ESSAYS ON ASSESSING THE IMPACT OF WIC FOOD PACKAGE REVISIONS ON PARTICIPANTS' FOOD SELECTION AND CONSUMPTION AND INFANT FEEDING PRACTICES

A Dissertation

by

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ABSTRACT

Healthy food choices and consumption during early childhood are important for growth and development and forming healthy eating habits, which could significantly impact individuals' long-term health outcomes. However, millions of children in the United States are still facing the problem of food insufficiency. Children from low-income households can be especially vulnerable to this problem. Food assistance programs play an important role in providing low-income households with access to nutritious foods and educational resources and help participants make healthy food choices within their budget.

For this reason, understanding the effect of food assistance programs on participants' food choices and consumption can provide more insights to help improve the effectiveness of assistance programs and provide better support to people in need. In this dissertation, we examine the impact of the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) food packages revisions and the effect of maternal nutrition knowledge on their feeding practices of infants, toddlers, and pre-school age children for WIC participating households.

The first study uses the mixed-effect regressions and the Texas Food and Nutrition Questionnaire (TEXFAN) data to examine how mothers' nutrition knowledge affects mothers' and children's consumption of fruits, vegetables, whole grain and refined grain products, and milk. Results show that better nutrition knowledge of daily food could significantly increase the WIC participants' likelihood to have healthier dietary patterns.

In the second and third studies, we use data from the National Food and Nutrition Survey for WIC (NATFAN) to investigate the effects of the revised WIC food packages on mothers' breastfeeding practices and time of introducing complementary foods. Findings reveal that the mothers are more likely to breastfeed their infants after the revisions in WIC and delay introducing complementary foods to infants. However, the level of improvement in participants' breastfeeding practices varies by poverty regions.

Overall, the results suggest that enhancing mothers' nutritional knowledge and revising the assistance policies to meet program participants' needs may shift the food consumption of mothers, infants, and children to healthier patterns.

DEDICATION

To my dear parents, Zhihua Yang and Yanfeng Di

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All other work conducted for the dissertation was completed by the student, under the guidance of Dr. Ariun Ishdorj.

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NOMENCLATURE

DGA	The Dietary Guidelines for Americans
NATFAN	The National Food and Nutrition Survey
PSM	Propensity Score Matching
TEXFAN	The Texas Food and Nutrition Survey
WIC	The Special Supplemental Nutrition Program for Women, Infants, and Children

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

Page

CHAPTER I

INTRODUCTION

Healthy food choices and consumption during infancy and pre-school years are important for developing healthy eating habits that have been found to be associated with positive long-term health outcomes (Schwarzenberg and Georgieff, 2018; Mikkilä et al. 2005; Movassagh et al. 2017). However, millions of children in the United States are still facing the problem of food insufficiency (Coleman-Jensen , et al., 2020). Children living in low-income households can be especially vulnerable to this problem due to limited resources. Public assistance programs play an important role in providing individuals from low-income households with better access to healthy foods and help them to establish healthier eating patterns.

The Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) is one of the 15 federally funded food and nutrition assistance programs in the United States that form a nutritional safety net for children and adults from low-income households. WIC Program plays a vital role in safeguarding the health of low-income women, infants, and children up to age five who are at nutritional risk by providing nutritious foods to supplement diets, information on healthy eating, and referrals to health care (USDA, FNS, 2009). In 2009, the WIC food packages were revised for the first time since 1972, which intended to 1) provide a strong incentive for postpartum women to breastfeed and 2) encourage more consumption of fruits and vegetables, more consumption of whole-grain food, and less intake of saturated fat and sugar for both adults and children.

The influence of maternal nutrition knowledge on mothers' and children's food consumption practices is examined in Chapter II. Existing studies suggest that mothers with higher nutrition knowledge level are more likely to have healthier dietary habits, choose more diverse and healthy foods for their families, and prevent their children from undernutrition (Vollmer, et al., 2017, Appoh and Krekling, 2005, Alderman and Headey, 2017, Hirvonen, et al., 2017, Yabancı, et al., 2014). With a dataset that provides the information on both mother and child's food consumption, we investigate the impact of the mother's nutrition knowledge on her own and her child's consumption of fruits, vegetables, whole grain and refined grain food, and milk. To account for the nested structure of the data, we use multi-level regression in the analysis (Hox et al. 2018). The results suggest that in general, mother and children's food consumption are shifted to healthier patterns if the mother has better nutrition knowledge, but the level of impact varies by type of food. We also evaluate the effect of revisions in WIC food packages on mother and children's food consumption. Both the diversity and frequency of mother and children's healthy food consumption are improved after the revision.

Chapters III and IV focus on the effect of the 2009 WIC food package revisions on infant breastfeeding practices and introduction to complementary foods. Existing literature on this topic mostly used data from few states and does not account for the potential effect of the participants' access to WIC clinics (Whaley et al. 2012, Chiasson et al. 2013, Langellier et al. 2014, Wilde et al. 2012, Reat et al. 2015). Furthermore, the effect of WIC food package revisions on caregivers' feeding practices related to complementary foods is not well known. To fill these gaps in the literature, in Chapter III of this dissertation, we compare the caregivers' infant feeding behaviors, which include their choices of infant feeding packages, such as fully breastfeeding, partially breastfeeding, and fully formula feeding, and the time of introducing complementary foods to infants, pre and post WIC revisions. Since individuals in the pre-WIC revision period of the dataset are different from those in the post WIC revision, the Propensity Score Matching (PSM) model is used in the analysis. To account for the different levels of access to the WIC clinic in the rural and non-rural areas (Rossin-Slater, 2013), we separate the sample based on the participants' location. The analysis with subgroup data provides more insights into how policy revision affects rural and non-rural areas. Our findings suggest the revision increased the percentage of caregivers willing to breastfeeding their infants, and in general, the caregivers delayed the time of introducing the complementary foods to infants.

Chapter IV focuses on the impact of the new WIC food package revisions on breastfeeding practices for individuals in areas with high poverty rates. The high poverty regions considered in this chapter include the US-Mexico-border area, the Appalachian Region, the Mississippi Delta Region, the diabetes belt, Indian Tribal Organizations (ITOs), and food deserts. Existing evidence suggests that women with high income are more likely to initiate breastfeeding and have significantly higher breastfeeding rates than women who have low income (McDowell et al. 2008). In addition to the selection of infant feeding packages offered to women by WIC, the effect of regional factors on the mother's breastfeeding initiation is also estimated. The results suggest that participants' feeding practices change after the revision is associated with the region where they are living.

The conclusion and main findings of this study are presented in Chapter V.

CHAPTER II

INFLUENCE OF MATERNAL NUTRITION KNOWLEDGE ON FOOD CHOICES AND CONSUMPTION OF MOTHERS AND CHILDREN

Introduction

A healthy diet in childhood leads to a similar behavioral pattern in adulthood (Mikkilä et al. 2005, Movassagh et al. 2017). The dietary patterns of young age children is positively correlated with the dietary pattern of the caregivers living in the same household, especially the mothers (Amugsi, et al., 2015, Banna, et al., 2018, Brown and Ogden, 2004, Vereecken, et al., 2010). For this reason, the effect of maternal education level and nutrition knowledge on children's food choices and consumption is a topic of particular interest. In general, the mother's better nutrition knowledge and higher education level have positive effects on children's nutrition condition. Children living in families where the mother has a higher education level are less likely to be malnourished (Vollmer, et al., 2017). Mothers who scored higher grades on a nutrition knowledge test were more likely to have well-nourished children (Appoh and Krekling, 2005). The mother's education and nutritional knowledge levels are also found to be positively associated with children's dietary diversity (Alderman and Headey, 2017, Hirvonen, et al., 2017) and eating habits (Yabancı, et al., 2014). The effect of nutrition knowledge on younger children is more substantial compared than that of older children (Variyam, et al., 1999).

Other than the knowledge-related effect, many studies have found that mothers could influence children's eating practices through their own eating practices, also known as the modeling effect. Kueppers et al. (2018) measured the mother's healthy-eater self-schema (HESS), which indicates if the mother is self-identified as a healthy eater, to analyze the relation between maternal HESS, mother's intake of food, and child dietary intake. The results suggest that there is a positive correlation between the mother's and children's consumption of fruits, vegetables, saturated fat, and added sugar. Musaad et al. (2017) use a sample of low-income children from the U.S. between three and five years old to examine the simultaneous effects of the environmental, parental, and children's factors on health-related behaviors. They find that the parental modeling effect is an important driver of healthy child behaviors. Diep et al. (2015) come to a similar conclusion that the caregiver's fruits and vegetables intake was positively associated with a child's fruits and vegetables intake, using a sample of Asian caregivers who participated in the Texas WIC program.

The existing studies address the relation between mother's nutrition knowledge level and children's dietary pattern using individual-level regression analysis or correlation analysis and do not consider the potential effect within the household. We conduct a secondary analysis of survey data collected from the participants in the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) living in Texas. WIC program provides federal grants to states for supplemental food, health care referrals, and nutrition education for low-income pregnant and postpartum women, and to infants and children under age five who are at nutrition risk. The program revised the packages for the first time in 2009 to align the WIC food package with the Dietary Guidelines for Americans (DGA), especially to encourage more consumption of fruits and vegetables, whole-grain foods, and less intake of saturated fat and sugar for adults and children.

The objective of this paper is to investigate how mother's nutrition knowledge affects her own and her child's consumption of fruits and vegetables, whole grain and refined grain foods, and milk, focusing on individuals from low-income households participating in WIC. Furthermore, we examine if the availability of WIC authorized stores affects WIC participants' food choices and consumption. Finally, the potential effects of WIC food package revisions are evaluated using data from pre- and post-revisions of WIC food packages.

Data

Data Source

Texas Food and Nutrition Questionnaire (TEXFAN) was developed by the Institute for Obesity Research and Program Evaluation at Texas A&M University and was distributed to Texas WIC participants both pre (Phase 1) and post (Phase 2) the 2009 WIC program revision. TEXFAN provides separate sections for family, woman, infant, and child, including the questions about participants' demographic information, dietary pattern, and parents' feeding practices to the infants and children up to age five. The purpose of TEXFAN is to evaluate the impact of the WIC food package revision on participants' food choices and feeding habits in Texas. The respondents completed the family and the woman sections of the questionnaire first. If the household has an infant and/or child who receives the WIC benefits, the respondents also complete the section for the infants and/or child. If the household has more than one child who participates in WIC, respondents only need to include the information for one representative child.

Approximately 14,000 questionnaires in total were sent out to 73 local WIC agencies in Texas pre and post the WIC revision, and a total of 13,879 responses were completed. In general, one questionnaire would include the information of a pregnant mother, the information of a mother and a child between 1 and 5 years old, or the information of a mother, a child, and an infant within the same household. We only include the responses with the complete mother's and child's information.

Additional data is used from USDA's Food Environment Atlas data, which provides information on three categories of food environment factors. The first part is about food choices, which contains the indicators of the community's access to and acquisition of healthy, affordable food; the second group of indicators relates to the community's health and well-being conditions; the third part focuses on community characteristics that may affect the food environments, such as the income level, demographic composition, and other factors. In addition to TEXFAN data, the USDA's Food Environment Atlas data on the number of stores in a county authorized to accept WIC Program benefits in 2012 were used in this research. HUB USPS ZIP Code Crosswalk file (2011 4th Quarter) is used to connect the USDA Food Environment Atlas data (county level) and TEXFAN data (ZIP code level). If a single ZIP code fell into multiple counties, we choose the one with the highest resident ratio. The resident ratio is the ratio of residential address in the ZIP part to the total number of residential addresses in the entire ZIP area.

Dependent Variables

The foods that are related to mother and child's food consumption practice include fruits and vegetables, whole grain and refined grain products, and milk. The same questions were asked from a mother and child.

Fruits and Vegetables Consumption

Existing literature provide evidence that increasing the consumption of fruits and vegetables in both amount and frequency is associated with many health benefits, such as reducing the risk of different types of cancer and rheumatoid arthritis, protecting against cardiovascular disease, and decreasing the probability of obesity, through providing vitamin C, carotene, fiber and other ingredients (Yahia, 2010). Furthermore, diversified consumption pattern of fruits and vegetables is recommended by DGA, to both mother and child.

Considering the potential benefits of consuming fruits and vegetable and the availability of information in TEXFAN data, we evaluate mother and children's consumption practices in two ways. First, we use fruits and vegetables consumption diversity as the first outcome to address the effect of maternal knowledge on mother's and children's food consumption patterns. The TEXFAN questionnaire provided the list of 26 different fruits and vegetables commonly available in the grocery store and ask the respondents to choose which fruits and vegetables they and their child usually ate during the past year. We count the types of fruits and vegetables the participants selected and use the sum of types as the measurements for the fruits and vegetables consumption diversity.

Another measurement for food consumption practice is children's and mothers' consumption frequency of fruits and vegetables. A higher frequency consumption of fruit and vegetables is likely to be associate with healthier lifestyle. The frequency of consumption used in the questionnaire include: "(0) - never", "(1) - 1 to 3 times per week", "(2) - 4 to 6 times per week", "(3) - 1 time per day", "(4) - 2 times per day", "(5) - 3 times per day", and "(6) - 4 or more times per day". The options are the same for all frequency-related questions. The frequency is recoded as "0" for less than one time per day and "1" otherwise.

Whole Grain and Refined Grain Product Consumption

The questions related to whole grain consumption ask for mother and children's consumption frequencies of whole-wheat tortillas, corn tortillas, whole-wheat or whole-grain bread, brown rice, and oatmeal. Refined grain products include white bread, white flour tortillas, and white rice. The frequency options are the same as the questions for fruit and vegetables.

To summarize the consumption of different types of products into a single variable that can be used to measure the respondents' overall consumption of whole and refined grains, we add the frequencies across different types of grain food and recode the results to less than one time per day as "0" and "1" otherwise. To compare mother and child's consumption of whole-grain products and refined grain products we transform the results to indicate whether whole grain or refined grain foods are consumed more frequently. If the mother consumed whole-grain products more frequently compared to refined grain foods, the outcome is coded as "1" and "0" otherwise.

Milk Consumption

The questions related to milk consumption include the type of milk and the amount of milk they usually consumed in a day. Because the amount of milk consumed by mother and by child cannot be directly compared, we standardize the amount based on the 2015-2020 DGA's suggestions across mother and child's age and made the amount comparable. Toddlers are suggested to take 2 cups of whole milk per day, while mothers and children over 2-year-old are encouraged to consume low-fat or fat-free milk, and the recommended amount is 3-cup for mother and 2.5-cup for children.

Explanatory Variables

One of the main explanatory variables is mother's nutrition knowledge level. The maternal nutrition knowledge level related to fruits and vegetables is measured by the mother's response to "I know how to pick out fresh fruits and vegetables" with a five-point Likert-style scale. The respondents self-evaluate their knowledge level and choose the answer as "(5) - strongly agree", "(4) - agree", "(3) - neither agree nor disagree", "(2) – disagree", and "(1) – strongly disagree" accordingly. Similarly, the nutrition knowledge level about whole grain products is measured by the mother's response to "I know how to use product labels to choose 100% whole grain bread". Considering the small sample size of the participants who self-evaluate as "neither agree nor disagree", "disagree", or "strongly disagree", the nutrition knowledge levels are reclassified as high, medium, or low. No question from TEXFAN could be used to measure mother's nutrition knowledge about milk in the questionnaire, but mothers are asked about if they would like to drink 2% milk, 1% milk, and skim milk, and which type of milk they are willing to give their child. We assume that mothers with nutrition knowledge would choose the type of milk scientifically supported by DGA, both for themselves and their child. With this assumption, mother's nutrition knowledge regarding milk is coded based on their attitude towards the different types of milk. If a mother prefers the type of milk for herself and the child that is suggested by DGA, she is classified as "high" level; if a mother's choices in either case are not properly, she is classified into "low" nutrition knowledge level; otherwise, the mother is classified as "medium" knowledge level.

The variable that indicates whether the data is collected pre- or post-WIC package revision is also included in the analysis to determine if mothers or children's food consumption practices change after the policy revision.

Other variables from TEXFAN that are considered for analysis include child's and mother's language most often spoken, race, education level, and employment status. In addition, the indicator for the number of stores that are authorized to accept WIC vouchers in each county is included in the regression. These WIC authorized stores also accept cash value vouchers that allow the purchase of fruits and vegetables.

Methods

Mother and child's food consumption can be expressed as a function of each individual's demographic factors and the mother's nutrition knowledge level.

One of the challenges of estimating this model is to account for the correlation between mother-child pairs who are from the same household. To account for the nested structure of the data, the mixed-effect models are estimated (Hox et al. 2010). Mother and child within the same household are nested into the same household ID, and the households living in the same FIPS code region are nested into the same county. By specifying a three-level hierarchical model, we are able to simultaneously estimate the variation associated with mother and child (level 1), household (level 2), and county (level 3) levels, and analyze the impact of mother's nutrition knowledge on mother and child food consumption.

The level-1 model of the mixed-effect linear model can be expressed as:

$$Y_{ihc} = \beta_{0hc} + \beta_{1hc} * X_i + \varepsilon_{ihc}.$$

This formula represents the food consumption practice of individual i in house h in county c. ε_{ihc} is the random individual-level error. X_i is the variable that indicate whether the individual is the child or mother within the household.

In level 2, the intercept β_{0hc} can be further modeled as:

$$\beta_{0hc} = \gamma_{00c} + \gamma_{01c} Z_h + u_{0hc}.$$

Z_h is characteristics that mother and child shared at the household level, such as the language most often spoken, mother's employment status, and race. Mother's nutrition knowledge is included in this level of modeling. Here u_{0hc} is the household level random effect.

