIC</td>
</tr>
<tr>
<td>N</td>
<td>1,686</td>
<td>5,999</td>
</tr>
<tr>
<td>Gender (% Female)</td>
<td>50.5</td>
<td>52.4</td>
</tr>
<tr>
<td>Age (Mean)</td>
<td>13.5</td>
<td>28.5</td>
</tr>
<tr>
<td>U.S. Citizen (% Yes)</td>
<td>85.4</td>
<td>91.1</td>
</tr>
<tr>
<td><strong>Race/Ethnicity (%)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mexican-American</td>
<td>40.5</td>
<td>19.5</td>
</tr>
<tr>
<td>Hispanic, non Mexican</td>
<td>13.6</td>
<td>12.3</td>
</tr>
<tr>
<td>Non-Hispanic Black</td>
<td>22.2</td>
<td>40.0</td>
</tr>
<tr>
<td>Non-Hispanic White</td>
<td>20.0</td>
<td>23.4</td>
</tr>
<tr>
<td>Other</td>
<td>3.9</td>
<td>4.9</td>
</tr>
<tr>
<td><strong>Annual Household Income (%)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$0 – $9,999</td>
<td>12.6</td>
<td>5.0</td>
</tr>
<tr>
<td>$10,000 – $19,999</td>
<td>24.1</td>
<td>11.5</td>
</tr>
<tr>
<td>$20,000 – $34,999</td>
<td>27.3</td>
<td>19.8</td>
</tr>
<tr>
<td>$35,000 – $54,999</td>
<td>15.8</td>
<td>16.6</td>
</tr>
<tr>
<td>$55,000 or more</td>
<td>11.2</td>
<td>41.1</td>
</tr>
</tbody>
</table>

**SOURCE:** NHANES Demographic data from 2007-2008 and 2009-2010\(^{72,73}\).
Table 4. Association of Food Package Revision with Food Availability and Health

<table>
<thead>
<tr>
<th>Variable</th>
<th>2007-2008 WIC Participants</th>
<th>2009-2010 WIC Participants</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fruit Availability†</td>
<td>1.54</td>
<td>1.46</td>
<td>0.001</td>
</tr>
<tr>
<td>Dark Green Vegetables Availability†</td>
<td>2.0</td>
<td>1.70</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Salty Snack Availability†</td>
<td>2.25</td>
<td>2.38</td>
<td>0.002</td>
</tr>
<tr>
<td>Low Fat Milk Availability†</td>
<td>4.22</td>
<td>3.87</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Soda Availability†</td>
<td>2.28</td>
<td>2.33</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Household Food Security‡</td>
<td>2.03</td>
<td>2.09</td>
<td>0.003</td>
</tr>
<tr>
<td>Child Food Security‡</td>
<td>1.56</td>
<td>1.38</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>BMI (Mean, kg/m²)</td>
<td>23.14</td>
<td>23.98</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td>Weight (Mean, kg)</td>
<td>38.7</td>
<td>43.70</td>
<td>&lt;0.001*</td>
</tr>
</tbody>
</table>

SOURCE: NHANES Questionnaires and Examination data from 2007-2008 and 2009-2010.[74-79]

† Food availability was measured in questionnaire on a scale of 1 to 5, 1=always available, 5=never available.
‡ Food Security was a composite score of 18 or 10 food security questions for homes with or without children in household, respectively. The composite score is coded as 1=full food security (best), to 4=very low food security (worst).
Pearson's Chi-squared test of all categorical bivariate comparisons.
*Independent t-test of continuous and categorical comparisons.
Among twelve peer-reviewed articles included in this review, most describe the program’s effect on infant health measures (birth weight, prematurity). All articles, except one, framed WIC cost-savings in terms of Medicaid spending.
APPENDIX 1: Limited Systematic Review

Key Questions

This review was guided by the following key questions:

• Are the 2009 WIC policy changes associated with a change in access to healthy foods for WIC participants?

• Is improved access to healthy foods associated with improved diet and health for WIC participants?

Methods

For this review, I conducted a preliminary search for articles related to the 2009 policy change of the WIC program in the following databases: MEDLINE, Web of Science, and PAIS International. Articles related to the 2009 WIC policy change were retrieved from the databases and catalogued by date, abstract, and source database. I found that the majority of articles of interest were located via the Web of Science database and that most of these were also absent from the other two databases. For simplicity and reproducibility, I limited the final search strategy to the Web of Science database.

On April 25, 2014 I conducted a search for the following topic terms: WIC, changes, food, package. I then added search limits of document type: journal article, and time: since 2009. Finally, I reviewed the abstracts of the resultant articles for the following inclusion and exclusion criteria. An article met the inclusion criteria if it described an outcome related to the 2009 WIC food package revision. An article was excluded if only breastfeeding outcomes were measured in the study or if there was a lack of description of food-related outcomes after the 2009 change to the WIC program.
If articles qualified for inclusion into the study as defined by the criteria above, each article was then critically appraised and graded for quality. I developed a grading system to assess the studies based on appropriate use of data sources, generalizability, potential for conflicts of interest, and risk of bias or confounding (rated from + to ++++, with +++ being highest risk of bias). I defined final quality grades as either good, fair ±, or poor. Justification for quality grades are included in Table 1.

Results

Studies Included in Review

The initial search of the Web of Science database as described above resulted in 35 publications. After applying the inclusion and exclusion criteria described above, 12 studies were ultimately included.