The level 3 model modeled the term γ_{00c} in level 2 as:

$$\gamma_{00c} = \alpha_{001} + \alpha_{002} W_c + \epsilon_{00c}.$$

W_c includes the indicator for the counties and the variable that indicates whether the data was collected pre or post the WIC food package revision. ϵ_{00c} is the county-level random effect.

The variable that captures the mother and child's fruits and vegetables consumption diversity is measured by the counts of fruits and vegetables types. Typically, Poisson regression would be used for modeling count data. Thus, a mixed-effect Poisson regression is applied in this analysis. The variables that measure mother and child's consumption frequency of fruit and vegetables, grain food products, and their preferences of grain products are recoded to binary variables. Thus, the outcome variables are binary in this case. A mixed-effect logit model is estimated to examine how nutrition knowledge and other factors affected mother and child's food consumption frequency and their preference for whole grain or refined grain product. Mother and child's consumption of milk is a continuous variable, which is modeled with a mixed-effect linear model.

Results

The data that describe the food choices and consumption of the mother and the child ages from 1 up to 5 years of age are retained for the analysis. After cleaning the missing values, the final sample includes the responses from 7,420 individuals from 3,710 households, of which 1,777 households are from pre-WIC food package revisions, and 1,933 households form post revision.

Table II-1 lists the information about the mother's and child's characteristics and county-level information used for the analysis. About 50% of children in our sample are girls and the average age on children is around two years.

The average age of mothers is around 28 years old. More than half of the mothers are Hispanic, and 75% spoke English. More than 30% of the mothers have some college or higher education, and majority are unemployed. As for the number of WIC authorized stores at the county level, the value ranges from 0 to 329. On average, there are 93 WIC authorized stores in each county.

The distribution of the mother's nutrition knowledge level regarding different food categories is presented in Table II-2. More than half of the mothers believed that they knew how to select fresh fruits and vegetables and how to use product labels to choose 100% whole grain bread. Mothers who self-evaluated as "neither agree nor disagree", "disagree", or "strongly disagree" are classified as having a "low" level of nutritional knowledge because of the small sample size in each group. As for the mother's nutrition knowledge about the choice of milk, around half of the mothers would prefer the low-fat and skim milk for both herself and the child who is older than two-year old. However, over 30% of the mother would prefer 2% milk to low-fat milk and skim milk.

Table II-1 Summary Statistics: Characteristics of Mothers and Children

	Mean	St. Dev.
Child's Characteristics		
Female	0.49	0.50
Age	2.3	1.07
Mother's Characteristics		
Age	27.81	7.19
Black	0.11	0.31
Hispanic	0.65	0.48
Language: English Only	0.46	0.5
Language: English and Spanish	0.29	0.46
Language: Spanish Only	0.23	0.42
Language: Others	0.01	0.09
Education: Less than High school	0.33	0.47
Education: High school or equivalent	0.36	0.48
Education: Some college or equivalent	0.28	0.45
Education: Bachelor or higher	0.03	0.18
Employment: No	0.64	0.48
Employment: Part-time	0.14	0.35
Employment: Full-time	0.22	0.41
County Level Characteristics		
Number of WIC Authorized Store	92.99	108.18
Pre/Post WIC Package Revision		
Post	0.52	0.50
N=	3,710	

Table II-2 Nutrition knowledge level by food categories

Nutrition Knowledge Level	Fruit & Vegetable		Whole Grain		Milk	
	N	%	N	%	N	%
Low	328	8.84%	795	21.43%	1132	30.51%
Medium	2045	55.12%	1905	51.35%	783	21.11%
High	1337	36.04%	1010	27.22%	1795	48.38%
Total =	3710					

Table II-3 provides summary statistics for the outcome variables. The variables related to fruits and vegetables consumption are presented in Part I. On average, a mother consumed 12 different types of fruit and vegetables during the last year, and a child consumed ten different types of fruits and eight types of vegetables. Over 60% of the children and mothers consume fruit one time per day, and around half of them consumed vegetables daily. Comparing mother and child's food consumption frequencies, the child would consume fruit more frequently and eat vegetables less frequently, compared to the mother. As for the consumption of whole-grain and refined grain foods, over 40% percent of mothers and children consume whole wheat tortillas, corn tortillas, whole wheat or whole grain bread, brown rice, or oatmeal every day. Compared to whole wheat food consumption, a higher percentage of mothers and children consume refined wheat products, such as white bread, white flour tortillas, and white rice every day. The outcome variables related to milk consumption are constructed based on DGA. Overall, more than half of mothers (65%) and children (57%) in our sample consume whole wheat products more frequently. Only 10% of mothers and 34% of children would consume the type of milk suggested by the DGA. On average, a mother drinks 1.5 cups of milk per day, which is less than DGA's 3-cup suggestion, and a child drinks 2.6 cups of milk per day, which meets the recommended 2.5-cups by the DGA.

Tables II-4 to II-8 present the estimation results the mixed-effect models.

Table II-3 Summary Statistics of Outcome Variables

	Mother		Child	
	Mean	St. Dev.	Mean	St. Dev.
Part I: Fruit and Vegetable Consumption				
Number of Different Fruits	11.90	4.62	10.31	4.72
Number of Different Vegetables	12.17	4.84	8.07	4.65
Frequency of Fruit Consumption	0.60	0.49	0.66	0.47
Frequency of Vegetable Consumption	0.54	0.50	0.54	0.50
Part II: Whole Grain and Refined Grain Consumption				
Frequency of Whole Wheat Food Consumption	0.48	0.50	0.44	0.50
Frequency of Refined Wheat Food Consumption	0.75	0.43	0.60	0.49
Consume Whole Wheat More Frequently	0.65	0.48	0.57	0.50
Part III: Milk Consumption				
Consume Milk based on DGA	0.10	0.30	0.34	0.48
Cups of Milk Consumed (Daily)	1.54	0.99	2.59	1.08

Table II-4 shows the estimates of mixed-effect Poisson regression for the types of fruit and vegetables. Columns (1) and (3) list the coefficients, while columns (2) and (4) present the marginal effect. The results show that, on average, mothers consumed around two more types of fruits and four more types of vegetables compared to children. Nutrition knowledge has a significant effect on fruits and vegetables consumption diversity. Compared with low-level nutrition knowledge about fruits and vegetables, individuals would consume one more type of fruit and vegetables in middle-level knowledge households and two more types each in high-level knowledge families. Hispanic households would consume one more type of fruit but one less type of vegetable than non-Hispanic families. The mother's education level is also positively correlated to fruits and vegetables consumption diversity. Individuals living in a household where the mother finished high school are more likely to consume one more type of fruit and vegetable. If the mother has a bachelor's degree or higher, the individuals' food choices are more diversified. Individuals living in households where mother has a part-time or full-time job tend to have a lower level of food diversity, but the effect is small and not significant. The households that speak Spanish are likely to have a higher level of food diversity. In comparison, the households that primarily speak English have a lower level of food diversity, though the differences are insignificant. The number of WIC authorized stores nearby have a minimal positive effect on individuals' fruit consumption diversity but no impact on their choice of vegetables. On average, individuals consume more types of fruit after the WIC food package revision, while the level of vegetable diversity stay nearly the same.

Table II-4 Estimates of Mixed-effect Poisson Regression for consumption diversity of fruit and vegetable

	Type of fruit consumed		Type of vegetable consumed	
	(1) Coefficient	(2) Marginal Effect	(3) Coefficient	(4) Marginal Effect
Mother	0.143***	1.570***	0.412***	4.034***
	(0.007)	(0.077)	(0.007)	(0.080)
Nutrition Knowledge Level: Mid	0.060**	0.663**	0.096***	0.941***
	(0.023)	(0.249)	(0.025)	(0.244)
Nutrition Knowledge Level: High	0.174***	1.908***	0.233***	2.287***
	(0.023)	(0.257)	(0.026)	(0.253)
Hispanic	0.066***	0.730***	-0.087***	-0.852***
	(0.016)	(0.178)	(0.018)	(0.177)
Black	-0.051*	-0.560*	-0.103***	-1.013***
	(0.022)	(0.247)	(0.024)	(0.240)
Education: High school or equivalent	-0.002	-0.020	-0.003	-0.027
	(0.015)	(0.168)	(0.017)	(0.165)
Education: Some college or equivalent	0.053**	0.584**	0.083***	0.813***
	(0.017)	(0.185)	(0.019)	(0.182)
Education: Bachelor or higher	0.135***	1.478***	0.213***	2.088***
	(0.036)	(0.394)	(0.039)	(0.383)
Employment: Part-time	-0.018	-0.202	-0.023	-0.230
	(0.018)	(0.199)	(0.020)	(0.195)
Employment: Full-time	-0.022	-0.246	-0.042*	-0.409*
	(0.016)	(0.173)	(0.017)	(0.169)
Language: English Only	-0.090	-0.994	-0.028	-0.271
	(0.067)	(0.740)	(0.073)	(0.717)
Language: Spanish Only	0.030	0.327	0.114	1.113
	(0.069)	(0.755)	(0.075)	(0.734)
Language: English and Spanish	0.048	0.532	0.019	0.191
	(0.068)	(0.751)	(0.074)	(0.730)
Toddler	-0.056***	-0.620***	-0.069***	-0.681***
	(0.014)	(0.149)	(0.015)	(0.145)
Number of WIC authorized store	0.000**	0.002**	0.000	0.000
	(0.000)	(0.001)	(0.000)	(0.001)
Post	0.044***	0.479***	0.026	0.258
	(0.012)	(0.135)	(0.014)	(0.132)
Constant	2.132***		1.919***	
	(0.071)		(0.078)	
N	7420	7420	7420	7420

*** p<0.01, ** p<0.05, * p<0.1

Table II-5 shows the estimates of mixed-effect logit regression for fruit and vegetable consumption frequency. Columns (1) and (3) show the coefficients, and columns (2) and (4) present the marginal effects. Compared to child, mother is about 7% less likely to have fruit daily, while there is no significant difference for vegetables. The mother's nutrition knowledge level is significantly positively associated with individuals' fruits and vegetables consumption frequency. Individuals living in a household with middle or high-level nutrition knowledge have 8% or 18% higher chances of having fruit more than one-time a day, respectively, than a household with a mother who has low-level nutrition knowledge. As for the vegetable consumption frequency, the probability of having vegetables more than once per day would increase by around 10 % and 21%, with an increase in nutrition knowledge level. The effect of race on fruits and vegetables consumption frequency is not significant. The mother's education level is positively associated with the individual's fruits and vegetables consumption frequency, but the effect is not significant. The individuals who mainly speak English only, Spanish only, and English and Spanish have 12%, 22%, and 19% higher chance of consuming fruit and 13%, 14%, and 17% higher chances of consuming vegetables on a daily basis, respectively. The effects of WIC-approved store density on vegetable and fruit consuming frequency are not significantly different from 0. If the child in the household is younger than 2-year old, the individuals have a 3% higher chance of consuming fruit on a daily basis. As for the effect of WIC package revision, the percentage of the individuals who would eat fruits and vegetables every day increases by around 8% and 4%, respectively.

Table II-5 Estimates of Mixed-effect Logit Regression for fruits and vegetables consumption frequency

	Fruits Consumption Frequency		Vegetables Consumption Frequency	
	(1) Coefficient	(2) Marginal Effect	(3) Coefficient	(4) Marginal Effect
Mother	-0.501***	-0.069***	0.000	0.000
	(0.064)	(0.009)	(0.060)	(0.009)
Nutrition Knowledge Level: Mid	0.578***	0.080***	0.623***	0.097***
	(0.170)	(0.023)	(0.162)	(0.025)
Nutrition Knowledge Level: High	1.305***	0.181***	1.361***	0.211***
	(0.180)	(0.025)	(0.171)	(0.026)
Hispanic	0.094	0.013	-0.041	-0.006
	(0.126)	(0.017)	(0.118)	(0.018)
Black	0.106	0.015	-0.256	-0.040
	(0.172)	(0.024)	(0.161)	(0.025)
Education: High school or equivalent	-0.142	-0.020	-0.127	-0.020
	(0.119)	(0.016)	(0.111)	(0.017)
Education: Some college or equivalent	0.023	0.003	0.112	0.017
	(0.132)	(0.018)	(0.123)	(0.019)
Education: Bachelor or higher	0.238	0.033	0.442	0.069
	(0.289)	(0.040)	(0.269)	(0.042)
Employment: Part-time	0.004	0.001	0.190	0.030
	(0.140)	(0.019)	(0.132)	(0.020)
Employment: Full-time	-0.383**	-0.053**	-0.216	-0.034
	(0.121)	(0.017)	(0.114)	(0.018)
Language: English Only	0.872	0.121	0.842	0.131
	(0.520)	(0.072)	(0.495)	(0.077)
Language: Spanish Only	1.609**	0.223**	0.893	0.139
	(0.534)	(0.074)	(0.506)	(0.078)
Language: English and Spanish	1.387**	0.192**	1.104*	0.171*
	(0.530)	(0.073)	(0.504)	(0.078)
Toddler	0.239*	0.033*	0.123	0.019
	(0.105)	(0.015)	(0.098)	(0.015)
Number of WIC authorized store	0.001	0.000	0.001	0.000
	(0.001)	(0.000)	(0.000)	(0.000)
Post	0.586***	0.081***	0.226*	0.035*
	(0.097)	(0.013)	(0.090)	(0.014)
Constant	-1.221*		-1.627**	
	(0.552)		(0.525)	
N	7420	7420	7420	7420

*** p<0.01, ** p<0.05, * p<0.1

The estimated results related to whole grain and refined grain product consumption frequency are presented in Table II-6. Columns (1) and (2) report the results of whether individuals consume whole-grain products every day and columns (3) and (4) show the estimates of if individuals' daily consumption of refined grain food. Mothers are more likely to consume whole grain and refined grain products on a daily, compared with children. Hispanic individuals are 4.4% more likely to have whole grain food, compared to non-hispanic individuals. Blacks are 14.5% more likely to eat refined food every day, compared to individuals of other races. Education level does not have a significant effect on individuals' whole grain product consumption frequency but is negatively associated with the frequency of consuming refined grain products. Individuals living in a household that mother finished high school, some college, or bachelor education have a 4.2%, 14.5%, or 26.5% lower chance of consuming refined grain products on a daily basis, respectively. Mother with a full-time job reduced the probability of daily consumption of whole grain and refined grain products by 4.6% and 5.1%, respectively. Regarding the language, individuals who mainly spoke Spanish have the highest probability of taking whole grain food and the lowest probability of having refined grain food every day. The number of WIC authorized stores has a significant but small effect on increasing an individual's intake of whole-grain food consumption frequency. Individuals interviewed after the WIC package revision are 5.3% more likely to have whole grain food and 6.1% less likely to have refined grain food every day, as compared to those interviewed before the revision.

Table II-6 Estimates of Mixed-effect Logit Regression for whole grain and refined grain foods consumption frequency

	Whole Grain Food Consumption Frequency		Refined Grain Food Consumption Frequency		Eat Whole Grain Food More frequently	
	(1) Coefficient	(2) Marginal Effect	(3) Coefficient	(4) Marginal Effect	(5) Coefficien t	(6) Marginal Effect
Mother	1.229***	0.149***	0.385***	0.049***	0.621***	0.089***
	(0.076)	(0.009)	(0.069)	(0.009)	(0.066)	(0.009)
Nutrition Knowledge Level: Mid	0.684***	0.083***	-0.335*	-0.043*	0.856***	0.122***
	(0.131)	(0.016)	(0.152)	(0.019)	(0.123)	(0.017)
Nutrition Knowledge Level: High	1.290***	0.157***	-0.616***	-0.079***	1.457***	0.208***
	(0.155)	(0.018)	(0.174)	(0.022)	(0.144)	(0.020)
Hispanic	0.365**	0.044**	0.141	0.018	0.073	0.010
	(0.136)	(0.016)	(0.156)	(0.020)	(0.125)	(0.018)
Black	0.311	0.038	1.140***	0.145***	-0.605***	-0.087***
	(0.184)	(0.022)	(0.217)	(0.027)	(0.170)	(0.024)
Education: High school or equivalent	-0.193	-0.023	-0.327*	-0.042*	0.012	0.002
	(0.130)	(0.016)	(0.147)	(0.019)	(0.119)	(0.017)
Education: Some college or equivalent	-0.265	-0.032	-1.138***	-0.145***	0.378**	0.054**
	(0.143)	(0.017)	(0.167)	(0.021)	(0.132)	(0.019)
Education: Bachelor or higher	0.166	0.020	-2.077***	-0.265***	1.377***	0.197***
	(0.313)	(0.038)	(0.367)	(0.046)	(0.308)	(0.044)
Employment: Part-time	0.262	0.032	0.083	0.011	0.003	0.000
	(0.153)	(0.019)	(0.173)	(0.022)	(0.139)	(0.020)
Employment: Full-time	-0.380**	-0.046**	-0.399**	-0.051**	-0.096	-0.014
	(0.130)	(0.016)	(0.152)	(0.019)	(0.121)	(0.017)

Table II-6 Continued

	Whole Grain Food Consumption Frequency		Refined Grain Food Consumption Frequency		Eat Whole Grain Food More frequently	
	(1) Coefficient	(2) Marginal Effect	(3) Coefficient	(4) Marginal Effect	(5) Coefficient	(6) Marginal Effect
Language: English Only	1.475**	0.179**	-3.425***	-0.437***	2.300***	0.329***
	(0.551)	(0.067)	(0.703)	(0.089)	(0.534)	(0.076)
Language: Spanish Only	2.941***	0.358***	-4.079***	-0.520***	4.303***	0.616***
	(0.571)	(0.069)	(0.720)	(0.091)	(0.555)	(0.078)
Language: English and Spanish	2.263***	0.275***	-3.175***	-0.405***	3.074***	0.440***
	(0.564)	(0.068)	(0.712)	(0.090)	(0.545)	(0.077)
toddler	-0.058	-0.007	-0.117	-0.015	0.029	0.004
	(0.113)	(0.014)	(0.130)	(0.017)	(0.104)	(0.015)
Number of WIC authorized store	0.003***	0.000***	-0.001	-0.000	0.003***	0.000***
	(0.001)	(0.000)	(0.001)	(0.000)	(0.001)	(0.000)
post	0.433***	0.053***	-0.478***	-0.061***	0.614***	0.088***
	(0.104)	(0.013)	(0.120)	(0.015)	(0.097)	(0.014)
Constant	-2.481***		4.016***		-4.008***	
	(0.571)		(0.725)		(0.556)	
N	7420	7420	7420	7420	7420	7420

*** p<0.01, ** p<0.05, * p<0.1

Columns (5) and (6) present the results of whether the individuals would consume whole-grain food more frequently than refined grain food. The probability of having whole grain food more frequently is 8.9% higher for mother than the child, and 8.7% lower for Black than for other races. Spanish speakers are more likely to have whole grain food more frequently, compared with individuals who spoke other languages. WIC package revision also shifts 8.8% of individuals consuming whole grain food more frequently than refined grain food. The level of nutrition knowledge level about whole grain food is positively associated with whole-grain food consumption frequency. Mother with a middle and high nutrition knowledge level would increase the chance of consuming whole-grain products daily by 8% and 16%, respectively, and decrease the probability of taking refined grain food by 4% and 8% for individuals within the household. Furthermore, it increases individuals' likelihood of having whole grain food more frequently by around 21%.