Article Characteristics

1. Authors

Many of the articles included in this review were written by the same research group or related collaborators. One of the first teams of researchers to describe the effect of the WIC policy change on food access is part of the Rudd Center for Food Policy and Obesity at Yale University. In fact, the first four articles published included in this review were written by members of this research group at Yale. Out of the twelve articles included in the review, half come from Yale University. Research source is important to consider in this review because it has the potential to skew search questions and data to what was of interest to members of the Rudd Center or to local
geographic variables not found in the rest of the country. The limited range of research
groups investigating the effects of the WIC policy change may be reflected in the narrow
geographic scope described in the available literature.

2. Geographic Distribution

More than half of the studies were conducted in the Northeast; of those, seven
focused either in part or exclusively in the state of Connecticut 37-42,47. Other New
England states included in studies were Pennsylvania 48, Massachusetts 41,42, and New
York 45. Five of the twelve studies reported data from across the country.

One study analyzed state-wide data from California 44 and two others studied
WIC-related changes in specific neighbors of cities in Illinois 46,49. Two studies that also
surveyed stores located in Connecticut included data from stores in seven other cities
throughout New England, the Midwest, Louisiana, and California 39,40.

3. Research Outcomes: Vendors and Participants

The articles included in this review focused primarily on two main types of
research outcomes. The first describes changes to variables related to WIC vendors,
while the other set of outcomes focuses on dietary changes among WIC participants.
There is a notable temporal shift among the studies in this regard. The first six articles
published focus exclusively on factors related to WIC vendors. WIC vendors are
community stores that provide approved foods to WIC participants. The majority of
publications, seven of the twelve articles in this review, focus exclusively on outcomes
related to retailers, either by measuring the perceptions of store owners or managers
about the changes caused by the policy change 37-39 or measuring inventory and
stocking behavior among stores. It is possible that these types of vendor-specific studies dominate the early part of the literature because analyzing inventory changes and conducting pre and post interviews may require shorter lengths of time than other study designs. These studies can be described as micro political-economic analyses of the local market changes caused by the WIC revisions. All of these studies found that the new policy caused some immediate changes to the local food economy.

Through interviews conducted with owners and managers in non-supermarket stores in Connecticut after the WIC policy change, Andreyeva, Middleton, Long, et al. report that WIC vendors made the necessary adjustments to comply with new inventory requirements. These adjustments include adding new products (93%), increasing delivery frequency (54%), training staff (54%), and purchasing new equipment (18%). The general perceptions were positive, as most retailers stated they had a positive (46%) or neutral (36%) overall impression of the WIC program changes. Andreyeva and colleagues also assessed the factors that influence stocking decisions among these small stores. They found that the most commonly cited reason was customer request, 81% mentioned it as the main factor, other factors mentioned were profitability, supplier recommendation and wholesale deals (20-30%). When this study was expanded to cities in six other states in addition to stores in New Haven, CT, the research team found that the same motivating factors guiding stocking practices among store owners in these areas as well. Customer requests were rated as “very important” by 86.5% of the stores interviewed, followed by profitability (71.2%). In a qualitative analysis, researchers noted that store owners did not equally weigh all instances of customer demand. Instead, WIC vendors reported relying most heavily on their repeat, regular customers, some going to great lengths to satisfy their food preferences. For example, one store
owner said “I stop [the customers] before they leave and I find out [what food item they want] and I make sure they have it the next day” 39.

WIC vendors perceived lower customer demand for healthy food compared to unhealthy food, both before and after the WIC program changes of October 2009. One of the most common reasons cited by store owners as barriers to offering healthier foods was customer dislike; 74% of those interviewed cited this as a barrier for soy milk, 41% for lower fat milk, and 35% for whole grain breads 37. As stated above, perceived profitability was the second most cited factor for guiding decisions. Unhealthy foods like soda, salty snacks, whole milk, and white bread were each perceived to be more profitable by more than 80% of WIC vendors 37. As a result of the WIC program changes, after October 2009 all WIC vendors were required to carry healthy food items such as whole wheat bread, lower fat milk (2%, 1%, or skim), fruits, and vegetables despite these food items being perceived on average as in low demand or not profitable in interviews conducted before the changes took place. This policy-mandated change in stocking behavior then lead to perceived changes in customer demand among these same WIC vendors. In 2010, 74% of WIC vendors reported increased customer demand for fresh fruits, whole grain bread (70%), lower-fat milk (63%), and fresh vegetables (48%) 37. Similarly, the expanded study found that most stores perceived increase in sales of whole grain bread (89% of stores), lower-fat milk (89%), fresh fruits (75%), and fresh vegetables (69%) 38. The dramatic increases in perceived demand and sales of healthy foods were not present among the comparable non-WIC stores 37,38.

The next study published by the Rudd Center for Food Policy and Obesity at Yale University compared changes in non-supermarket store inventories between WIC and non-WIC stores in five Connecticut towns 40. Presence, variety, and quality of healthy foods in store inventories was quantified by a composite score which ranged from 0 (no
supply of healthy foods) to 31 (varied supply of excellent quality healthy foods). Compared to baseline scores done prior to the 2009 WIC policy change, WIC vendors had an unadjusted average healthy food supply score increase of 4.06 points compared to 0.49 increase in non-WIC stores (p <0.001). Increases in the supply of whole-wheat products contributed the largest portion of the total change. In a similar study done by Havens, et al., in which store inventories were analyzed in Hartford, Connecticut, WIC-vendors were found to carry more varieties of fresh fruit, a greater proportion of lower-fat milk, and had greater availability of whole grain bread than non-WIC vendors.

In the analysis of store inventories (including supermarkets) in the Philadelphia area, Hillier, et al. use a different food component score that considers price and that has a range from –7 to 106, with higher numbers indicating greatest variety, quality, and value. In this study, WIC-vendors were again found to respond to the policy change by increasing the supply of healthy foods. The average overall healthy food score in this study increased 7.7 points among WIC-approved stores, compared to 4.9 in non-WIC stores. The authors regard the smaller but still positive change in food score among non-WIC stores illustrates the community-wide effect the policy may have to improve access to healthy food even in stores that are not required to do so to maintain program eligibility.

Zenk, et al. studied changes in product availability after the WIC policy change in seven counties in Illinois. Although it is unclear in the methods of this study whether the research team analyzed store inventories directly or personally performed in-store product counts, the study found that the odds of all types of WIC-approved stores (including pharmacies) carrying fruits and vegetables that are either fresh, frozen, or canned improved after the policy change ( p < 0.05).
In 2012, researchers from the Public Health Foundation Enterprises WIC Program (PHFE WIC) in California and UC Berkley evaluated changes in consumption of healthy foods among WIC participants associated with the WIC program change \(^{44}\).

PHFE WIC is the largest local WIC agency in the country and provides WIC services in the Los Angeles area. The study was funded by a grant from the USDA, Food and Nutrition Services. Whaley and colleagues conducted telephone surveys of randomly sampled pregnant or postpartum women, and caregivers of children enrolled in WIC before and after the changes to the food packages. In this survey of approximately three thousand WIC participants, the responses were entered into an ANOVA predictive model that showed changes in consumption of fruit, vegetables, whole grains, and lower-fat milk. The greatest changes were seen in consumption of whole grain, which increased by 17.3% points, or a 51% increase over baseline \(^{44}\). Milk consumption also changed drastically, after the food package change. The number of children who consumed whole milk decreased by 19.7 percentage points (a 63% reduction over baseline) while the consumption of lower-fat milk (2%, 1%, or slim) increased by 19.5 percentage points (a 29% increase over baseline). There was no changes in the percentage of participants who reported no consumption of milk \(^{44}\).

Another study done in conjunction with the New York State Department of Health analyzed the state WIC database and conducted in-person interviews to measure changes in infant feeding practices, daily consumption of healthy foods, screen-time, and obesity in children after the WIC policy change \(^{45}\). The database included data from more than 3.5 million WIC participants, the number varied between 6-month study intervals averaging 508,883 infants and children per interval. The database included administrative data such as age, race/ethnicity, gender, and height and weight (which were used to calculate BMI). In-person interviews asked participants about behavioral
and dietary habits; these were conducted at WIC centers by program staff during mandatory certification (initial) and mid-certification visits. The study found steady increases among 1- to 4-year olds in daily consumption of fruits (5.3% increase from baseline), vegetables (3.5%), and whole grain (9.1%). There were also more children who drank lower-fat milk (4.5%). This percentage varied by age group as 3-4 year-olds consumed more lower-fat milk than children less than 2 years of age. The proportion of children who were overweight or obese decreased by 2.9% over the 3 year study period; this reduction in BMI varied by age and race. Notably, more than a third of Hispanic children ages 2-4 were overweight or obese at baseline. These children showed the smallest relative reduction in BMI (1.6%) during the study period. In comparison, 29% of White and Black children were overweight or obese at baseline. Black children experienced a 4.5% reduction in obesity prevalence and White children experienced a 3.8% reduction in obesity prevalence.

In-person interviews and written questionnaires were used by Odoms-Young, et al. to study whether home food availability and dietary intake changed among children participating in the WIC program. The interviews were conducted six months after the WIC food packages were changed and the study chose to focus on child-mother dyads that self-identified as Hispanic or African American in the Chicago area. Baseline data indicated that 57% of Hispanic and 42% of African American respondents qualified to have low or very low food security. After WIC food packages were revised, the study found the most statistically significant change in food consumption for children occurred with milk. Among Hispanic children there was a 0.34 serving/day increase of lower fat milk accompanied by a 0.33 serving/day decrease in whole milk. Similarly, among African American children there was a 0.24 serving/day increase in lower fat milk consumption with an equal (0.24 serving/day) drop in consumption of whole fat milk.
There were measurable increases in consumption of fruits, vegetables, and whole grains, however most of these were not statistically significant. Participants also reported having high availability of fruits and vegetables at home both before and after the changes in WIC. The authors note that this and other self-reported measures of healthy food consumption and availability may be higher than the actual values due to potential measurement bias from respondents wishing to provide more desirable answers during their WIC clinic appointments. Additionally, the reportedly high availability of specific fruits and vegetables is inconsistent with the high percentage of respondents who qualify as experiencing low and very food security.

Andreyeva, Luedicke used scanner data provided by one (undisclosed) large supermarket chain in Connecticut and Massachusetts to study changing consumer habits of bread and rice purchases made with WIC payment benefits. The results of this study show a shift in bread purchases (from white bread to whole grains) following the policy change; purchases with WIC benefits explained all of the growth of 100% whole-grain bread, which tripled from 6 to 18 oz. per household. Brown rice purchases made with WIC funds increased from almost zero (0.3 oz.) to 2.4 oz. per household after the policy change. White rice did not increase in the same time frame, so there was no compensatory purchase of white rice. This study was expanded to measure other food purchases in addition to bread and rice.

Andreyeva, Luedicke, Tripp, et al. then used data from presumably the same supermarket chain and found changes in juice and beverage purchases after the WIC policy change. The total volume of juice purchased by WIC funds decreased by 43.5% from baseline, which reflects lower allowances in the revised food packages. At the same time, there was a small rise (13.5%) in juice purchased by personal funds, SNAP benefits, and nonfood cash assistance. However, in this study the authors do not clearly
state whether purchases with different payment sources are from the same consumers. The level of compensatory purchases of juice is unclear, and even if the purchases were made by the same consumers, the amount of juice consumption from other funds would still not match the level of reduction seen in WIC-provided juice.