Table II-7 reports the estimations of the mixed-effect models related to mother and child's milk consumption practices. Columns (1) and (2) present the result for if the mother and child's consumption of milk is consistent with the DGA's recommendations. The results suggest that mothers are less likely to choose low-fat milk, compared to the children. Black mothers and children are more likely to choose 2% or whole milk.

If the mother has a higher level of education, the individuals living in the same household are more likely to take low-fat milk. Around 5% of the individuals are more likely to choose the milk recommended by DGA. The household with a toddler would increase the probability of selecting the recommended milk type by 32%. The spoken

Table II-7 Estimates of Mixed-effect Regression for Milk Consumption Practices

	Type of Milk		Amount of Milk
	(1) Coefficient	(2) Marginal Effect	(3) Coefficient
Mother	-2.526***	-0.242***	-0.611***
	(0.110)	(0.013)	(0.009)
Nutrition Knowledge Level: Mid	0.601***	0.058***	-0.005
	(0.125)	(0.012)	(0.015)
Nutrition Knowledge Level: High	1.586***	0.152***	0.005
	(0.118)	(0.011)	(0.012)
Hispanic	-0.001	-0.000	-0.015
	(0.105)	(0.010)	(0.014)
Black	-0.439**	-0.042**	-0.010
	(0.146)	(0.014)	(0.019)
Education: High school or equivalent	0.003	0.000	-0.018
	(0.100)	(0.010)	(0.013)
Education: Some college or equivalent	0.500***	0.048***	-0.028
	(0.109)	(0.011)	(0.014)
Education: Bachelor or higher	0.786***	0.075***	-0.021
	(0.213)	(0.021)	(0.030)
Employment: Part-time	-0.079	-0.008	-0.010
	(0.116)	(0.011)	(0.015)
Employment: Full-time	-0.038	-0.004	-0.007
	(0.101)	(0.010)	(0.013)
Language: English Only	0.745	0.071	-0.025
	(0.460)	(0.044)	(0.057)
Language: Spanish Only	0.674	0.065	0.005
	(0.470)	(0.045)	(0.058)
Language: English and Spanish	0.677	0.065	0.023
	(0.467)	(0.045)	(0.057)
Toddler	3.348***	0.321***	0.238***
	(0.144)	(0.017)	(0.011)
Number of WIC authorized store	-0.001	-0.000	0.000
	(0.001)	(0.000)	(0.000)
Post	0.516***	0.049***	-0.082***
	(0.081)	(0.008)	(0.010)
Constant	-3.825***		1.117***
	(0.495)		(0.058)
N	7420	7420	7420

languages, the employment status, and the number of WIC authorized stores in the neighborhood does not have a significant effect on participants' choice of milk. Column (3) shows the estimation results for the amount of milk consumed by mother and child on a daily basis. The amount of milk that mother consumed is significantly less than the amount of milk that child drinks after the amount is adjusted based on the recommendation from DGA. In the meanwhile, individuals drink less milk after the package revision. Individuals in households with a toddler present drink more milk. The nutrition knowledge level, race, education level, employment status, and language do not significantly affect the amount of milk consumed.

Discussion

The findings of this study show that the mother's nutritional level, the household demographic information, and related policy revision affected both mother's and child's food consumption practices. Furthermore, our analysis suggests that the effect of these factors on different food products varies substantially.

The mother's nutrition knowledge is the factor that we are most interested in. Higher nutrition knowledge level has a positive impact on the mother's and child's healthy food consumption. A household where the mother has a higher level of nutrition knowledge increases mother and child's fruits and vegetables consumption diversity. Mother's and child's fruits and vegetables consumption frequency also increases with the mother's nutrition knowledge level. One issue of note is that the effect of nutrition knowledge on consumption behaviors of vegetables is consistently larger than on the that of fruits. One potential explanation could be that both mother and child prefer fruits over vegetables because of the taste, regardless of the mother's nutrition knowledge about fruits and vegetables.

As for the consumption of grain products and milk, mother's higher nutrition knowledge level increases both mother and child's consumption frequency of whole-grain products and decrease the frequency of refined grain product intake. A higher level of nutrition knowledge about milk also increases the probability that the mother and child to drink the milk following the DGA's recommendations. However, the amount of milk consumed is not significantly affected by the nutrition knowledge level.

WIC package revision also played an essential role in shifting the individuals to a healthier food consumption pattern. The fruits and vegetables consumption diversity is slightly improved after the revision, and the likelihood of consuming fruits and vegetables and whole grain food daily is significantly increased. Furthermore, individuals are more likely to choose the type of milk that is recommended by DGA.

Demographic differences also shift the individuals' food consumption practices to some degree. Higher education level is positively associated with more diverse fruits and vegetables consumption and negatively associated with the frequency of consuming refined grain products. It would also increase the probability of the individuals choosing low-fat and skim milk over whole and reduced-fat milk. The consumption frequency of fruits and vegetables and whole grain products are not significantly influenced by education level. Hispanic individuals favor having more types of fruits and more likely to have whole grain food every day. The fact that Black individuals tend to consume a fewer type of fruits and vegetable, to be more likely to have refined grain food on the daily basis, and more likely to have the lower fat milk suggests that more specific support should be targeted to this group of WIC participants. The overall effect of WIC authorized store availability at the county-level has little effect on individuals' healthy food consumption practices.

Conclusion

Mothers' nutrition knowledge of the daily food plays an essential role in the young children's food consumption. We analyze data collected from participants in the Texas WIC program, and after controlling for the potential random effect at the household and the county levels, we find that the mother's better nutrition knowledge about daily food, such as the fruits and vegetables, the grain products, and milk, would have a positive impact on mother and child's healthy eating practices.

Our findings suggest that increased nutrition knowledge could significantly improve the WIC participants' likelihood to have healthier dietary habits. Mother who strongly agree that they can pick out fresh fruits and vegetables would have been two more types of fruits and vegetables, compared to a mother who indicate that she does not know how to select fresh fruits and vegetables. The probably of consuming fresh fruits and vegetables daily increases by about 20% if mothers know how to select fresh fruits and vegetables. If the mothers strongly believe that they know how to use product labels to choose 100% whole grain food, the probability of the children and the mother living in the same household to eat eating whole-grain foods increases by 16%, and for refined grain products, the probability decreases by 8%, as compared to the households where mothers do not know how to use the labels. Furthermore, the increase in the probability of having whole-grain food every day almost doubled if the mothers' self-evaluation changes from "agree" to "strongly agree". Mother who shows tendency of drinking milk at lower fat level are more likely to take the milk that is recommended by the DGA guidelines.

Besides the nutrition knowledge, assistant programs that provide the individuals at nutrition risk with more chances to access healthy food could also help the participants form a healthier dietary pattern. After the WIC package revision in 2009, mothers and children are more likely to consume fruits, vegetables, and whole-grain foods daily, suggesting that revisions to WIC food packages have been effective.

One limitation of the present research is that the analyses are conducted using the data on Texas WIC participants only. Future studies can build on current findings and compare our findings to non-WIC individuals and extending the research to include more states.

CHAPTER III

IMPACT OF THE REVISED WIC FOOD PACKAGES ON INFANT FEEDING PRACTICES AND TRANSITION TO COMPLEMENTARY FOODS

Introduction

An increasing number of studies have suggested that health at birth plays an important role in individuals' long-term achievements. The health outcomes during infancy and early childhood are highly dependent on caregivers' feeding practices. Infant feeding practices normally include mother's feeding choices between breastfeeding or formula-feeding, and the time of introducing complementary foods, which include foods other than breast milk or infant formula.

Breastfeeding is the first linkage built between mothers and babies when the babies come into the world. Other than this emotional connection, the importance of breastfeeding from the perspective of health status is emphasized by the American Academy of Pediatrics (AAP). AAP initiated the policy statement of "Breastfeeding and the Use of Human Milk" in 1997 and updated the report in 2005 and 2012. The statements claim that breastfeeding ensures the best possible health for the infants, as well as the most preferred developmental and psychosocial outcomes (Gartner et al. 2005; Eidelman et al. 2012). AAP suggests "exclusive breastfeeding for about six months, with a continuation of breastfeeding for one year or longer as mutually desired by mother and infant" Furthermore, the benefits of breastfeeding have been widely discussed by many studies in different areas. Breastfeeding can reduce the risk of sudden death and postneonatal death of infants, compared with formula-feeding (Chen and Rogan 2004; Vennemann et al. 2009). The rates of type-1, type-2 diabetes, overweight, and obesity are significantly lower in breastfed infants (Owen et al. 2005; Rosenbauer et al. 2008; Horta, Loret de Mola, and Victora 2015). The mother's health condition could also be better off with breastfeeding. Breastfeeding is likely to improve the health outcomes both in the short and long term for mothers. It is associated with a reduced risk of breast cancer and maternal ovarian cancer (Ip et al. 2009). The economic benefit of breastfeeding is also significant. Breastfeeding saves costs for parents, insurers, employers, and society (Ball and Bennett 2001). Studies also find that low breastfeeding rates would result in high excess costs to society in the U.S. (Bartick and Reinhold 2010).

With regards to the time of introducing complementary foods, the AAP (Ronald and Kleinman, 2014) Committee's Pediatric Nutrition Handbook recommends that infants could begin consuming foods in addition to breastmilk or formula after six months old. More specifically, the United States Department of Agriculture (USDA) provides certain feeding guidelines regarding when to introduce complementary foods to infants (USDA, FNS, 2009). For juice and solids such as cereal, vegetables, and fruit, these are suggested to be introduced after the infants are six months old. Meat and meat alternatives are suggested after eight months. Sweeteners and sweetened foods should never be fed to a baby who is less than one year old.

The AAP guidelines claim that "introduction to solids prior to 4 months is associated with increased weight gain and adiposity, both in infancy and early childhood." Existing studies have suggested that a late introduction of complementary food and juice to infants may decrease the likelihood of future disease and obesity (Schack-Nielsen et al. 2010; Huh et al. 2011). Breastfeeding and delaying complementary foods are associated with lower obesity rates and a higher probability of healthy weight status (Moss and Yeaton, 2013).

Breastfeeding rates for infants in high-income families are significantly higher than those in low-income families (McDowell et al. 2008). The federal government funds a group of Child nutrition programs to support children living in low-income, and the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) is the one which aims to improve the health and nutritional conditions of low-income pregnant women, breastfeeding, or non-breastfeeding postpartum women, as well as infants and children up to age five who are at nutritional risks. The WIC program provides monthly federal grants to each state in the U.S. for supplementary food, health care referrals, and nutrition education. The program has been implemented in the U.S. for over 40 years and has benefited countless families. In 2018, the total amount of grant money for the WIC program reached $5.3 billion, and the system served more than 6.9 million participants, including about half of all infants born in the United States (USDA, FNS, 2020).

In 2009, the WIC food package policies were revised for the first time since 1972. The revisions intend to improve the health and nutritional quality of the foods provided to participants, keeping consistent with the Dietary Guidelines for Americans and infant feeding practice guidelines of AAP. Breastfeeding promotion is part of the crucial missions for the WIC policy revision of the infant food packages. Compared to previous food packages, the value of the revised food packages is increased substantially for participants who choose to breastfeed. Furthermore, the relative value of food packages for fully breastfeeding participants is higher than the participants who used formula. The changes intend to provide a stronger incentive for mothers to choose breastfeeding or exclusive breastfeeding.

As for the time to introduce complementary foods, the WIC committee recommends postponing the time to 6 months of life. For this reason, the infants will start to get complementary food only if they are 6 to 11 months old, and the package contains infant cereal, baby food fruits, and baby food vegetables. The baby food meats are available for fully breastfeeding infants when they are older than 6-month but will not be provided to partially breastfeeding and fully formula feeding babies. The amount of food in the baby food package is also positively associated with the caregiver's breastfeeding level.

A few studies have addressed the effects of the WIC program and the revision in 2009 with respect to caregivers' feeding practices. Some have considered the effects of an increase in the use of fully breastfeeding packages in California (Whaley et al. 2012), New York (Chiasson et al. 2013), and Los Angeles County (Langellier et al. 2014), where no formula was distributed through WIC. Wilde et al. (2012) find that within 17 local WIC agencies in 10 states (California, Florida, Georgia, Idaho, Illinois, Minnesota, Rhode Island, Tennessee, Texas, and Utah), more WIC mothers of newborns (aged up to five months) chose either fully breastfeeding or fully formula packages than partially breastfeeding packages. Reat et al. (2015) demonstrate that the average breastfeeding duration is almost four weeks shorter in south-central Texas after the revision took effect.

To sum up, the effects of the WIC program revision on caregivers' breastfeeding behavior are still unclear.

The research about the relationship between the WIC program and the participants' feeding practices of complementary foods to infants is quite limited. Existing studies find that WIC participants are more likely than nonparticipants to introduce complementary food to infants aged four to six months, which suggests a side effect of the WIC program on infant feeding practices (Bronner et al. 1999; Jacknowitz, Novillo and Tiehen 2007). However, there is no paper that discussed the effect of WIC package revision on participants' feeding practices of introducing complementary foods.

Furthermore, Rossin-Slater's study (2013) suggests that the effect of the WIC program is associated with geographic access to WIC clinics. The author uses ZIP-code-level data from Texas and finds that geographic access to WIC affects the WIC food benefit take-up. Another important finding of this study is that participants living in urban areas could access to WIC clinics easier than participants living in rural areas. These results suggest that the participants in urban and rural areas could behave differently because of their distance to the nearest local WIC clinic. Based on the conclusion from this study, it is reasonable to consider that the level of urbanization of the regions where the participants live may also differ the effect of policy revision.

The inconsistent findings and the gaps in previous literature suggest that a study from a more general perspective is necessary. Existing research in this area has primarily used data from only a few states or WIC agencies to analyze the impacts of these changes to the WIC food package. Different from that, we use a unique national-wide dataset that contains the information about participants' feeding behavior for both pre- and post-revision period, which is provided by the National Food and Nutrition Survey for WIC (NATFAN), to identify changes in the practice patterns of WIC participants. Based on the information from our dataset, we analyze the effect of WIC policy revision on caregivers' feeding behaviors to their infants and their decision regarding the time of introducing complementary foods.

This research intends to provide a more general evaluation of the effect of the WIC package revision in 2009. The main objectives are to better understand changes in infant feeding practices occurring after the revisions made to the WIC food packages, including choice changes related to fully or partially breastfeeding packages and fully formula packages, and changes to the time of introducing solid foods and juice to infants. In this work, we assume that the revision motivated WIC participants to live healthier lives and feed their infants in preferable ways. Furthermore, considering the potential geographic access effect, we compare the behavioral differences between non-rural and rural participants after the WIC package revision, which is not addressed in previous studies.

Methodology

The specification of the average treatment effect is considered significant when evaluating the effects of WIC revision on participants' feeding practices (Fisher, 1935). The treatment variable, T_i, is equal to 1 if the individual, i, belonged to a post-revision sample, and 0 if the individual, i, belonged to a pre-revision sample. Using the potential outcomes framework proposed by Rubin (1974), we let y_{1i} be the potential outcome for an individual, i, in the post-revision period, and y_{0i} be the potential outcome for an individual, i, in the pre-revision period. The observable outcome is expressed as $y_i = T_i y_{1i} + (1 - T_i) y_{0i}$. The effect of the WIC revision on the individual i, $y_{1i} - y_{0i}$, is the difference between the potential outcomes of the pre- and post-revision period. The problem is that we could not observe y_{1i} and y_{0i} in the same individual. The effect of the WIC revision could be estimated by the average treatment effect (ATE), which is given by $ATE = E[y_{1i} - y_{0i}]$. The estimation is taken for the entire sample.