Changes in consumer and dietary behavior and health require a longer study period, which may explain why only a minority of the studies including the four most recently published focus on the effects the policy may have on the dietary and food purchasing behaviors of WIC participants. Within this group there was a range of methodological approaches.

4. Evidence Table with Article Quality Assessment

Refer to Table A1.

Discussion

Despite various methodologies and differences in dietary and food purchasing outcomes, all of the studies included in this review found similar trends in how food purchases and food consumption changed after the WIC food packages were revised. When the Institute of Medicine (IOM) published the report *WIC Food Packages: Time for Change* in 2005, the goal was to bring attention to the unique opportunity to tackle the duality of nutritional challenges facing poor Americans: hunger and obesity. Taken together, the results of the included studies suggest that the WIC program is making progress in meeting these goals.

For example, six months of the policy change, Whaley and colleagues found statistically significant changes in the dietary habits of WIC participants in California to
include healthier foods\textsuperscript{44}. Similarly, Chiasson et al. \textsuperscript{45} as well as Odoms-Young et al. \textsuperscript{46} found improved dietary changes among WIC participants in New York State and Chicago, respectively. The degree to which participants adjusted their dietary behavior in response to the changes in the WIC food packages varied among the studies, and also among racial/ethnic groups, types of food, and age. This is to be expected, health behavior literature widely supports the idea that changing behaviors, particularly dietary behaviors, is challenging and can take much time and effort to accomplish.

WIC is a program that relies on community stores and state-run clinics to provide services to participants, therefore it is important to study how local food vendors and food businesses fared through the transitional period of policy implementation. For the policy implementation to be successful, vendors must adjust stocking behavior, inventories, and suppliers so that improved food packages are available to participants in all neighborhoods. Researchers at the Rudd Center for Food Policy and Obesity at Yale University focused on the potential effects on the local businesses and economy due to the WIC policy change. Through a series of publications, six of which are included in this review, the Center analyzed the changes in local business perception, gauged vendor interest to participate in the changes, and measured the perceived challenges and benefits of the policy for local business. These studies show that in general, small corner stores and other local vendors in New England that largely serve a low-income and minority communities, accepted the WIC changes and adapted to the new requirements. Stores were therefore able to provide a greater selection of healthy foods to their customers. The Center also measured the response of a large multi-state supermarket chain by analyzing the store’s inventory data before and after the policy change. Here, researchers were not measuring whether the supermarket had increased its supply of healthy foods, as most large supermarkets provide a large variety of
options, but whether WIC participants changed their purchasing behavior. In a series of two studies, the group found that participants increased their purchases of whole grain products in response to receiving benefits to do, and reduced their purchases of fruit juice, as that was reduced from the WIC food package. The Rudd Center provides a large number of studies to show that the WIC program is increasing access to healthy foods to participants and that the WIC-approved vendors who were required to adjust their inventory were able to do so with general success. However, the overarching limitation in the Center’s research is the geographic centralization of their work. The research overrepresents the Northeastern region of the United States, particularly the state of Connecticut, where the Center is based. The limited distribution of studies geographically reflects the location of the researchers and is not necessarily related to other factors of interest such as areas of greatest potential change in food accessibility or significant nutritional deficiency. As discussed in the article quality section above, many of the sample locations were determined in a macro and micro level by researcher convenience. Little evidence was provided to help readers compare the chosen locations to average characteristics of WIC participants within the larger region or throughout the country. This limited contextualization of local data limits the generalizability of the findings.

Limitations of this Review

I limited this review to one database, given limitations of time and resources, which excluded three articles that would have otherwise met inclusion criteria. As mentioned in the first portion of the results segment, nine articles did not meet criteria for inclusion. Among these, seven articles studied the effect the WIC policy changes on
breastfeeding and infant nutrition. The new policy change incorporates significant changes to the infant nutrition packages and provides more resources for women to initiate and continue breastfeeding. Studying whether this aspect of the policy has met its stated goals is an important area of research. However, as a focused systematic review, I elected to focus solely on the changes related to non-infant food as a result of the WIC policy revisions.

**Conclusions**

Changes to federal nutritional policy through the WIC food package revisions have the potential to benefit millions of low-income children and women. Nearly half of all children born in the United States are eligible for WIC benefits and the new requirements to encourage breastfeeding, reduce intake of high-fat foods (like whole milk), and increase intake of whole grains, fresh fruits and vegetables are all measures that can improve the health and well-being of entire generations of young Americans. This data show that in the first key years of implementation, WIC vendors were able to adjust to administrative, logistical, and market requirements. With increased supply of healthy foods included in otherwise food-deprived low-income neighborhoods, WIC participants responded to the program’s financial incentives by purchasing healthier food. In turn, these participants reported having a healthier diet, effectively changing their health behavior as a direct effect of the WIC policy change. Finally, within the first year, a small but significant reductions in weight and BMI were measured in subsets of children participating in the WIC program. As the program continues to educate participants about food purchases and nutrition, and dietary behavioral changes become more
established, the WIC program could directly result in a healthier and better nourished population.