Since the samples of the participant for before and after the WIC revision are not the same group of people in our dataset, the post-revision participants could have differed from the pre-revision participants with respect to relevant characteristics. This condition might have led to a biased estimation of the treatment effect if we compared the outcomes directly. Rosenbaum and Rubin (1984) suggest that propensity score matching (PSM) could play an important role in adjusting for such a lack of randomization in observational studies. They define the propensity score, $e(x_i)$, for a participant to be the conditional probability of an assignment to a particular treatment ($T_i = 1$), given a vector of the observed covariates, x_i:

$$p(x_i) = Pr(T_i = 1 | X_i = x_i).$$

Matching the propensity score provides the treatment group with a good counterfactual collection that shares similar characteristics and makes the outcomes for both groups more comparable. Then, the *ATE* could be estimated as:

$$ATE = E[y_{1i} - y_{0i} | p(\mathrm{x})] = E[y_{1i} | p(\mathrm{x})] - E[y_{0i} | p(\mathrm{x})].$$

We use a propensity score matching (PSM) technique to evaluate the effects of the WIC revision on participants' feeding practices. First, the PSM process requires the selection of a set of covariates; estimates of the propensity score are based on these. We then estimate the propensity scores using a binary logistic regression model:

$$\ln\left[\frac{exp(x_i)}{1 - exp(x_i)}\right] = \boldsymbol{\beta} x_i$$

where x_i is the series of explanatory variables used to estimate the propensity score, and $\boldsymbol{\beta}$ is a vector of the regression coefficients. The explanatory variables used for analysis are included here in Table III-1.

Two assumptions need to be satisfied when we use the PSM technique: conditional independence and overlapping. In general, a conditional independence assumption (CIA) means that the treatment assignment, T_i and response (y_{1i}, y_{0i}), are conditionally independent, given x_i. In other words, conditional on the propensity score, the covariates are independent of the treatment, which can be expressed as: $(y_{1i}, y_{0i}) \perp T|x_i$. Thus, each individual has the same probability of being treated, and the treatment is randomly assigned to all participants. However, the CIA cannot be directly tested. A balancing test can be helpful with strengthening a CIA argument because it can show if the distribution of post-matching observed characteristics is balanced across both groups. The assumption of overlapping, which is also known as common support, assumes common support of each group. One of the most straightforward methods for testing an overlapping assumption is a visual analysis of the density distribution of the propensity score in both groups (Caliendo and Kopeinig 2008). We show the results of this test in the following parts.

Based on the estimated propensity score, we employ several algorithms to implement and review the robustness of our matching results. Nearest-neighbor matching (NNM) matches each treated subject to the untreated subject, whose propensity score is closest (Austin 2011). Caliper Matching (CM) matches individuals from the post-revision group with individuals from the pre-revision group if they are within a specified range of propensity scores. Any values that fall outside that range are removed. Moreover, we also employ an inverse-probability-weighted regression adjustment (IPWRA) estimator. IPWRA estimators use models to predict treatment status and other models to demonstrate outcomes, making the estimators doubly robust. We are able to obtain a consistent estimate of the treatment effect as long as one of the models is correctly specified.

Data

We use the responses from the WIC participants to a questionnaire about infant feeding practice, which is a part of the National Food and Nutrition Survey Questionnaire for WIC (NATFAN), to evaluate the effects of WIC program revisions. The original purpose of the questionnaire was to conduct a national study about the effect of the new WIC package on the consumption of healthy food choices for WIC participants from different states, territories, and Indian Tribal Organizations (ITOs). The questionnaire was distributed to the WIC participants prior to and after the implementation of the revisions to the WIC food packages, and data from both periods were collected. We use pre-revision data to present the information from the period prior to the food package revision and post-revision for the period after the revision. The pre-revision period NATFAN data were collected in 38 states, 10 ITOs, Washington DC, and one U.S. Territory (50 WIC programs in total) in 2009. For the post-revision period, 40 states, 16 ITOs, Washington DC, and one U.S. Territory (58 WIC programs in total) re-administered the NATFAN to WIC participants in late 2010 and early 2011, which was at least six months after implementation.

NATFAN includes a series of questions about food choice and frequency instruments developed specifically for WIC participants. Specifically, the NATFAN infant questionnaire contains 33 questions about participants' infant feeding practices. It provides information on 21,768 infants during pre-revision and 22,951 infants during post-revision. We use participants' answers to the questions on food choices and feeding frequency as instruments to develop the outcome variables to measure the participants' practices. Besides, the NATFAN data also includes information about participants' age, ZIP code, language, race, and education level. The NATFAN data provides us with a good opportunity to evaluate the national-level effects of revised WIC packages on the change of participants' behavior.

Furthermore, the ZIP code of each observation could provide more detailed geographic information about participants' living area. The USDA ERS Rural-Urban Continuum Codes (RUCC) database in 2013 formed a classification scheme that distinguishes metropolitan (metro) counties by the population size of their metro area, and nonmetropolitan (non-metro) counties by the degree of urbanization and adjacency to metro areas. RUCC includes the FIPS county codes and ZIP codes of all counties in the U.S., as well as socioeconomic information on respondents. Since the respondents' ZIP codes information is provided in the NATFAN data, we merge it with RUCC data and use the ZIP-code information to identify if the participants are living in rural or non-rural areas. We classify the participants from metro counties as “non-rural” and the participants from non-metro counties as “rural.”

We limit the sample to those participants with non-missing information for demographic information and feeding practices. After dropping individuals with missing information, we have a sample of 9,260 participants for pre-revision and 10,264 participants for post-revision.

Results

In our pre-revision sample of participants, 20.51% are from rural areas, and 79.49% are from non-rural areas. Around 19.75% of post-revision participants are from rural areas, and 80.25% are from non-rural areas. Table III-1 shows the summary statistics related to participants’ and infants’ characteristics before and after the revision. In Part I, we describe the data for all participants, both pre- and post-revision. In both periods, roughly half of the infants are female. The ages of the infants are almost evenly distributed from less than one month old to 11 months old. The average age of the caregivers is around 25 years old. Approximately 15% of the participants are black, and 31% are Hispanic. Most of the caregivers have achieved a high school level of education or attended some college and only spoke English. The summary statistics of characteristics of non-rural and rural participants are presented separately in Parts II and III.

Table III-1 Summary Statistics: Characteristics of Infants and Caregiver Pre- and Post- the food package revision

	Part I. Overall				Part II. Rural				Part III. Non-rural			
	Pre-revision		Post-revision		Pre-revision		Post-revision		Pre-revision		Post-revision	
Variable	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Infant Characteristics												
Female	50.29%	0.5000	49.81%	0.5000	48.08%	0.4998	49.78%	0.5001	50.86%	0.5000	49.81%	0.5000
Less than 1 month old	10.99%	0.3128	10.79%	0.3102	11.01%	0.3130	9.52%	0.2936	10.99%	0.3128	11.10%	0.3141
1 to 2 months old	14.91%	0.3562	14.08%	0.3478	14.43%	0.3515	16.03%	0.3670	15.04%	0.3575	13.60%	0.3428
3 to 4 months old	19.07%	0.3929	18.69%	0.3898	17.17%	0.3772	17.46%	0.3798	19.56%	0.3967	18.99%	0.3922
5 months old	6.98%	0.2548	7.77%	0.2678	6.95%	0.2544	9.37%	0.2915	6.98%	0.2549	7.38%	0.2615
6 months old	11.70%	0.3214	11.85%	0.3232	12.95%	0.3359	11.84%	0.3232	11.37%	0.3175	11.85%	0.3232
7 to 8 months old	14.73%	0.3544	13.93%	0.3463	14.64%	0.3536	13.12%	0.3377	14.75%	0.3547	14.13%	0.3484
9 to 10 months old	16.02%	0.3668	16.43%	0.3705	16.27%	0.3692	15.59%	0.3628	15.95%	0.3662	16.63%	0.3724
11 months old	5.60%	0.2300	6.47%	0.2460	6.58%	0.2480	7.05%	0.2561	5.35%	0.2251	6.33%	0.2434
Caregiver's Characteristics												
Age	25.29	5.9704	25.11	6.0864	24.87	6.0599	24.21	6.0280	25.39	5.9428	25.33	6.0809
Age: less or equal to 20	22.52%	0.4177	23.84%	0.4261	23.75%	0.4257	28.66%	0.4523	22.20%	0.4156	22.65%	0.4186
Age: between 21 to 25	35.50%	0.4785	35.52%	0.4786	37.81%	0.4850	36.70%	0.4821	34.90%	0.4767	35.23%	0.4777
Age: between 26 to 30	24.23%	0.4285	22.49%	0.4175	23.96%	0.4270	19.59%	0.3970	24.30%	0.4289	23.20%	0.4221
Age: between 31 to 35	11.59%	0.3201	11.87%	0.3234	9.69%	0.2959	9.97%	0.2996	12.08%	0.3259	12.33%	0.3289
Age: between 36 to 40	4.71%	0.2118	4.81%	0.2141	3.42%	0.1819	4.24%	0.2016	5.04%	0.2188	4.95%	0.2170
Age: older or equal to 41	1.46%	0.1008	1.47%	0.1053	1.37%	0.1162	0.84%	0.0912	1.48%	0.1208	1.63%	0.1265
Black	14.71%	0.3542	15.74%	0.3642	6.42%	0.2453	5.72%	0.2323	16.85%	0.3743	18.21%	0.3860
Hispanic	31.07%	0.4628	30.84%	0.4618	17.54%	0.3804	17.46%	0.3798	34.56%	0.4756	34.13%	0.4742
Education: Less than high school	24.00%	0.4271	21.72%	0.4123	20.27%	0.4021	17.37%	0.3789	24.96%	0.4328	22.79%	0.4195
Education: High school or GED	33.14%	0.4708	32.71%	0.4692	38.23%	0.4861	37.00%	0.4829	31.83%	0.4658	31.65%	0.4651
Education: Some college	36.56%	0.4816	37.97%	0.4853	36.28%	0.4809	37.25%	0.4836	36.63%	0.4818	38.14%	0.4858
Education: College+	6.31%	0.2431	7.61%	0.2652	5.21%	0.2224	8.39%	0.2773	6.59%	0.2481	7.42%	0.2621
Language: English Only	71.90%	0.4495	71.88%	0.4496	84.83%	0.3588	86.38%	0.3430	68.56%	0.4643	68.31%	0.4653
Language: English and Spanish	13.57%	0.3425	13.47%	0.3415	9.11%	0.2878	8.19%	0.2743	14.73%	0.3544	14.77%	0.3549
Language: Spanish Only	12.75%	0.3336	13.07%	0.3371	5.48%	0.2276	4.59%	0.2093	14.63%	0.3534	15.16%	0.3587
Language: Others	1.77%	0.1319	1.57%	0.1243	0.58%	0.0759	0.84%	0.0912	2.08%	0.1427	1.75%	0.1311
N=	9,260		10,264		1,899		2,027		7,361		8,237	

Table III-2 presents the comparison of the participants' characteristics between the pre- and post-revision periods, at the national level and within rural/non-rural areas. The difference is highlighted if it is significant at the 10% level. From our analysis of the differences across all characteristics, we find that the differences are significant in infant and caregivers' ages, and caregivers' education levels cross pre- and post-revision period. Comparing the characteristics of rural and non-rural participants also shows pre/post differences. The differences between the pre- and post- samples suggest that the potential bias may exist if we compare the outcomes directly, and the analysis based on the propensity score is important.

We also compare the participants' characteristics between the rural and non-rural areas within each period. Participants living in rural areas tend to be younger than non-rural participants. There are fewer black and Hispanic participants and more English speakers in rural areas than in non-rural areas. The distribution of education levels in non-rural and rural areas is not the same, either. More participants in the rural area finish high school or GED education, while the percentages of WIC participants who attend some college in both regions are similar. Considering the significant differences between rural and non-rural participants, we separate our analysis into three parts: an overall analysis of all participants, one focusing just on rural participants, and one exclusively addressing non-rural participants.

Table III-2 Differences of Characteristics of Infants and Caregiver Pre- and Post- the food package revision

	Overall		Non-rural-Rural				Post-Pre			
			Pre		Post		Rural		Non-rural	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Variable	Diff	P-value	Diff	P-value	Diff	P-value	Diff	P-value	Diff	P-value
Infant Characteristics										
Female	-0.49%	0.4973	2.78%	**0.0305**	0.03%	0.9782	1.70%	0.2870	-1.05%	0.1901
Less than 1 month old	-0.21%	0.6408	-0.02%	0.9847	1.57%	**0.0406**	-1.48%	0.1253	0.11%	0.8332
1 to 2 months old	-0.84%	**0.0977**	0.61%	0.5058	-2.44%	**0.0047**	1.60%	0.1623	-1.44%	**0.0102**
3 to 4 months old	-0.38%	0.4928	2.40%	**0.0178**	1.52%	0.1150	0.30%	0.8057	-0.58%	0.3633
5 months old	0.80%	**0.0333**	0.03%	0.9614	-1.99%	**0.0027**	2.42%	**0.0057**	0.40%	0.3362
6 months old	0.15%	0.7425	-1.58%	**0.0556**	0.01%	0.9912	-1.11%	0.2896	0.48%	0.3522
7 to 8 months old	-0.80%	0.1119	0.11%	0.9004	1.01%	0.2402	-1.52%	0.1694	-0.62%	0.2697
9 to 10 months old	0.41%	0.4365	-0.32%	0.7324	1.04%	0.2564	-0.68%	0.5594	0.68%	0.2489
11 months old	0.86%	**0.0115**	-1.23%	**0.0378**	-0.73%	0.2316	0.47%	0.5577	0.97%	**0.0099**
Caregiver's Characteristics										
Age	-0.18	**0.0385**	0.52	**0.0007**	1.11	**0.0000**	-0.66	**0.0007**	-0.07	0.4935
Age: less or equal to 20	1.32%	**0.0286**	-1.55%	0.1491	-6.01%	**0.0000**	4.91%	**0.0005**	0.46%	0.4958
Age: between 21 to 25	0.03%	0.9704	-2.91%	**0.0182**	-1.47%	0.2144	-1.10%	0.4743	0.33%	0.6653
Age: between 26 to 30	-1.75%	**0.0039**	0.34%	0.7553	3.61%	**0.0005**	-4.37%	**0.0009**	-1.10%	0.1058
Age: between 31 to 35	0.28%	0.5449	2.39%	**0.0037**	2.37%	**0.0031**	0.28%	0.7716	0.26%	0.6240
Age: between 36 to 40	0.10%	0.7321	1.62%	**0.0030**	0.71%	0.1806	0.82%	0.1820	-0.09%	0.8038
Age: older or equal to 41	0.01%	0.9385	0.11%	0.7175	0.79%	**0.0083**	-0.53%	0.1106	0.15%	0.4623
Black	1.04%	**0.0444**	10.42%	**0.0000**	12.49%	**0.0000**	-0.70%	0.3573	1.36%	**0.0253**
Hispanic	-0.23%	0.7249	17.02%	**0.0000**	16.66%	**0.0000**	-0.07%	0.9532	-0.43%	0.5688
Education: Less than high school	-2.28%	**0.0002**	4.68%	**0.0000**	5.42%	**0.0000**	-2.91%	**0.0197**	-2.17%	**0.0015**
Education: High school or GED	-0.44%	0.5174	-6.40%	**0.0000**	-5.35%	**0.0000**	-1.23%	0.4266	-0.18%	0.8094
Education: Some college	1.41%	**0.0415**	0.34%	0.7819	0.90%	0.4556	0.96%	0.5311	1.52%	**0.0503**
Education: College+	1.30%	**0.0004**	1.38%	**0.0279**	-0.97%	0.1405	3.17%	**0.0001**	0.83%	**0.0432**
Language: English Only	-0.02%	0.9773	-16.27%	**0.0000**	-18.07%	**0.0000**	1.55%	0.1666	-0.25%	0.7370
Language: English and Spanish	-0.10%	0.8380	5.62%	**0.0000**	6.59%	**0.0000**	-0.92%	0.3049	0.05%	0.9320
Language: Spanish Only	0.32%	0.5043	9.15%	**0.0000**	10.58%	**0.0000**	-0.89%	0.2026	0.53%	0.3517
Language: Others	-0.20%	0.2696	1.50%	**0.0000**	0.91%	**0.0032**	0.26%	0.3345	-0.33%	0.1319

We report our findings from the NATFAN data in Table III-3 to Table III-10. In Table III-3, we compare the changes in the rate of breastfeeding initiation before and after the WIC package revision. If the mother breastfeeds her infants at least one time postpartum, we will say she initiates breastfeeding. The percentage of parents who are not sure if they ever breastfed their kids is close in both pre and post periods. At the national level, the rate of initiation before the revision is around 85% and increases slightly by 1.43 percentage points after the revision, which suggests that a higher percentage of participants intend to initiate breastfeeding to their infants after the revision across in our sample. The regional analysis of rural and non-rural areas shows a consistent trend when comparing the percentage change in breastfeeding initiation between pre-revision and post-revision. However, we find that even though the initiation rates change in both areas are not significant, it is observed that the increase in the non-rural area is higher than the increase in the rural area. The difference in the changes between rural and non-rural areas suggests that non-rural participants are more likely to try to breastfeed their infants after the revision, compared with the rural participants.

Table III-3 Initiation rate before and after the WIC package revision

	Part I. Overall		Part II. Rural		Part III. Non-rural	
	Pre-revision	Post-revision	Pre-revision	Post-revision	Pre-revision	Post-revision
No	14.30%	12.86%	14.80%	14.26%	14.17%	12.52%
Yes	85.32%	86.75%	85.04%	85.30%	85.40%	87.11%
Not sure	0.38%	0.39%	0.16%	0.44%	0.43%	0.38%
N=	9,260	10,264	1,899	2,027	7,361	8,237

In Table III-4, we compare the time when parents stop breastfeeding pre- and post-revision.

Table III-4 Time when stopped breastfeeding before and after the WIC package revision

	Part I. Overall			
	Pre-revision		Post-revision	
Less than 1 month old	46.34%	53.66%	45.19%	54.81%
1 to 2 months old	27.10%	26.57%	27.04%	27.77%
3 to 4 months old	16.31%	10.26%	17.18%	10.59%
5 to 6 months old	6.20%	4.06%	6.35%	4.24%
7 to 8 months old	2.26%	1.80%	2.41%	1.83%
9 to 10 months old	1.09%	0.71%	1.25%	0.58%
11 months old	0.71%	0.00%	0.58%	0.00%
N=	6,632		7,374	
	Part II. Rural			
	Pre-revision		Post-revision	
Less than 1 month old	47.57%	52.43%	48.30%	51.70%
1 to 2 months old	27.80%	24.63%	27.14%	24.56%
3 to 4 months old	15.50%	9.13%	14.81%	9.75%
5 to 6 months old	5.07%	4.06%	5.93%	3.82%
7 to 8 months old	2.53%	1.53%	2.18%	1.63%
9 to 10 months old	1.09%	0.44%	1.09%	0.54%
11 months old	0.44%	0.00%	0.54%	0.00%
N=	1,381		1,466	
	Part III. Non-rural			
	Pre-revision		Post-revision	
Less than 1 month old	46.01%	53.99%	44.42%	55.58%
1 to 2 months old	26.92%	27.07%	27.02%	28.57%
3 to 4 months old	16.53%	10.54%	17.77%	10.79%
5 to 6 months old	6.49%	4.05%	6.45%	4.34%
7 to 8 months old	2.19%	1.86%	2.47%	1.87%
9 to 10 months old	1.08%	0.79%	1.28%	0.59%
11 months old	0.79%	0.00%	0.59%	0.00%
N=	5,251		5,908	

The parents who are still breastfeeding are excluded from the analysis. In other words, we only include observations that have stopped breastfeeding when they complete the questionnaire. The numbers on the left side represent the percentage of participants fell into each group, and the numbers on the right side are the probability that the participants would not stop breastfeeding until the different age of the infants. For example, the national-level analysis suggests that 46.34% of the participants would stop breastfeeding when their infants are less than one month of age before the revision, which suggests that 53.66% of the participants would keep breastfeeding till their infants are one month or older. Overall, we find that more parents would keep breastfeeding their infants after six months of birth. AAP and the World Health Organization recommend exclusive breastfeeding up to 6 months old. Though the results in Table III-4 do not provide the information about exclusive breastfeeding, the evidence still suggests a tendency to extend the period of breastfeeding. The regional analysis shows some inside stories. The increase in breastfeeding after the policy revision mostly happens in the non-rural area. Some change in the rural area is opposite to what we expect: a higher percentage of participants in the rural area would like to stop breastfeeding their infants earlier after the revision.

We then employ the PSM to evaluate the effect of WIC package revision. First, we test the assumptions for PSM. We test the overlapping assumptions by showing the distribution of the estimated propensity scores for pre- and post-revision groups. We observe that most of the propensity scores for the pre- and post- revision groups fell into the same range, which suggests that the common support assumption is satisfied. Tables III-5 and III-6 show the results of balancing tests that compare the mean of each covariate pre- and post-revision. The matched and unmatched t-test results across the various treatments support the CIA. Most of the t-statistics for the three tests are not significant at the 0.05 level after matching, suggesting that there are no significant differences between the pre- and post-revision groups after matching.

Table III-5 Balancing tests for Pre- and Post-Matching Comparisons of all participants

	Unmatched	Mean		Reduction		t-test		
Variable	Matched	Treated	Control	%bias		bias	t	p>|t|
female	U	0.49805	0.50292	-1			-0.68	0.497
	M	0.4982	0.49927	-0.2	77.9		-0.15	0.878
infant1_2	U	0.14078	0.14914	-2.4			-1.66	0.098
	M	0.14093	0.1422	-0.4	84.8		-0.26	0.795
infant3_4	U	0.18687	0.19071	-1			-0.69	0.493
	M	0.18707	0.18677	0.1	92.4		0.05	0.957
infant5	U	0.07775	0.06976	3.1			2.13	0.033
	M	0.07783	0.07383	1.5	49.9		1.08	0.279
infant6	U	0.11847	0.11695	0.5			0.33	0.743
	M	0.1186	0.11899	-0.1	74.3		-0.09	0.931
infant7_8	U	0.13932	0.1473	-2.3			-1.59	0.112
	M	0.13947	0.13879	0.2	91.4		0.14	0.888
infant9_10	U	0.16426	0.16015	1.1			0.78	0.437
	M	0.16444	0.16551	-0.3	73.9		-0.21	0.836
infant11	U	0.06469	0.05605	3.6			2.53	0.011
	M	0.06388	0.06691	-1.3	65		-0.88	0.381
hispanic	U	0.30836	0.31069	-0.5			-0.35	0.725
	M	0.3082	0.30898	-0.2	66.5		-0.12	0.904
black	U	0.15744	0.14708	2.9			2.01	0.044
	M	0.15761	0.1582	-0.2	94.4		-0.11	0.909
age21_25	U	0.35522	0.35497	0.1			0.04	0.970
	M	0.3556	0.3595	-0.8	-1432.7		-0.58	0.560
age26_30	U	0.22486	0.24233	-4.1			-2.88	0.004
	M	0.22491	0.22286	0.5	88.3		0.35	0.725
age31_35	U	0.11867	0.11587	0.9			0.61	0.545
	M	0.1185	0.11626	0.7	19.7		0.50	0.618

Table III-5 Continued

	Unmatched	Mean		Reduction		t-test		
Variable	Matched	Treated	Control	%bias		bias	t	p>|t|
age36_40	U	0.04813	0.04708	0.5			0.34	0.732
	M	0.04799	0.05111	-1.5	-198.6		-1.03	0.303
age41plus	U	0.01471	0.01458	0.1			0.08	0.939
	M	0.01473	0.01073	3.3	-2911.6		2.55	0.011
less_than_high_school	U	0.21717	0.23996	-5.4			-3.79	0.000
	M	0.2172	0.21886	-0.4	92.7		-0.29	0.774
high_school_ged	U	0.32707	0.33143	-0.9			-0.65	0.517
	M	0.32742	0.32946	-0.4	53		-0.31	0.755
some_college_associate_technical	U	0.37968	0.36555	2.9			2.04	0.042
	M	0.38008	0.37999	0	99.3		0.01	0.989
english	U	0.71882	0.71901	0			-0.03	0.977
	M	0.7192	0.72603	-1.5	-3622.4		-1.09	0.275
spanish_english	U	0.13474	0.13575	-0.3			-0.20	0.838
	M	0.13489	0.13528	-0.1	61.1		-0.08	0.935
spanish	U	0.13075	0.12754	1			0.67	0.504
	M	0.1304	0.12913	0.4	60.5		0.27	0.787

Table III-6 Balancing tests for Pre- and Post-Matching Comparisons of non-rural and rural participants

		Non-rural						Rural					
	Unmatched	Mean		Reduction		t-test		Mean		Reduction		t-test	
Variable	Matched	Treated	Control	%bias	bias	t	p>|t|	Treated	Control	%bias	bias	t	p>|t|
female	U	0.49778	0.48078	3.4		1.06	0.287	0.49812	0.50863	-2.1		-1.31	0.19
	M	0.49627	0.50373	-1.5	56.1	-0.47	0.636	0.49812	0.5031	-1	52.6	-0.64	0.523
infant1_2	U	0.16034	0.14429	4.5		1.4	0.162	0.13597	0.15039	-4.1		-2.57	0.01
	M	0.16028	0.15729	0.8	81.4	0.26	0.796	0.13604	0.13519	0.2	94.1	0.16	0.873
infant3_4	U	0.17464	0.17167	0.8		0.25	0.806	0.18987	0.19563	-1.5		-0.91	0.363
	M	0.17571	0.1777	-0.5	33	-0.17	0.869	0.18997	0.18851	0.4	74.7	0.24	0.811
infant5	U	0.09373	0.06951	8.9		2.77	0.006	0.07381	0.06983	1.5		0.96	0.336
	M	0.0886	0.09209	-1.3	85.6	-0.39	0.7	0.07385	0.06948	1.7	-9.7	1.09	0.277
infant6	U	0.1184	0.12954	-3.4		-1.06	0.29	0.11849	0.11371	1.5		0.93	0.352
	M	0.11946	0.12195	-0.8	77.7	-0.24	0.809	0.11855	0.11721	0.4	72.1	0.27	0.79
infant7_8	U	0.13123	0.14639	-4.4		-1.37	0.169	0.14131	0.14753	-1.8		-1.1	0.27
	M	0.1324	0.12992	0.7	83.6	0.23	0.815	0.14138	0.14102	0.1	94.1	0.07	0.946
infant9_10	U	0.1559	0.16272	-1.9		-0.58	0.559	0.16632	0.15949	1.9		1.15	0.249
	M	0.15729	0.15231	1.4	27	0.44	0.663	0.1664	0.16956	-0.9	53.8	-0.54	0.588
infant11	U	0.07055	0.06582	1.9		0.59	0.558	0.06325	0.05353	4.1		2.58	0.01
	M	0.07018	0.07068	-0.2	89.5	-0.06	0.951	0.06304	0.06826	-2.2	46.3	-1.35	0.176
hispanic	U	0.17464	0.17536	-0.2		-0.06	0.953	0.34127	0.34561	-0.9		-0.57	0.569
	M	0.17372	0.15879	3.9	-1994	1.27	0.204	0.34119	0.34617	-1	-14.7	-0.67	0.501
black	U	0.05723	0.06424	-2.9		-0.92	0.357	0.18211	0.16846	3.6		2.24	0.025
	M	0.05774	0.0453	5.2	-77.3	1.78	0.074	0.18219	0.18049	0.4	87.5	0.28	0.777
age21_25	U	0.36704	0.37809	-2.3		-0.72	0.474	0.35231	0.349	0.7		0.43	0.665
	M	0.36934	0.38726	-3.7	-62.2	-1.17	0.242	0.35248	0.36244	-2.1	-200.8	-1.33	0.182
age26_30	U	0.19586	0.2396	-10.6		-3.33	0.001	0.232	0.24304	-2.6		-1.62	0.106
	M	0.19761	0.19263	1.2	88.6	0.4	0.691	0.23187	0.23333	-0.3	86.8	-0.22	0.825
age31_35	U	0.09965	0.09689	0.9		0.29	0.772	0.12335	0.12077	0.8		0.49	0.624
	M	0.10055	0.10851	-2.7	-188.4	-0.82	0.409	0.12316	0.12061	0.8	0.9	0.5	0.617
age36_40	U	0.04243	0.03423	4.3		1.33	0.182	0.04953	0.0504	-0.4		-0.25	0.804
	M	0.04181	0.03335	4.4	-3.2	1.41	0.159	0.04956	0.04421	2.5	-515.6	1.62	0.105
age41plus	U	0.00839	0.01369	-5.1		-1.6	0.111	0.01627	0.01481	1.2		0.74	0.462
	M	0.00846	0.00896	-0.5	90.6	-0.17	0.865	0.01628	0.013	2.7	-124.6	1.75	0.08
less_than_high_school	U	0.17366	0.20274	-7.4		-2.33	0.02	0.22787	0.24956	-5.1		-3.17	0.002
	M	0.17521	0.17521	0	100	0	1	0.22774	0.22835	-0.1	97.2	-0.09	0.926
high_school_ged	U	0.37	0.38231	-2.5		-0.8	0.427	0.3165	0.3183	-0.4		-0.24	0.809
	M	0.37332	0.37133	0.4	83.8	0.13	0.896	0.31665	0.32066	-0.9	-122.6	-0.55	0.581
some_college_associate_technical	U	0.37247	0.36282	2		0.63	0.531	0.38145	0.36625	3.1		1.96	0.05
	M	0.37581	0.3768	-0.2	89.7	-0.07	0.948	0.38163	0.38273	-0.2	92.8	-0.14	0.885
english	U	0.86384	0.84834	4.4		1.38	0.167	0.68314	0.68564	-0.5		-0.34	0.737
	M	0.86262	0.88651	-6.8	-54.2	-2.29	0.022	0.68347	0.6859	-0.5	3	-0.34	0.737
spanish_english	U	0.08189	0.0911	-3.3		-1.03	0.305	0.14775	0.14726	0.1		0.09	0.932
	M	0.08263	0.05973	8.1	-148.7	2.82	0.005	0.14782	0.15037	-0.7	-425.5	-0.46	0.646
spanish	U	0.04588	0.05477	-4.1		-1.27	0.203	0.15163	0.14631	1.5		0.93	0.352
	M	0.04629	0.04978	-1.6	60.8	-0.52	0.606	0.15146	0.15037	0.3	79.5	0.2	0.845

Table III-7 shows the summary statistics of all outcome variables. Overall, we find that the percentage of participants who prefer to use FBPs increases by around 4.5 percentage points after the revision. The increase in FBPs is almost balanced by the decrease in PBPs. The percentage of participants who choose FFPs does not change significantly. The tendency in rural and non-rural areas is quite consistent with the national changes. More detailed, we observe that compared with the non-rural participants, the rural participants are more likely to use FBPs or FFPs and less likely to use PBPs in both pre- and post-revision periods. As for the time of complementary foods introduction, non-rural caregivers are less likely to introduce complementary foods to their infants earlier than four months of age relative to rural participants do in both the pre- and post-revision periods. The effects of the WIC food package revision on each kind of food will be described in more detail in the following section.

The results of the estimated ATE by PSM are presented in Table III-8 to Table III-11. The second column shows the results of the NNM with 10-to-1 matching. The third column indicates the results of the caliper matching with $r = 0.25\sigma$, where σ is the standard deviation of the propensity score. Column four contains the estimation of the IPWRA. We have also included the results of the unmatched items in the last column.

Table III-7 Summary Statistics of Outcome variables

Variable	Overall				Rural				Non-rural			
	Pre		Post		Pre		Post		Pre		Post	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
FBF	10.01%	0.3002	14.45%	0.3516	11.85%	0.3233	17.76%	0.3823	9.54%	0.2937	13.63%	0.3432
PBF	23.20%	0.4221	19.34%	0.3950	18.54%	0.3887	14.65%	0.3537	24.40%	0.4295	20.49%	0.4037
FFF	66.79%	0.4710	66.21%	0.4730	69.62%	0.4600	67.59%	0.4682	66.06%	0.4735	65.87%	0.4742
Introduce Cereal earlier than 4-month	19.60%	0.3970	17.90%	0.3830	23.01%	0.4210	20.47%	0.4036	18.76%	0.3904	17.25%	0.3778
Introduce Cereal 4 to 6 month	39.90%	0.4900	40.50%	0.4910	40.71%	0.4914	39.37%	0.4887	39.65%	0.4892	40.78%	0.4915
Introduce Cereal after 6-month	2.01%	0.1400	2.02%	0.1410	1.69%	0.1287	1.73%	0.1303	2.09%	0.1431	2.09%	0.1430
Introduce Vegetable earlier than 4-month	5.35%	0.2250	4.71%	0.2120	6.48%	0.2462	5.62%	0.2304	5.05%	0.2191	4.48%	0.2069
Introduce Vegetable 4 to 6 month	44.50%	0.4970	46.80%	0.4990	46.13%	0.4986	47.36%	0.4994	44.06%	0.4965	46.61%	0.4989
Introduce Vegetable after 6-month	4.59%	0.2090	3.68%	0.1880	4.74%	0.2125	3.01%	0.1709	4.55%	0.2084	3.85%	0.1924
Introduce Fruit earlier than 4-month	6.58%	0.2480	5.82%	0.2340	8.06%	0.2722	6.31%	0.2433	6.19%	0.2411	5.69%	0.2317
Introduce Fruit after 4 to 6 months	43.90%	0.4960	46.40%	0.4990	44.71%	0.4973	46.13%	0.4986	43.69%	0.4960	46.44%	0.4988
Introduce Fruit after 6-month	4.88%	0.2150	3.90%	0.1940	5.16%	0.2213	3.31%	0.1788	4.81%	0.2140	4.04%	0.1970
Introduce Meat earlier than 4-month	1.19%	0.1080	0.95%	0.0968	1.32%	0.1140	1.23%	0.1104	1.15%	0.1068	0.87%	0.0931
Introduce Meat after 4 to 6 months	17.40%	0.3790	17.40%	0.3790	18.69%	0.3900	17.71%	0.3819	17.09%	0.3764	17.31%	0.3784
Introduce Meat after 6-month	13.60%	0.3430	13.50%	0.3420	14.22%	0.3493	12.73%	0.3334	13.42%	0.3409	13.72%	0.3441
Introduce Dessert earlier than 4-month	2.02%	0.1410	1.68%	0.1280	2.21%	0.1471	2.02%	0.1408	1.97%	0.1390	1.59%	0.1251
Introduce Dessert 4 to 6 months	16.30%	0.3700	13.50%	0.3420	18.38%	0.3874	13.32%	0.3399	15.79%	0.3646	13.55%	0.3423
Introduce Dessert after 6-month	9.85%	0.2980	9.54%	0.2940	9.90%	0.2987	9.97%	0.2996	9.84%	0.2978	9.43%	0.2923
Introduce Juice earlier than 4-month	7.38%	0.2610	5.86%	0.2350	8.85%	0.2840	6.22%	0.2415	7.00%	0.2551	5.77%	0.2331
Introduce Juice 4 to 6 months	30.40%	0.4600	27.30%	0.4460	31.44%	0.4644	26.49%	0.4414	30.12%	0.4588	27.53%	0.4467
Introduce Juice after 6-month	8.52%	0.2790	9.05%	0.2870	8.06%	0.2722	9.42%	0.2922	8.64%	0.2810	8.96%	0.2856
N=	9,260		10,264		1,899		2,027		7,361		8,237	

The outcomes of our study are twofold. The first part of the analysis addresses the change of packages chosen by participants. From Table III-8, we find that among all of the participants in our sample, the use of the FBPs significantly increases by around 4.3 percentage points after the WIC revision, and the PBPs decrease by 3.8 to 3.9 percentage points.