### Table A1. Evidence Table with Article Quality Grading

<table>
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<tr>
<th>Article</th>
<th>Quality Grade</th>
<th>Justification</th>
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<tr>
<td>Ayala G. X., M. N. Laska, S. N. Zenk, J. Tester, D. Rose, A. Odoms-Young, T. McCoy, J. Gittelsohn, G. D. Foster and T. Andreyeva. Stocking characteristics and perceived increases in sales among small food store managers/owners associated with the introduction of new food products approved by the Special Supplemental Nutrition Program for Women, Infants, and Children. Public health nutrition. Sep 2012;15(9):1771-1779.</td>
<td>Fair +</td>
<td>Methods: +++ Selection Bias: Non-random site selection, in eight cities due to research cite’s affiliation with Robert Wood Johnson: convenience sampling. This study expand a prior study (article #1, Andreyeva 2011) from stores in CT to stores in seven different states, improves generalizability. 57.5% of stores refused or did not complete survey. ++ Measurement Bias: Personal interviews, concerning perceptions increase risk for recall bias. Chose to exclude supermarkets from study sample, however most of WIC purchases occur in supermarkets Outcomes: Perceptions of food retailers about changes in WIC policy, and the effect on their inventory and business. Results: Customer requests were the most important (87%) factor in stocking decision. Most retailers perceived increases in sales of new WIC-approved foods. Limitations: Same as Andreyeva 2011.</td>
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<tr>
<td>Study</td>
<td>Method Quality</td>
<td>Methods</td>
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+ Measurement Bias: Inventory review using systematic scoring system. Scoring system was adapted to reflect WIC-specific food products to measure all potential changes in stocking related to new regulations.  
Outcomes: Inventory review to measure effect of WIC package changes on store provisions.  
Results: Stores increased healthy food provisions after WIC change, greatest percent change in lower-income neighborhoods.  
Limitations: Did not include supermarkets, stating they would have “diluted the effect” of the WIC changes, this may be true, but it may also be helpful to compare inventories of convenience stores with supermarkets as well. |  

++ Measurement Bias: Measured food availability using food inventory, however it is unclear if researchers counted stock at each store or relied on internal inventories from each store.  
Outcomes: Inventory review to measure changes in store provisions comparing WIC and non-WIC stores in Hartford, CT.  
Results: Using models, and adjusting for covariates, WIC stores carried more fresh fruit, lower-fat milk, and whole grain bread than non-WIC stores.  
Limitations: Small sample size and there is uncertainty about their data collection. |  

+ Measurement Bias: Canvassed neighborhoods to verify store count which improved accuracy of stores represented. Provided data on distance to stores which relates to access to food across a community.  
Outcomes: Survey of retailers expanding the typical business databases used in other studies to ensure all eligible stores are counted to measures the change in healthy food availability after the WIC package revision.  
Results: After policy change, WIC stores increased their supply of healthy foods, non-WIC stores also increased |
<table>
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<tr>
<th>Study</th>
<th>Supply, but to a smaller extent. <strong>Limitations:</strong> Did not include frozen or canned vegetables in modified score, limitation because WIC does count these as sources of vegetables.</th>
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<tr>
<td>Whaley S. E., L. D. Ritchie, P. Spector and J. Gomez. Revised WIC Food Package Improves Diets of WIC Families. Journal of Nutrition Education and Behavior. May-Jun 2012;44(3):204-209.</td>
<td><strong>Methods:</strong>&lt;br&gt;<strong>+</strong> Selection Bias: Random sample selection – WIC participants in all of California (&gt;3,000)&lt;br&gt;<strong>++</strong> Measurement Bias: Retrospective surveys – recall bias. 6 month time frame, a relatively short time to measure behavior change. Didn’t describe variables in regressions model.&lt;br&gt;<strong>Outcome:</strong> Telephone survey of random sample of entire WIC participant population in California to measure behavior change after WIC policy change.&lt;br&gt;<strong>Results:</strong> Consumption of whole wheat bread, lower-fat milk increased after policy change. Intake of fruits and vegetables was small.&lt;br&gt;<strong>Limitations:</strong> Did not stratify or match randomization by agencies so larger regions were over represented in the random sample. Six months may be too brief to measure behavioral and dietary changes.</td>
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<td>Zenk S. N., A. Odoms-Young, L. M. Powell, R. T. Campbell, D. Block, N. Chavez, R. C. Krauss, S. Strode and J. Armbruster. Fruit and Vegetable Availability and Selection Federal Food Package Revisions, 2009. American Journal of Preventive Medicine. Oct 2012;43(4):423-428.</td>
<td><strong>Methods:</strong>&lt;br&gt;<strong>+++</strong> Selection Bias: High uncertainty about sampling method, but not clear if all eligible WIC vendors were assessed or if it was a subsample. No explanation of why only 8 counties in Illinois were surveyed (convenience sampling?). Not clear why all vendors were included, even pharmacies which are excluded from other studies due to their low inventories of produce. If intention was to provide a comprehensive look at all WIC eligible vendors despite those that may not meet standards maybe helpful, but unsure of reasons.&lt;br&gt;<strong>+++</strong> Measurement Bias: Type of sampling is not clear, was it direct observation by team or review of inventories? There are 2 pre-change observations and 1 post-observation. Does this imbalanced analysis skew results?&lt;br&gt;<strong>Outcomes:</strong> Inventory review of stores to measure changes in fruit and vegetable availability after the WIC food package revisions.&lt;br&gt;<strong>Results:</strong> There were various degrees of improvement in availability of fruits and vegetables after the policy change, depending on type (fresh vs canned vs frozen) and by vendor size.&lt;br&gt;<strong>Limitations:</strong> See “Methods”</td>
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<tr>
<td>Andreyeva T. and J. Luedicke. Federal food package revisions: effects on purchases of whole-grain products. Am J Prev Med. Oct 2013;45(4):422-429.</td>
<td><strong>Methods:</strong>&lt;br&gt;<strong>+++</strong> Selection Bias: Non-random selection, used loyalty card membership from one supermarket chain in 2 New England states. Extracted only those that had history of paying with WIC benefits – unsure if this is this a valid sampling method. No secondary analysis to describe how many WIC participants in the area use this supermarket, what percentage of their food purchases are done in this (or any supermarket) vs corner stores, etc. Assume that 1 loyalty member account = 1 household (very uncertain if this is true)&lt;br&gt;<strong>+++</strong> Measurement Bias: Data was provided by the store. Only measured bread and rice purchases. No sensitivity analyses to show validity of data source. No account of shopping habits of participants, whether they buy all produce at this chain, buy specific items at different stores.&lt;br&gt;<strong>Outcomes:</strong> Used store data to measure participant</td>
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<td>Source</td>
<td>Methods</td>
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<tr>
<td>Fair –</td>
<td>Methods: +++ Selection Bias: non-random selection of participants, used loyalty card membership from one supermarket chain in 2 New England states. Assumed that 1 loyalty member account = 1 household (very uncertain if this is true) ++ Measurement Bias: Data provided by (unnamed) supermarket. No demographic/social measures are linked to store data. Focused on 100% juice consumption, provided reasoning behind that decision and also studied if there were any changes in the purchase of other beverages Generalizability: only 2 states in New England. Were not provided with demographics of people who shop at the specific store (or name of store), is there something about the people that shop there that is different from other WIC participants? What percentage of WIC purchases occur at supermarkets? Outcomes: Used store data to measure participant purchasing behavior. Results: After WIC changes purchases for fruit juice decreased among those who paid with WIC benefits. Limitations: See “Methods”</td>
</tr>
<tr>
<td>Chiasson M. A., S. E. Findley, J. P. Sekhobo, R. Scheinmann, L. S. Edmunds, A. S. Faly and N. J. Mcleod. Changing WIC Changes What Children Eat. Obesity (Silver Spring). Jul 2013;21(7):1423-1429.</td>
<td>Good Methods: + Selection Bias: More than 2 years worth of official WIC data from NY state (more than 500,000 children in each six month interval). Only children included in sample, did not explain why women were excluded. Appropriate time frames for before and after data collection around WIC policy change ++ Measurement Bias: WIC data plus personal interviews and WIC clinics about dietary and purchasing behavior. High risk of Hawthorne effect. High likelihood participants provided desirable answers to WIC employees. Measured all applicable foods: fruits, vegetables, different types of milk, whole grains foods, and anthropomorphic measures such as weight and BMI – provides more comprehensive view of policy effects outcomes: Interviewed participants and analyzed program data to measure the effect of the WIC policy change on infant feeding practices, daily consumption of healthy foods in children, screen time, and obesity among children. Results: After the WIC changes, there were measurable increases in breastfeeding initiation, fruit, vegetable, and whole grain consumption among children, and a decrease in the proportion of 2-4 year olds who were obese. Limitations: There may be important characteristics of WIC participants in New York that are different from those around the country, study did provide table with participant characteristics to compare.</td>
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+++ Measure Bias: 24 hr recall (only 1 per participant). Interviewed to ask about food availability - High risk of Hawthorne effect. Participants reported suspiciously high levels of fruit and vegetable availability, despite most scoring high on "food insecurity" score – likely a result of wanting to increase desirable responses.

Generalizability: Most WIC participants are Hispanic and African American, so limiting the study to these two subpopulations does not limit its interpretation by much.

**Outcomes:** Interviewed participants to measure the effect of the WIC policy change on home food availability and dietary intake among children and their primary caretaker.

**Results:** Modest increases in consumption of fruits and lower-fat milk was observed. Results varied by demographic group (Hispanic or African American). Changes in home food availability were not significantly correlated with changes in diet.

**Limitations:** In-person interviews at the WIC clinic likely resulted in participants providing what they thought would be desirable answers. There was a discrepancy between their reported home food availability, their reported food security, and food consumption.
APPENDIX 2: Methods

In the secondary analysis of cross-sectional NHANES data, I used the following questionnaires, demographic datasets, and examination datasets:

2007 – 2008 Consumer Behavior Questionnaire 76
2007 – 2008 Food Security Questionnaire 74
2007 – 2008 Demographic Data 72
2007 – 2008 Examination Data: Body Measures 75

2009 – 2010 Consumer Behavior Questionnaire 78
2009 – 2010 Food Security Questionnaire 79
2009 – 2010 Demographic Data 73
2009 – 2010 Examination Data: Body Measures 77

To download datasets from the NHANES website, I went to this location and downloaded the associated SAS data for each of the datasets above http://wwwn.cdc.gov/nchs/nhanes/search/datapage.aspx?Component=Questionnaire.

The final variables used in my analysis are:

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<td>sddsrvyr</td>
<td>Survey year number</td>
<td>5 = 2007-2008 6= 2009-2010</td>
</tr>
<tr>
<td>cbq020</td>
<td>The next questions ask how often (your family has/you have) certain types of food available at home. How often (does your family/do you) have fruits available at home? This includes fresh, dried, canned and frozen fruits. Would you say always, most of the time, sometimes, rarely, or never?</td>
<td>1=always, 2=most of the time, 3=sometimes, 4=rarely, 5=never, 77=refused, 99=don't know</td>
</tr>
<tr>
<td>cbq030</td>
<td>How often (does your family/do you) have any of these dark green vegetables available at home? This includes fresh, dried, canned, and frozen vegetables. [Would you say always, most of the time, sometimes, rarely, or never?]</td>
<td>1=always, 2=most of the time, 3=sometimes, 4=rarely, 5=never, 77=refused, 99=don't know</td>
</tr>
<tr>
<td>cbq040</td>
<td>How often (does your family/do you) have salty snacks such as chips and crackers available at home? Do not include nuts. [Would you say always, most of the time, sometimes, rarely, or never?]</td>
<td>1=always, 2=most of the time, 3=sometimes, 4=rarely, 5=never, 77=refused, 99=don't know</td>
</tr>
<tr>
<td>cbq050</td>
<td>How often (does your family/do you) have 1% fat, skim or fat-free milk available at home? Please do not include 2% milk. [Would you say always, most of the time, sometimes, rarely, or never?]</td>
<td>1=always, 2=most of the time, 3=sometimes, 4=rarely, 5=never, 77=refused, 99=don't know</td>
</tr>
<tr>
<td>cbq060</td>
<td>How often (does your family/do you) have soft</td>
<td>1=always, 2=most of the</td>
</tr>
</tbody>
</table>
drinks, fruit-flavored drinks, or fruit punch available at home? Please do not include diet drinks, 100 percent juice or sports drinks. [Would you say always, most of the time, sometimes, rarely, or never?]