Table III-8 The changes in infant feeding packages

	NNM N=10	**CM** r=0.25σ	**IPWRA**	**Unmatched**
	Overall			
Fully Breastfeeding Package	4.34%	4.27%	4.33%	4.44%
	-0.0054	-0.0023	-0.0045	-0.0047
Partially Breastfeeding Package	-3.89%	-3.86%	-3.84%	-3.86%
	-0.0065	-0.0023	-0.0057	-0.0058
Fully Formula Feeding Package	-0.45%	-0.41%	-0.49%	-0.58%
	-0.0075	-0.0028	-0.0064	-0.0068
	Rural			
Fully Breastfeeding Package	4.40%	4.52%	4.89%	5.91%
	-0.0117	-0.0114	-0.0108	-0.0113
Partially Breastfeeding Package	-3.85%	-4.07%	-3.80%	-3.88%
	-0.0123	-0.0115	-0.0117	-0.0118
Fully Formula Feeding Package	-0.55%	-0.45%	-1.09%	-2.03%
	-0.015	-0.0142	-0.014	-0.0148
	Non-rural			
Fully Breastfeeding Package	4.23%	4.09%	4.13%	4.10%
	-0.0055	-0.0037	-0.0049	-0.0051
Partially Breastfeeding Package	-3.80%	-3.87%	-3.88%	-3.91%
	-0.007	-0.0048	-0.0064	-0.0067
Fully Formula Feeding Package	-0.43%	-0.22%	-0.25%	-0.19%
	-0.008	-0.0054	-0.0072	-0.0076

The change of FFPs decreases by around 0.4 to 0.5 percentage points, but not significantly. The estimation results for rural and non-rural participants show the same trends as the overall estimation, but the magnitudes are different. The rates for FBPs, PBPs, and FFPs changed by around 4.5 percentage points, -4 percentage points, and -0.5 percentage points in rural areas, and 4.1 percentage points, -3.9 percentage points, and -0.3 percentage points in non-rural areas, respectively. This demonstrates that the use of the FBPs increases and the PBPs decreases significantly. Changes related to the FFPs are not significant.

The second part of the outcomes involved feeding pattern changes related to the introduction of complementary foods. The time of introducing five kinds of solid food – cereal, vegetables, fruits, meat, and dessert – as well as juice, is included in the questionnaire. Table III-9 presents the results with the national data. We find that WIC revision significantly postpones the time that caregivers introduce complementary foods to infants. After the revision, they are less likely to introduce cereal, vegetables, fruits, meat, desserts, and juice to infants when the infants are younger than 4-month old. The probability that the caregivers introduce vegetables to infants till infants are four to six months old increased by around 1.5 percentage points, and the likelihood of introducing vegetables to infants after six-month-old decreased by around one percentage point. Additionally, around two more percentage points of caregivers would introduce fruits to infants aged four to six months. Approximately one percentage point of participants is less likely to introduce fruit to their infants after six months old. The changes in the feeding practices of dessert and juice are larger relative to other complementary foods. Around three percentage points or even more of participants are less likely to introduce dessert and juice to their infants at the age of four and six months old. Additionally, 1.6 percentage points of caregivers are less likely to introduce juice to infants earlier than four-month-old.

Table III-9 The changes of all participants feeding practices

	NNM N=10	CM r=0.25σ	IPWRA	Unmatched
Introduce Cereal earlier than 4-month	-1.83%	-1.90%	-1.94%	-1.75%
	(0.0065)	(0.0026)	(0.0054)	(0.0056)
Introduce Cereal 4 to 6-month	-0.55%	-0.17%	-0.16%	0.63%
	(0.0068)	(0.0026)	(0.0056)	(0.0070)
Introduce Cereal after 6-month	0.12%	-0.04%	-0.03%	0.01%
	(0.0022)	(0.0008)	(0.0020)	(0.0020)
Introduce Vegetable earlier than 4-month	-0.77%	-0.64%	-0.65%	-0.64%
	(0.0037)	(0.0020)	(0.0031)	(0.0031)
Introduce Vegetable 4 to 6-month	1.86%	1.47%	1.45%	2.27%
	(0.0061)	(0.0037)	(0.0049)	(0.0071)
Introduce Vegetable after 6-month	-1.30%	-1.03%	-1.02%	-0.91%
	(0.0032)	(0.0012)	(0.0028)	(0.0028)
Introduce Fruit earlier than 4-month	-1.10%	-0.73%	-0.75%	-0.76%
	(0.0041)	(0.0022)	(0.0034)	(0.0035)
Introduce Fruit after 4 to 6-month	2.15%	1.65%	1.65%	2.48%
	(0.0062)	(0.0038)	(0.0050)	(0.0071)
Introduce Fruit after 6-month	-1.38%	-1.10%	-1.11%	-0.98%
	(0.0033)	(0.0019)	(0.0028)	(0.0029)
Introduce Meat earlier than 4-month	-0.22%	-0.23%	-0.23%	-0.24%
	(0.0017)	(0.0009)	(0.0015)	(0.0015)
Introduce Meat after 4 to 6-month	0.02%	-0.24%	-0.25%	-0.03%
	(0.0058)	(0.0034)	(0.0049)	(0.0054)
Introduce Meat after 6-month	-0.98%	-0.63%	-0.57%	-0.06%
	(0.0051)	(0.0030)	(0.0042)	(0.0049)
Introduce Dessert earlier than 4-month	-0.29%	-0.34%	-0.34%	-0.34%
	(0.0023)	(0.0013)	(0.0019)	(0.0019)
Introduce Dessert 4 to 6-month	-3.07%	-2.90%	-2.88%	-2.81%
	(0.0055)	(0.0032)	(0.0047)	(0.0051)
Introduce Dessert after 6-month	-0.52%	-0.80%	-0.76%	-0.31%
	(0.0046)	(0.0026)	(0.0038)	(0.0042)
Introduce Juice earlier than 4-month	-1.90%	-1.54%	-1.54%	-1.52%
	(0.0041)	(0.0023)	(0.0036)	(0.0036)
Introduce Juice 4 to 6-month	-3.42%	-3.53%	-3.52%	-3.06%
	(0.0065)	(0.0039)	(0.0055)	(0.0065)
Introduce Juice after 6-month	0.63%	0.24%	0.25%	0.53%
	(0.0044)	(0.0026)	(0.0037)	(0.0041)

Tables III-10 and III-11 present the results for both rural and non-rural participants. Similar to the findings from national data, the analysis of rural samples shows that more rural participants would put off the time of introducing complementary foods until four-month-old. We find that WIC revisions do not significantly affect caregivers' feeding practices of meat and cereal, and most of the changes are related to vegetables, fruits, dessert, and juice in the rural areas. More than two percentage points caregivers would like to introduce vegetables and fruits to infants when infants are between 4 and 6 months old in rural areas. More than four percentage points of caregivers are less likely to introduce dessert or juice to infants earlier than 6-month old.

The analysis of the changes in the feeding pattern with the non-rural sample is quite similar. More caregivers would delay the time to introduce complementary foods until the infants are older than four months. Approximately two percentage points of caregivers leave the group of those who introduced cereal to infants younger than four months old. The changes in feeding practices of vegetables and fruits are consistent—more than one percentage point of caregivers would shift from introducing vegetables and fruits to infants before 4-month-old or after 6-month-old and choose to introduce them to the infant at the age of four to six-month-old. The early introduction of meat before 4-month-old decreases, even though the magnitude of change is small. Over three percentage points of caregivers would not introduce deserts to infants before they are 6-month-old. More than four percentage points of caregivers would prefer to feed their infants juice after 6-month of age.

Table III-10 The changes in rural participants feeding practices

	NNM N=10	CM r=0.25σ	IPWRA	Unmatched
Introduce Cereal earlier than 4-month	-1.29%	-1.87%	-2.23%	-2.54%
	(0.0137)	(0.0129)	(0.0128)	(0.0132)
Introduce Cereal 4 to 6-month	-1.83%	-1.37%	-1.07%	-1.34%
	(0.0148)	(0.0133)	(0.0127)	(0.0156)
Introduce Cereal after 6-month	0.20%	0.16%	0.17%	0.04%
	(0.0042)	(0.0042)	(0.0041)	(0.0041)
Introduce Vegetable earlier than 4-month	-1.03%	-0.73%	-0.81%	-0.85%
	(0.0079)	(0.0075)	(0.0076)	(0.0076)
Introduce Vegetable 4 to 6-month	3.11%	2.34%	2.33%	1.23%
	(0.0141)	(0.0124)	(0.0110)	(0.0159)
Introduce Vegetable after 6-month	-1.69%	-1.62%	-1.62%	-1.73%
	(0.0063)	(0.0060)	(0.0060)	(0.0061)
Introduce Fruit earlier than 4-month	-2.07%	-1.61%	-1.70%	-1.74%
	(0.0087)	(0.0079)	(0.0082)	(0.0082)
Introduce Fruit after 4 to 6-month	3.54%	2.74%	2.71%	1.42%
	(0.0142)	(0.0127)	(0.0113)	(0.0159)
Introduce Fruit after 6-month	-1.89%	-1.74%	-1.77%	-1.86%
	(0.0067)	(0.0063)	(0.0063)	(0.0064)
Introduce Meat earlier than 4-month	-0.09%	-0.05%	-0.05%	-0.08%
	(0.0035)	(0.0034)	(0.0036)	(0.0036)
Introduce Meat after 4 to 6-month	0.37%	0.14%	0.06%	-0.98%
	(0.0123)	(0.0116)	(0.0111)	(0.0123)
Introduce Meat after 6-month	-1.47%	-1.46%	-1.49%	-1.49%
	(0.0107)	(0.0096)	(0.0094)	(0.0109)
Introduce Dessert earlier than 4-month	-0.20%	-0.14%	-0.13%	-0.19%
	(0.0049)	(0.0044)	(0.0047)	(0.0046)
Introduce Dessert 4 to 6-month	-3.41%	-3.83%	-3.82%	-5.06%
	(0.0114)	(0.0105)	(0.0107)	(0.0116)
Introduce Dessert after 6-month	0.29%	0.12%	0.01%	0.07%
	(0.0100)	(0.0087)	(0.0085)	(0.0096)
Introduce Juice earlier than 4-month	-2.66%	-2.41%	-2.57%	-2.63%
	(0.0087)	(0.0081)	(0.0084)	(0.0084)
Introduce Juice 4 to 6-month	-3.13%	-3.90%	-3.95%	-4.95%
	(0.0140)	(0.0127)	(0.0124)	(0.0145)
Introduce Juice after 6-month	1.48%	1.57%	1.67%	1.37%
	(0.0092)	(0.0086)	(0.0083)	(0.0090)

Table III-11 The changes in non-rural participants feeding practices

	NNM N=10	CM r=0.25σ	IPWRA	Unmatched
Introduce Cereal earlier than 4-month	-2.02%	-1.81%	-1.82%	-1.51%
	(0.0066)	(0.0045)	(0.0060)	(0.0062)
Introduce Cereal 4 to 6-month	0.04%	0.08%	0.04%	1.12%
	(0.0073)	(0.0051)	(0.0062)	(0.0079)
Introduce Cereal after 6-month	0.02%	-0.09%	-0.07%	0.00%
	(0.0024)	(0.0017)	(0.0022)	(0.0023)
Introduce Vegetable earlier than 4-month	-0.50%	-0.61%	-0.60%	-0.57%
	(0.0036)	(0.0025)	(0.0034)	(0.0034)
Introduce Vegetable 4 to 6-month	1.12%	1.29%	1.27%	2.55%
	(0.0067)	(0.0047)	(0.0055)	(0.0080)
Introduce Vegetable after 6-month	-0.93%	-0.89%	-0.88%	-0.70%
	(0.0034)	(0.0024)	(0.0031)	(0.0032)
Introduce Fruit earlier than 4-month	-0.36%	-0.54%	-0.54%	-0.50%
	(0.0041)	(0.0028)	(0.0038)	(0.0038)
Introduce Fruit after 4 to 6-month	1.42%	1.47%	1.46%	2.75%
	(0.0068)	(0.0047)	(0.0055)	(0.0080)
Introduce Fruit after 6-month	-0.92%	-0.95%	-0.95%	-0.77%
	(0.0036)	(0.0024)	(0.0032)	(0.0033)
Introduce Meat earlier than 4-month	-0.16%	-0.28%	-0.28%	-0.28%
	(0.0016)	(0.0012)	(0.0016)	(0.0016)
Introduce Meat after 4 to 6-month	-0.30%	-0.25%	-0.28%	0.22%
	(0.0062)	(0.0042)	(0.0055)	(0.0061)
Introduce Meat after 6-month	-0.24%	-0.39%	-0.37%	0.30%
	(0.0055)	(0.0037)	(0.0047)	(0.0055)
Introduce Dessert earlier than 4-month	-0.17%	-0.40%	-0.40%	-0.38%
	(0.0022)	(0.0016)	(0.0021)	(0.0021)
Introduce Dessert 4 to 6-month	-2.46%	-2.56%	-2.58%	-2.24%
	(0.0058)	(0.0040)	(0.0053)	(0.0057)
Introduce Dessert after 6-month	-0.93%	-0.98%	-0.96%	-0.40%
	(0.0049)	(0.0033)	(0.0043)	(0.0047)
Introduce Juice earlier than 4-month	-1.46%	-1.25%	-1.24%	-1.23%
	(0.0044)	(0.0029)	(0.0039)	(0.0039)
Introduce Juice 4 to 6-month	-3.23%	-3.42%	-3.44%	-2.58%
	(0.0070)	(0.0048)	(0.0061)	(0.0073)
Introduce Juice after 6-month	0.13%	-0.08%	-0.07%	0.32%
	(0.0047)	(0.0032)	(0.0042)	(0.0045)

Discussion

Many studies have emphasized the importance of caregivers' feeding practices during the early stage of life on infants' long-term health outcomes. The 2009 WIC food package revision provides disadvantaged families with more benefits for encouraging caregivers' breastfeeding. To have a more in-depth view of the effect of this revision, we use the PSM method to conduct a comprehensive analysis with the infant data from NATFAN, which is a national representative pooled cross-sectional survey.

The results from the national-level analysis show that the participants are more likely to choose FBPs rather than PBPs, whereas there is no significant change in the use of FFPs. The increase in FBPs is balanced by the decrease in PBPs and FFPs, which suggests an overall increase in the preference for breastfeeding. The policy revision encourages more caregivers to breastfeed their infants. In general, the WIC revision's objective of breastfeeding promotion is achieved to some degree. Furthermore, we find that the level of increase use of the FBPs is higher in rural areas, and the decreased use of the PBPs and FFPs are almost the same in rural and non-rural areas. This phenomenon suggests that rural participants benefit more from the revision in terms of breastfeeding, relative to non-rural participants. One more aspect that attracts our attention is that compared to the non-rural participants, the rural participants are more likely to use FBPs and less likely to use PBPs before and after the revision, but also more likely to use FFPs. Considering together with the evidence that the participants in the non-rural area are more likely to initiate breastfeeding after the revision, one potential explanation of the fact could be that non-rural caregivers do aware of the benefits of breastfeeding and intend to breastfeed their infants. However, they cannot achieve fully breastfeeding because of some blockers, such as breastfeeding conditions at work or the period allowing for maturity leave, which has been addressed by many studies in public health (Yilmaz et al. 2001; Arora et al. 2000; Maharlouei et al. 2018). Our findings of the change in breastfeeding package usage suggest that in the process of promoting breastfeeding, not only stimulus policies could be helpful to achieve the goal, but also provide the participants with assistances based on their actual situations may reinforce the effect.

There is also some suggestive evidence regarding the time when complementary foods are introduced. Our study shows that the caregivers are less likely to introduce complementary foods to their infants earlier than 4-month old after the revision. Even though the time that most of the caregivers introduce solids to infants is still earlier than the recommended timeline after the revision, both non-rural and rural participants in the post-revision period tend to introduce complementary foods later than in the pre-revision period. Significant changes related to the feeding practices of desserts and juice suggest that more parents realize the potential harmfulness of the earlier introduction of the sweeteners and sweetened foods. The detailed regional analysis shows that rural participants are more likely to introduce complementary foods earlier than the recommended age before and after the revision. However, the fact that the percentage of caregivers who are willing to postpone the dessert and juice introducing time till 6-month-old is higher in rural areas than in non-rural areas suggests that more rural participants are likely to switch their behavior following the guidance from USDA after the revision.

Comparing to the caregivers who have a higher level of access to the WIC clinics, caregivers with lower-level access to WIC clinics benefit more from the revision.

Conclusions

Our findings from NATFAN data suggest that the goals of the 2009 WIC food package revision are achieved to a certain extent. The participants improve their infant feeding practices. Overall, mothers are more likely to breastfeed their infants at least one time and to choose fully breastfeeding packages rather than partially breastfeeding packages. Even though the percentage of participants who prefer to choose fully formula feeding package does not change significantly after the revision, the overall changes in caregivers' choices of WIC food package suggest an increase in breastfeeding.