time, 3=sometimes, 4=rarely, 5=never, 77=refused, 99=don’t know


<table>
<thead>
<tr>
<th>seqn</th>
<th>Individual ID number</th>
</tr>
</thead>
<tbody>
<tr>
<td>sddsrvyr</td>
<td>Survey year number</td>
</tr>
<tr>
<td>fsqhh</td>
<td>Household food security</td>
</tr>
<tr>
<td>fsdch</td>
<td>Childhood food security</td>
</tr>
<tr>
<td>fsq162</td>
<td>In the last 12 months, did (you/you or any member of your household) receive benefits from the WIC program, that is, the Women, Infants and Children program?</td>
</tr>
</tbody>
</table>

**2007 – 2008 and 2009 – 2010 Demographic Data**

<table>
<thead>
<tr>
<th>seqn</th>
<th>Individual ID number</th>
</tr>
</thead>
<tbody>
<tr>
<td>sddsrvyr</td>
<td>Survey year number</td>
</tr>
<tr>
<td>riagendr</td>
<td>Gender of the sample person</td>
</tr>
<tr>
<td>ridageyr</td>
<td>Age in years of the sample person at time of HH screening.</td>
</tr>
<tr>
<td>ridreth1</td>
<td>Reported race and ethnicity information.</td>
</tr>
<tr>
<td>dmdcitzn</td>
<td>(Are you/Is SP) a citizen of the United States?</td>
</tr>
</tbody>
</table>
| indhhin2 | Annual. Total household income (reported as a range value in dollars) | 1= $0-4,999, 2= $5,000-9,999, 3= $10,000-14,999, 4= $15000-19999, 5= $20,000-

<table>
<thead>
<tr>
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<th>Individual ID number</th>
</tr>
</thead>
<tbody>
<tr>
<td>sddsrvyr</td>
<td>Survey year number</td>
</tr>
<tr>
<td>5</td>
<td>2007-2008</td>
</tr>
<tr>
<td>6</td>
<td>2009-2010</td>
</tr>
<tr>
<td>bmxwt</td>
<td>Weight (kg)</td>
</tr>
<tr>
<td>Continuous 3.1 - 218.2 (range in kg)</td>
<td></td>
</tr>
<tr>
<td>bmxbmi</td>
<td>BMI (kg/m²)</td>
</tr>
<tr>
<td>Continuous 12.5-84.87</td>
<td></td>
</tr>
</tbody>
</table>

Data analysis with R Software
The code below was used to compile, organize, and calculate statistical analyses of the NHANES data for this analysis.

Simplified steps
1. Download data, covert SAS format to R
2. Merge data sets of the same survey period by individual ID (variable: seqn)
3. Remove unwanted variables and subset data by WIC participation (variable: fsq162 = 1 “yes”)
4. Create dummy variables to remove non-WIC participants and missing values and separate pre-post data, dummy is subset by survey year (variable sddsrvyr)
5. Conduct chi squared test on categorical bivariate comparisons, independent t-tests on continuous-categorical comparisons, and mean calculations
#importing data from CDC

Body78 <- sasxport.get("Body78.xpt")

Body91 <- sasxport.get("NHANES 09-10 Body BMX.F.XPT")

#Merging by year

A0708 <- merge(Body78, Demog78, by="seqn")

B0708 <- merge(A0708, Food78, by="seqn")

Full78 <- merge(B0708, ConsBeh78, by="seqn")

A910 <- merge(Body91, Demog0910, by="seqn")

B910 <- merge(A910, Food91, by="seqn")

Full91 <- merge(B910, ConsBeh0910, by="seqn")

#create one combined data frame (with survey year number)

ComboWic <- rbind(first78, Final91)

#Removing unwanted variables


#Subsetting only WIC and non-WIC (removing 7,9, NA)

wic_samp7 <- subset(first78, fsq162 <= 2,
                      select=c(seqn:cbq190))

wic_samp9 <- subset(Final91, fsq162 <= 2,
                      select=c(seqn:cbq190))

OnlyWic_combo <- subset(ComboWic, fsq162 <= 2,
                         select=c(seqn:cbq190))
# Frequencies

# Demographic table info
attach(wic_samp7)
gendertable <- table(riagendr.x, fsq162)
gendertable

attach(wic_samp9)
gendertable9 <- table(riagendr.x, fsq162)
gendertable9

racetable9 <- table(ridreth1.x, fsq162)
racetable9

data(wic_samp9)
citztable9 <- contingency.tables(row.vars=d(dmdcitzn.x),col.vars=d(fsq162))
citztable9 <- add.chi.squared(citztable9)
print(citztable9,prop.r=T,prop.c=T,prop.t=F)

HHFStable9 <- contingency.tables(row.vars=d(fsdhh),col.vars=d(fsq162))
HHFStable9 <- add.chi.squared(HHFStable9)
print(HHFStable9,prop.c=T,prop.t=F)

CHFStable9 <- contingency.tables(row.vars=d(fsdch),col.vars=d(fsq162))
CHFStable9 <- add.chi.squared(CHFStable9)
print(CHFStable9,prop.c=T,prop.t=F)

Incometable9 <- contingency.tables(row.vars=d(indhhin2.x),col.vars=d(fsq162))
Incometable9 <- add.chi.squared(Incometable9)
print(Incometable9,prop.c=T,prop.r=T,prop.t=F)

# 2007-2008 Demographics table
attach(wic_samp7)
```r
racetable7 <- table(ridreth1.x, fsq162)
racetable7

data(wic_samp7)
citztable7 <- contingency.tables(row.vars=d(dmdcitzn.x),col.vars=d(fsq162))
citztable7 <- add.chi.squared(citztable7)
print(citztable7, prop.r=T, prop.c=T, prop.t=F)

HHFStable7 <- contingency.tables(row.vars=d(fsdhh), col.vars=d(fsq162))
HHFStable7 <- add.chi.squared(HHFStable7)
print(HHFStable7, prop.c=T, prop.t=F)

CHFStable7 <- contingency.tables(row.vars=d(fsdch), col.vars=d(fsq162))
CHFStable7 <- add.chi.squared(CHFStable7)
print(CHFStable7, prop.c=T, prop.t=F)

Incometable7 <- contingency.tables(row.vars=d(indhhin2.x), col.vars=d(fsq162))
Incometable7 <- add.chi.squared(Incometable7)
print(Incometable9, prop.c=T, prop.r=T, prop.t=F)

NowWICtable7 <- contingency.tables(row.vars=d(fsd660zc), col.vars=d(fsq162))
NowWICtable7 <- add.chi.squared(NowWICtable7)
print(NowWICtable7, prop.c=T, prop.r=T, prop.t=F)

attach(wic_samp9)
NowWICtable9 <- contingency.tables(row.vars=d(fsd660zc), col.vars=d(fsq162))
NowWICtable9 <- add.chi.squared(NowWICtable9)
print(NowWICtable9, prop.c=T, prop.r=T, prop.t=F)

mean(subset(wic_samp7$ridageyr.x, fsq162==1), na.rm=TRUE)
mean(subset(wic_samp7$ridageyr.x, fsq162==2), na.rm=TRUE)
mean(subset(wic_samp9$ridageyr.x, fsq162==1), na.rm=TRUE)
mean(subset(wic_samp9$ridageyr.x, fsq162==2), na.rm=TRUE)
```
#subsetting only WIC yes data by variables of interest (fruit, veg, milk, soda, salty snacks, weight, BMI)

combowic2 <- subset(ComboWic, fsq162 == "1", select = c(sddsrvyr.x, fsq162, cbq020, cbq030, cbq040, bmxbmi, bmxwt, fsdhh, fsdch, cbq050, cbq060))

#new dataframe of just WIC participants for each variable (subset variables to include only WIC = yes)

#to then use for WIC only means of outcomes

onlywic9 <- subset(wic_samp9, fsq162 == "1", select = c(sddsrvyr.x, fsq162, cbq020, cbq030, cbq040, bmxbmi, bmxwt, fsdhh, fsdch))

onlywic7 <- subset(wic_samp7, fsq162 == "1", select = c(sddsrvyr.x, fsq162, cbq020, cbq030, cbq040, bmxbmi, bmxwt, fsdhh, fsdch))

#MILK and soda

mswic9 <- subset(wic_samp9, fsq162 == "1", select = c(cbq050, cbq060))

mswic7 <- subset(wic_samp7, fsq162 == "1", select = c(cbq050, cbq060))

#to collapse variables (Chisq test returned as error due to small size of variable =5)

combowic3$collapse20 <- ifelse(combowic3$cbq020 == "1", 1, ifelse(combowic3$cbq020 == "2", 2, ifelse(combowic3$cbq020 == "3", 3, 4)))

combowic3$collapse30 <- ifelse(combowic3$cbq030 == "1", 1, ifelse(combowic3$cbq030 == "2", 2, ifelse(combowic3$cbq030 == "3", 3, 4)))

combowic3$collapse30 <- ifelse(combowic3$cbq030 == "1", 1, ifelse(combowic3$cbq030 == "2", 2, ifelse(combowic3$cbq030 == "3", 3, 4)))

#Recode 99 as NA in milk and soda

combowic4$cbq050[combowic4$cbq050 == 99] <- NA

combowic4$cbq060[combowic4$cbq060 == 99] <- NA

# statistical tests (chi squared tests, t-test)

chisq.test(cmbowic3$sddsrvyr.x, combowic3$collapse20)

chisq.test(cmbowic3$sddsrvyr.x, combowic3$collapse30)

chisq.test(cmbowic3$sddsrvyr.x, combowic3$cbq040)

chisq.test(cmbowic4$sddsrvyr.x, combowic4$cbq050)
chisq.test(combowic4$sddsrvyr.x, combowic4$cbq060)
chisq.test(combowic3$sddsrvyr.x, combowic3$fsdhh)
chisq.test(combowic3$sddsrvyr.x, combowic3$fsdch)
t.test(combowic3$sddsrvyr.x, combowic3$bmxbmi)
t.test(combowic3$sddsrvyr.x, combowic3$bmxwt)

#means
mean(onlywic9$cbq020, na.rm=T)
[1] 1.456858
> mean(onlywic7$cbq030, na.rm=T)
[1] 2
> mean(onlywic9$cbq030, na.rm=T)
[1] 1.703741
> mean(onlywic7$cbq040, na.rm=T)
#etc...