As for the time of introducing complementary foods to infants, generally, parents preferred to delay the time after the revision. The changes suggest that caregivers' feeding practices are consistent with the USDA guidelines. Furthermore, compared to the percentage of caregivers who postponed the introduction of healthy food (vegetables and fruits) to their infants, a higher percentage of caregivers put off the time to introduce the food that might be harmful to infants' health condition. The evidence suggests that more caregivers are trying to feed their infants in a health pattern, and participants living in both rural and non-rural areas benefited significantly from the WIC food package revision. The change in caregivers' feeding practices could improve infants' health conditions in both the short-term and long-term.

CHAPTER IV

WIC REVISION IMPROVES FEEDING PRACTICES OF PARTICIPANTS LIVING IN HIGH POVERTY REGIONS

Introduction

Poverty[1] is one of the major social problems in the United States today. The official poverty rate is 12.7% in 2016, in contrast to 22.4% in 1959, when poverty rates are first officially recorded. Although the poverty rate has decreased by approximately 10% over these years, more than 40 million Americans still lived in poverty in 2016 (Semega et al. 2017). Among those living in poverty, 15.3 million (37.7%) of this population are children, which is about one-fifth of total children in the United States. A National Health Interview Survey conducted between 2001 and 2007 suggested that children from families in higher levels of poverty are more likely to be diagnosed with asthma and one or more chronic conditions.

Parents' feeding practices of young age children have been proved to be associated with their children's long-term health outcomes. Several studies have shown that breastfeeding may have a beneficial effect on child's health and help prevent subsequent diseases, such as type-2 diabetes, hypertension, and obesity, in adulthood. Breastfeeding can also reduce the risk of post-neonatal deaths (Chen and Rogan 2004;

[1] The standard of poverty threshold is $12,486 for a single individual under age 65, $14,507 for a household of two people with a householder 65 year or older and no children, and $24,339 for a family of four with two children under age 18 (United States Census Bureau, 2016).

Owen et al. 2005; Horta, Loret de Mola and Victora 2015). A child who is exclusively fed breast milk for 15 weeks after their birth and without being fed solid foods during this period is less likely to have any respiratory illness compared to those who are not exclusively breastfed (Wilson et al. 1998).

WIC Program and Revision in 2009

Improving the nutritional status and health outcomes of individuals living in poverty is one of the priorities of the U.S. Department of Agriculture (USDA). The Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) is the third-largest out of fifteen USDA's food and nutrition assistance programs and provides supplemental nutritious foods and services to its participants. These services include nutritional education, breastfeeding support, and health care referrals for pregnant and postpartum women, infants, and children up to age 5years living in low-income households. The WIC program has grown rapidly since its founding in 1972. In 2019, WIC served nearly 7 million participants, including 1.7 million infants and almost 3.6 million children ages 1 to 4 years (USDA, FNS, 2018). Approximately 54 percent of infants and more than a quarter of the pregnant women in the United States received WIC services in 2014 (USDA/FNS, 2016). The income eligibility criterion for WIC program is that the individual is either living in a household with an income less than or equal to 185 percent of the federal poverty level or be enrolled in the Temporary Assistance for Needy Families program, Supplemental Nutrition Assistance Program, or Medicaid program. Almost two-thirds of the WIC participants live below the federal poverty level. To promote breastfeeding, the WIC food package policies were revised for the first time in

2009. The revision is intended to provide incentives and support breastfeeding by increasing the values of WIC food packages for mothers who choose fully breastfeeding packages (FBP) that do not contain baby formula and reducing the amount of baby formula from partially breastfeeding packages (PBP) or fully formula-fed packages (FFP). Further, the amount of baby formula to WIC participants is now adjusted for infants' age, and the time of introduction of complementary infant foods has been postponed. Considering the greater disparities of health conditions in regions with high poverty levels, the effect of federal policies, which is the introduction of the revised food packages, is important to assess, especially for residents in these regions.

High-Poverty Regions

Remote areas, such as the counties near the United States-Mexico border, near the Appalachian Mountains, within the Delta region, the area with low access to healthy food or Indian Tribal Organizations, have higher poverty rates than other areas in the United States, which create disadvantages for the people living in these regions. We will describe some of the high-poverty regions in the following sections.

The United States-Mexico border region

The counties in the U.S.-Mexico border region struggle with poverty. The U.S.-Mexico border region is defined as the area of land being 100 kilometers (62.5 miles) north and south of the international boundary (La Paz Agreement, 1983). It comprises 44 counties across California, Arizona, New Mexico, and Texas. The total length of the continental border is approximately 2000 miles from the southern tip of Texas to California. The income of individuals residing in U.S.-Mexico border areas is lower than that of individuals living in other regions of the U.S. The border area includes 3 of the ten poorest counties in the U.S., in addition to 21 counties designated as economically distressed. Figure 1 shows the counties in the United States-Mexico border region.

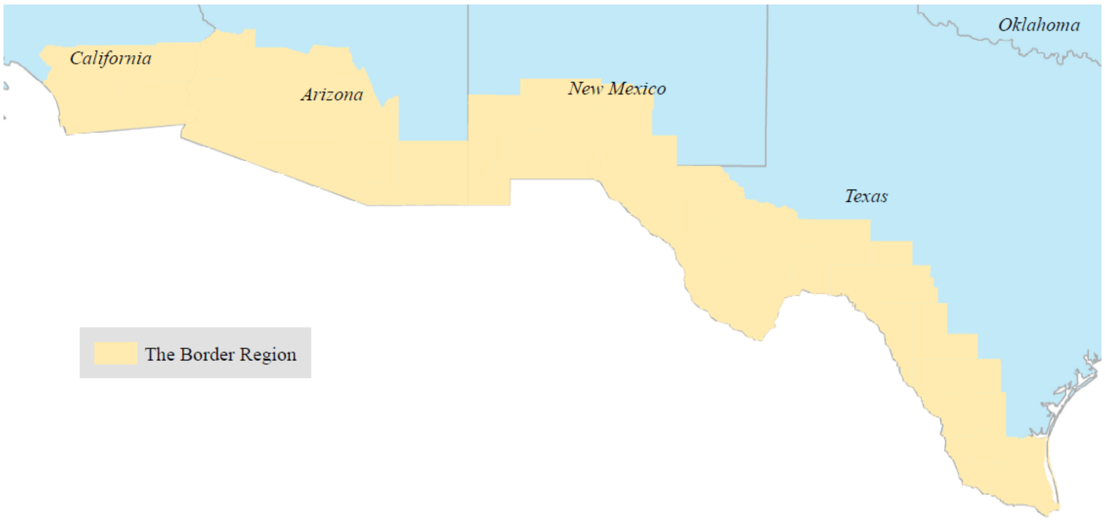

Figure 1. The counties in the United States-Mexico border region

Appalachia Region Counties

Poverty is a severe problem in the Appalachian Region. This region includes 420 counties from 13 states. It extends more than 1,000 miles, from southern New York state to northeastern Mississippi, and it is home to more than 25 million people. In 2012, the poverty rate in this region was 19.7%, as opposed to 15.6% in the US as a whole (Appalachian Regional Commission, 2014). Even within the states in this region, poverty rates differ considerably. For example, in Virginia, the poverty rate is 18.6% in the Appalachian region, versus 11.1% in the state as a whole. The state with the highest poverty rate in this region is Kentucky, which a 25.1% rate for the Appalachian portion and an 18.6% rate for the in its entirety. Figure 2 shows the counties in the Appalachian region.

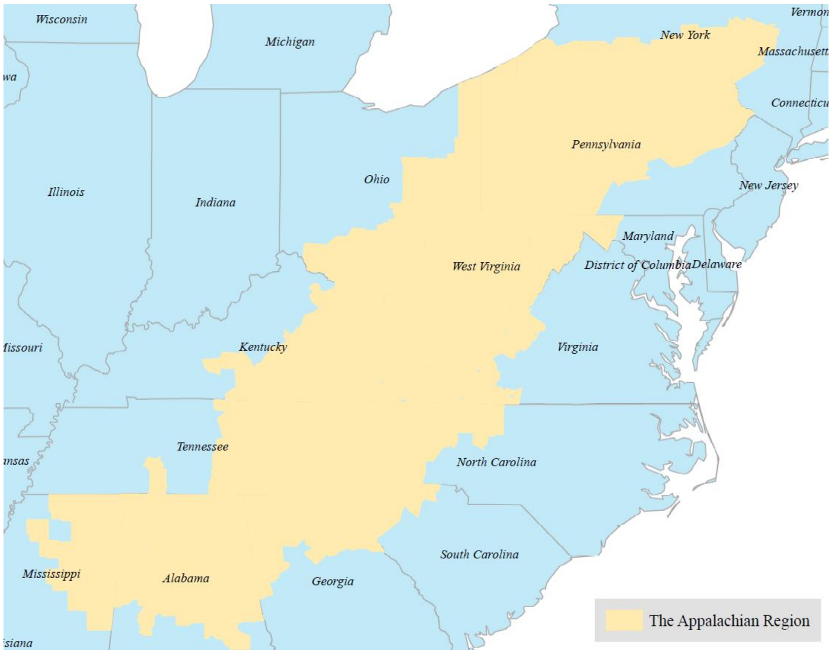

Figure 2. The counties in the Appalachian region

Delta Region

Another region with serious poverty is the Mississippi Delta Region. This region consists of 252 counties and parishes across eight states. People in the Delta region are more likely to live in poverty than U.S. residents in the rest of the country. The Delta Regional Authority (DRA) is a Federal-State partnership whose mission is to improve the quality of life for the residents of the Delta Region. Among the 252 counties and parishes served by the DRA, 210 are deemed "distressed" if they have per capita income of 80 percent or less of the national per capita income. Further, according to the 2008-2012 American Community Survey, the poverty rate in the Delta region was 20.6% compared with 15.6% across the US. Approximately 89% of the counties in the Delta region exceeded the national poverty rate. One more indicator provided by the DRA report is “persistent poverty.” USDA deems counties or parishes as in “persistent poverty” if 20 percent or more of their populations were living in poverty over the last 30 years. In the Delta region, 43.3 percent of the counties fell into the group of “persistent poverty,” compared with 11.2 percent nationwide. Figure 3 shows the counties in the Delta region.

Figure 3. The counties in the Delta Region

The Diabetes Belt

The “diabetes belt” is identified by the Centers for Disease Control and Prevention (CDC) and includes 644 counties in 15 states. Most residents there are African Americans.

More than 11 percent of the people in the diabetes belt have diagnosed type 2 diabetes, compared with 8.5 percent at the national level. People with a higher level of poverty are more likely to have type 2 diabetes. At least about 17 percent of the people in the Diabetes Belt lived below the poverty line in 2011. The average poverty rate of the counties within the Diabetes Belt was over 22 percent in 2011. Figure 4 shows the location of the Diabetes Belt.

Figure 4. The counties in the Diabetes Belt

Food Deserts

The USDA defines food deserts as geographical areas within the country where there are shortages on the supply of fresh fruit, vegetables, and other healthful whole foods. Food deserts are usually found in impoverished areas, which tend to lack grocery stores, farmers' markets, and healthy food providers. Two major indicators have been used to identify a census tract as a food desert: low-income (LI) and low-access (LA) (USDA ERS[2]). Low income is defined as annual family income at or below 200% of the Federal poverty threshold. According to the 2008-2012 American Community Survey, the estimated poverty rate was about 24% in food desert areas and 14% in non-food desert areas. Figure 5 shows the distribution of Food Desert Area.

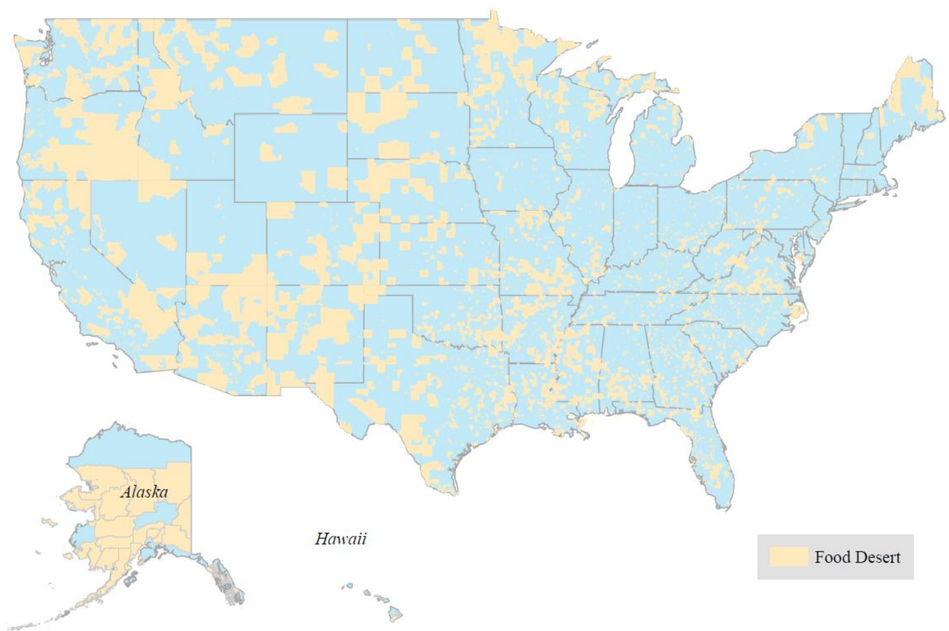

Figure 5. Food Desert Area

Indian Tribal Organizations (ITOs)

Poverty rates among American Indians are high. The percentage of single-race American Indians and Alaska Natives who were in poverty in 2015 was 26.6 percent, the highest rate of any race group. WIC ITOs are among the largest tribal organizations in the

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[2] The identify standard is from USDA ERS: https://www.ers.usda.gov/data-products/food-access-research-atlas/documentation/.

United States, accounting for roughly two-thirds of Native Americans living on reservations and three-fourths of Native Americans living within tribal jurisdictions (Cole, 2002).

Some regional studies suggest that the new policies may encourage more participants to breastfeed. Improved breastfeeding outcomes are found among WIC participants after the revision in Los Angeles, with both breastfeeding initiation and exclusive breastfeeding at 6-month (Whaley et al., 2012; Langellier et al., 2014). In New York State, the prevalence of breastfeeding initiation increased significantly from 72.2 percent in 2008 to 77.5 percent in 2011 (Chiasson et al. 2013). Small increases in both the prevalence of breastfeeding initiation and duration are achieved in central Texas among WIC participants (Thornton et al. 2014). Despite the evidence that breastfeeding outcomes are improved after the package revision, questions remain about whether the new food package will change the breastfeeding outcomes of the WIC participants living in high poverty.

Previous studies have found that income affects the mother's breastfeeding behavior differently. The breastfeeding rates for women with higher income are significantly higher than breastfeeding rates for the mother with lower income (McDowell et al. 2008). Furthermore, the breastfeeding initiation rate is higher, and the duration of breastfeeding is longer if the poverty income ratio is higher than 185% of the federal poverty level (Jensen 2011). The proportion of mothers who breastfeed their infants at seven days, at one month, at three months, and at six months increases with the poverty income ratio (Li et al. 2005).

In this paper, we use national-level data to examine the effect of the WIC Food Package revisions on breastfeeding practices, which include the breastfeeding initiation and choice of breastfeeding, of program participants living in high-poverty regions or areas described above. By separating the counties by each indicator, we intend to explore the breastfeeding practices in the high-poverty regions.

Methods

Data

The WIC program implemented the new food package revisions in 2009, based on the 2005 Institute of Medicine (IMO) report *WIC Food Packages: Time for a Change*. The primary dataset we use for analysis is from the National Food and Nutrition Questionnaire (NATFAN). NATFAN is a repeated cross-sectional survey that includes questions about food choice and frequency instruments developed specifically for WIC participants. We use responses to items on the infant questionnaire for the NATFAN to evaluate the effects of WIC's program revisions. The NATFAN infant questionnaire contains 33 questions about infant feeding practices adapted from WIC interviews both before and after implementation of the revisions to the WIC food packages. We use pre-revision data to present the period before the food package revision and post-revision information for the period after the revision. The NATFAN questionnaire addressing the pre-revision period was collected in 38 states, 10 Indian Tribal Organizations (ITOs), Washington DC, and one US Territory (50 WIC programs in total) in 2009. After the revision, 40 states, 16 ITOs, Washington DC, and one US Territory (58 WIC programs in total) re-administered the NATFAN questionnaire to WIC participants in late 2010 and early 2011. Figure 6 shows the region covered by NATFAN. Besides questions about food choice and frequency of consumption, the NATFAN also asks a series of questions related to caregivers' feeding practices and information about participants' age, ZIP code, language, race, and education level. The NATFAN project provides us with a good opportunity to study the national-level effects of the revised WIC program on the participants' choice of feeding packages.

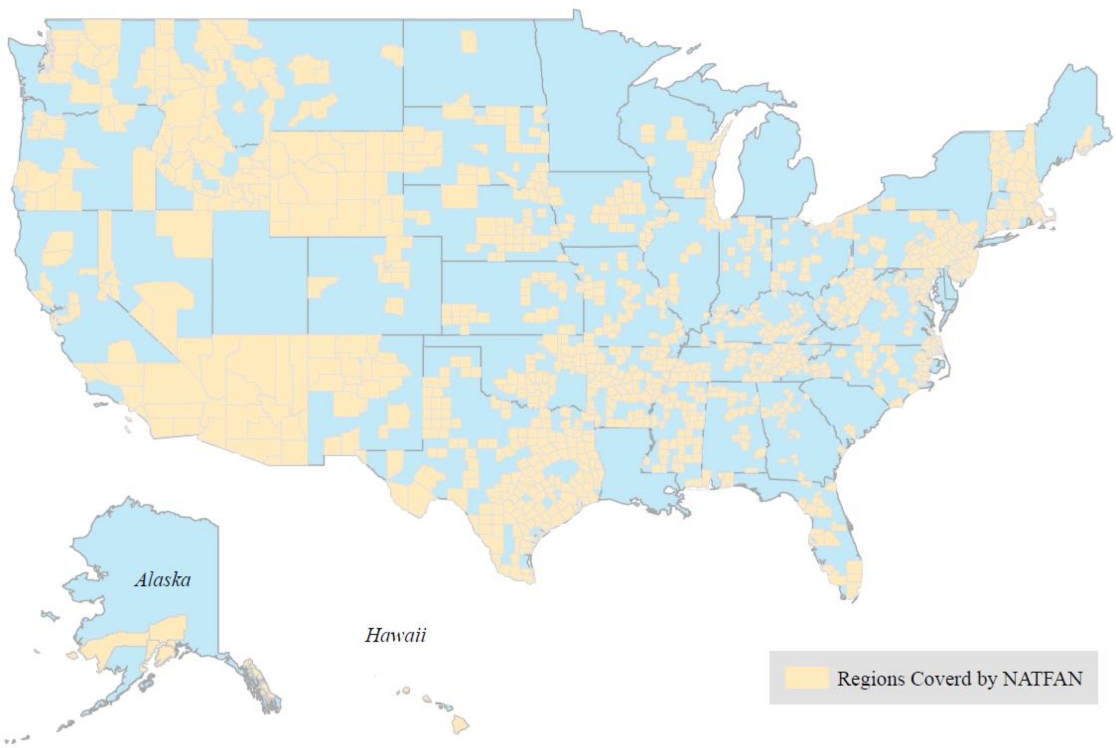

Figure 6. Regions covered by NATFAN in the United States

We use other datasets to identify the high-poverty regions. To identify the U.S.-Mexico border counties, we use the *shapefile* of the United States from ArcGIS and combine it with the layer of the U.S. and Mexico border. We select the counties within 100 kilometers of the border and specify them as border counties. All other counties are marked as non-border. The list of counties in the Appalachia Region and the Delta Region are provided by their official website. The Center for Disease Control and Prevention provides the list of counties in the Diabetes Belt. All these regions are linked with NATFAN data by FIPS codes.

To identify the food deserts, we use the dataset from the 2010 USDA ERS Food Access Research—the "Food Desert Locator," which is initially used by USDA to improve the accessibility to nutritious food in food deserts and low-income communities. Food deserts are identified at the census tract level instead of the ZIP-code level. Since respondents' ZIP-codes are provided in the NATFAN data, we use the Housing and Urban Development Secretary (HUD)-USPS ZIP Crosswalk file to convert ZIP-code to census tract code and link food desert information with the NATFAN data.

We retain only those participants whose questionnaires have no missing values for demographic information and feeding practices. After eliminating individuals with missing information, we have a sample of 9,956 participants for pre-revision and 11,104 participants for post-revision.

Variables and Analyses

We use two sets of variables to evaluate the breastfeeding outcomes: whether the participants choose to initiate breastfeeding or not and the choices of WIC packages among full breastfeeding package (FBP), partially breastfeeding package (PBP), or fully formula-feeding package (FFP). Based on the responses of the participants, we generate the variables which clarified their choices. The participants are specified to use FBP if they are still breastfeeding and feeding no formula to their infants, specified to use PBP if they breastfed and formula-fed their infants, and specified to use FFP if they never breastfed their infants when interviewed at WIC clinics. Also, if an infant is ever breastfed at least one time, we classify the participant as initiated breastfeeding.

The independent variables have two parts. The demographic variables are the gender and the age of the infants, the education level and the age of the caregivers, and the race and the region of each participated household. The second part is the dummy variable to identify if the sample was collected before or after the revision and the dummy variables to identify different geographic regions.

As the dependent variables are measured on a binary scale, a logistic model is used to estimate the probability that a WIC participant chooses to initiate breastfeeding or not. As the choices among FBP, PBP or FFP are not ordered, and the participants would only choose one of them, we use Multinomial Logistic regression to estimate the participants' probabilities for choosing each package and evaluate the effect of food package revision and regional effect on participants' choices.

Results

Description of Samples

We provide the summary statistics of characteristics of infants and caregivers before and after the WIC food package revision by each geographic region in Table IV-1.

The samples for the pre- and post-revision period shared similar characteristics. About 16% of the participants in NATFAN data are from rural area in both periods. There is a more rural area in ARC, ITO, Delta regions, and the Diabetes Belt than in non-ARC, non-ITO, non-Delta regions, and non-Diabetes Belt. On the contrary, food desert and border regions contain more non-rural area than non-food desert and border regions compared to the national level. The average age of caregivers is around 25, which is almost identical across different regions. Half of the infants in NATFAN are female. As for the education level, most of the participants have an education level of high school or GED or some college. Less than 10% of the WIC participants in NATFAN data have a college degree. There are no significant differences in education levels between participants living in the food desert region and the non-food desert region. On average, the education level of participants living in the border region is lower than the participants living in the non-border region. Most of the participants living in the ARC region have a high school or GED degree than the participants living in the non-ARC region. Less than 4% of the participants living in ITO regions have a college or higher degree. In Delta and Diabetes Belt region, more participants have a degree higher or equal to high school.

The components of the participants' race are significantly different when separated by geographic regions. Most of the participants in the border region are Hispanic; in ARC, Delta, and Diabetes Belt regions are white, and in ITOs are other races, which are mainly native American.

Table IV-1 Characteristics of Infants and Caregivers Pre- and Post- the WIC Food Package Revision by Geographic regions

	Food Desert		Non-Food Desert		Border		Non-border	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Rural	0.078	0.068	0.188	0.181	0.114	0.133	0.168	0.159
Gender of Infant	0.498	0.496	0.503	0.499	0.494	0.492	0.502	0.498
Age of Caregivers	25.000	24.739	25.441	25.309	25.507	25.663	25.331	25.158
Education: Less than high school	0.269	0.240	0.245	0.223	0.340	0.297	0.243	0.222
Education: High school or GED	0.344	0.327	0.326	0.328	0.290	0.304	0.333	0.329
Education: Some college	0.338	0.357	0.364	0.375	0.328	0.336	0.360	0.373
Education: College+	0.050	0.076	0.065	0.075	0.042	0.063	0.063	0.076
Race: Hispanic	0.326	0.334	0.322	0.316	0.741	0.713	0.292	0.293
Race: white	0.390	0.406	0.436	0.441	0.115	0.152	0.448	0.453
Race: black	0.166	0.157	0.142	0.157	0.017	0.017	0.157	0.167
Race: Other race	0.118	0.103	0.100	0.086	0.127	0.118	0.102	0.087
N=	2215	2315	7741	8789	686	697	9270	10407

	ARC		Non-ARC		ITO		Non-ITO	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Rural	0.362	0.380	0.152	0.143	0.389	0.346	0.159	0.153
Gender of Infant	0.514	0.517	0.501	0.497	0.486	0.487	0.502	0.498
Age of Caregivers	24.984	24.788	25.364	25.216	24.792	24.944	25.355	25.196
Education: Less than high school	0.194	0.191	0.253	0.229	0.222	0.264	0.251	0.226
Education: High school or GED	0.413	0.374	0.325	0.325	0.352	0.379	0.330	0.326
Education: Some college	0.342	0.366	0.359	0.371	0.394	0.323	0.357	0.372
Education: College+	0.051	0.069	0.062	0.075	0.032	0.033	0.062	0.076
Race: Hispanic	0.104	0.097	0.335	0.334	0.153	0.178	0.326	0.323
Race: white	0.744	0.771	0.407	0.412	0.278	0.260	0.429	0.438
Race: black	0.124	0.106	0.149	0.161	0.028	0.007	0.150	0.161
Race: Other race	0.027	0.025	0.109	0.093	0.542	0.554	0.094	0.078
N=	547	669	9409	10435	216	269	9740	10835

	Delta		Non-Delta		Diabetes Belt		Non-Diabetes Belt	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Rural	0.314	0.272	0.160	0.154	0.357	0.333	0.148	0.142
Gender of Infant	0.509	0.513	0.501	0.498	0.515	0.514	0.500	0.497
Age of Caregivers	24.487	24.424	25.367	25.215	24.624	24.643	25.403	25.237
Education: Less than high school	0.218	0.169	0.251	0.228	0.201	0.170	0.254	0.231
Education: High school or GED	0.376	0.347	0.329	0.327	0.365	0.386	0.327	0.323
Education: Some college	0.343	0.415	0.359	0.370	0.376	0.385	0.357	0.370
Education: College+	0.063	0.069	0.062	0.075	0.058	0.058	0.062	0.076
Race: Hispanic	0.041	0.043	0.331	0.328	0.078	0.069	0.343	0.341
Race: white	0.535	0.453	0.422	0.433	0.607	0.607	0.410	0.419
Race: black	0.410	0.473	0.140	0.147	0.286	0.291	0.136	0.146
Race: Other race	0.015	0.032	0.107	0.091	0.029	0.033	0.110	0.094
N=	271	349	9685	10755	765	872	9191	10232

Impact of WIC Food Package Revision on infant feeding practices

In Table IV-2, we provide the breastfeeding initiation and infant food package usage by geographic indicators and compared the differences by pre- and post- revision. The significant changes are highlighted. In most of the regions, the usage of FBP increases and the usage of PBP and FFP decreased after the revision. In regions that are not at a disadvantage, the changes are relatively consistent. They all experience a significant increase in using FBP and a decrease in using PBP. The change of FFP is not significant in all these regions. The changes suggest that some of the participants who used to choose PBP switched to FBP after the revision. When focusing on the regions in high poverty, we find that participants living in food deserts, border area, ARC, and Diabetes Belt regions achieved a significant increase in FBP usage and a decrease in PBP usage. The package usage condition in the ITOs and Delta regions does not change significantly after the revision. As for the initiation, the breastfeeding initiation rate increased after the food package revisions in all regions except ITOs.

Tables IV-3 and IV-4 report the regression results from multinomial logistic regression for the package type. The marginal effects of the multinomial logistic model can be interpreted as the status changes in the independent variable increases or decrease the probability of selecting a specific package by the marginal effect expressed as a percent. From the marginal effects in Table IV-5, the usage of FBP increases by 4%, whereas the probability of using PBP decreases by 3.7%, and FFP decreases by 0.3% after the WIC food package revisions. Participants living in the rural area are 1.5% more likely to use FBP and 2.5% less likely to use PBP. Caregivers are 1.7% more likely to feed female infants with FBP. Education also varies the caregivers' choice of the packages. Participants who have a high school or higher education are more likely to use FBP. Participants who have a college or higher education are 16.3% more likely to choose FBP and are 20.3 less likely to choose FFP. Hispanic participants are 2.6% more likely to use PBP and 3.1% less like to use FFP. White participants are 5.9% more likely to use FBP and 9.0% less like to use PBP. Black participants are 7.0% less likely to use PBP, and 8.9% more like to use FFP. The effects of disadvantage regions are not the same. The choice of participants living in the food desert or non-food desert and living in the border region or non-border region have no significant differences. Participants living in ARC, ITO, and Delta regions are more likely to use FFP by 4.4%, 6.3%, and 7.1%, respectively, and less likely to use FBP or PBP. The percentage of participants who used FBP decreased by 2.2% in the ARC region and 4.9% in the Delta region.

We report the result of logit regression for participants' breastfeeding initiation in Table IV-5. We find that the food package revision made the participants 1.29 percentage points more likely to initiate breastfeeding. The change is small but quite significant. As for the regional effects, the behavior of participants living in food desert, border, or ARC regions has no significant difference compared with the corresponding regions that are not in high poverty. Participants living in ARC, ITO, and Delta regions are less likely to initiate breastfeeding by 3.69%, 7.12%, and 5.12%, respectively. Demographic factors are also associated with initiation conditions. Women with a higher level of education are more likely to initiate breastfeeding, and the magnitude of changes also increase with education.

Table IV-2 Initiation and Food Package Usage Conditions within and cross Geographic Regions

		Initiation rates	FBP	PBP	FFP			Initiation rates	FBP	PBP	FFP
Food Desert	Pre	0.845	0.084	0.220	0.697	Non-Food Desert	Pre	0.864	0.100	0.238	0.662
	Post	0.877	0.141	0.197	0.662		Post	0.873	0.138	0.196	0.666
	P-value	**0.002**[*]	**0.000**	**0.058**	**0.012**		P-value	**0.086**	**0.000**	**0.000**	0.596
Border	Pre	0.888	0.070	0.309	0.621	Non-border	Pre	0.858	0.098	0.229	0.673
	Post	0.898	0.126	0.232	0.641		Post	0.873	0.140	0.194	0.667
	P-value	0.558	**0.000**	**0.001**	0.434		P-value	**0.003**	**0.000**	**0.000**	0.320
ARC	Pre	0.773	0.099	0.161	0.740	Non-ARC	Pre	0.865	0.096	0.238	0.666
	Post	0.812	0.141	0.148	0.712		Post	0.878	0.139	0.199	0.662
	P-value	0.105	**0.027**	0.536	0.262		P-value	**0.006**	**0.000**	**0.000**	0.599
ITO	Pre	0.898	0.097	0.171	0.731	Non-ITO	Pre	0.859	0.096	0.236	0.668
	Post	0.833	0.104	0.167	0.729		Post	0.875	0.140	0.197	0.663
	P-value	**0.041**	0.804	0.907	0.944		P-value	**0.001**	**0.000**	**0.000**	0.460
Delta	Pre	0.723	0.063	0.162	0.775	Non-Delta	Pre	0.864	0.097	0.236	0.667
	Post	0.751	0.080	0.163	0.756		Post	0.878	0.141	0.197	0.662
	P-value	0.459	0.406	0.974	0.592		P-value	**0.003**	**0.000**	**0.000**	0.479
Diabetes Belt	Pre	0.752	0.064	0.165	0.771	Non-Diabetes Belt	Pre	0.869	0.099	0.240	0.661
	Post	0.789	0.099	0.133	0.768		Post	0.881	0.142	0.201	0.656
	P-value	**0.083**	**0.011**	**0.072**	0.890		P-value	**0.010**	**0.000**	**0.000**	0.462

Table IV-3 Coefficient estimates of Multinomial Logistic Regression for Package Type

	FBP vs FFP	PBP vs FFP	FBP vs PBP
Post	0.361***	-0.173***	0.534***
	(0.046)	(0.035)	(0.052)
Rural	0.146*	-0.119*	0.265***
	(0.059)	(0.053)	(0.072)
Age of Caregivers	0.014***	0.032***	-0.018***
	(0.004)	(0.003)	(0.004)
Female Infant	0.171***	-0.011	0.181***
	(0.045)	(0.035)	(0.051)
Education: High school or GED	0.246***	-0.148**	0.394***
	(0.072)	(0.047)	(0.080)
Education: Some college	0.671***	0.062	0.609***
	(0.069)	(0.047)	(0.077)
Education: College+	1.765***	0.500***	1.265***
	(0.090)	(0.078)	(0.101)
Race: Hispanic	0.088	0.169**	-0.081
	(0.093)	(0.062)	(0.101)
Race: white	0.494***	-0.477***	0.971***
	(0.087)	(0.063)	(0.097)
Race: black	-0.726***	-0.209**	-0.518***
	(0.115)	(0.071)	(0.124)
Food Desert	-0.050	0.051	-0.101
	(0.100)	(0.067)	(0.109)
Border	0.014	-0.056	0.070
	(0.056)	(0.043)	(0.064)
ARC	-0.216	-0.358**	0.142
	(0.161)	(0.129)	(0.190)
ITO	0.043	-0.026	0.069
	(0.112)	(0.094)	(0.134)
Delta	-0.364*	-0.087	-0.277
	(0.166)	(0.120)	(0.191)
Diabetes Belt	-0.578***	-0.298***	-0.281*
	(0.115)	(0.086)	(0.134)
Constant	-3.069***	-1.648***	-1.421***
	(0.139)	(0.096)	(0.153)

Standard errors in parentheses

Significant level: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table IV-4 Marginal Effects of Multinomial Logistic Regression for Package Type

	FBP	PBP	FFP
Post	0.040***	-0.037***	-0.003
	(0.004)	(0.006)	(0.006)
Rural	0.017**	-0.023**	0.006
	(0.006)	(0.009)	(0.009)
Age of Caregivers	0.001	0.005***	-0.005***
	(0.000)	(0.000)	(0.001)
Female Infant	0.017***	-0.006	-0.011
	(0.004)	(0.006)	(0.006)
Education: High school or GED	0.028***	-0.030***	0.002
	(0.007)	(0.008)	(0.009)
Education: Some college	0.065***	-0.006	-0.059***
	(0.007)	(0.007)	(0.009)
Education: College+	0.162***	0.040**	-0.202***
	(0.008)	(0.012)	(0.014)
Race: Hispanic	0.005	0.025*	-0.030*
	(0.009)	(0.010)	(0.012)
Race: white	0.060***	-0.089***	0.029*
	(0.008)	(0.010)	(0.012)
Race: black	-0.067***	-0.017	0.084***
	(0.011)	(0.011)	(0.014)
Food Desert	-0.006	0.009	-0.003
	(0.010)	(0.011)	(0.013)
Border	0.003	-0.009	0.007
	(0.005)	(0.007)	(0.008)
ARC	-0.013	-0.053*	0.066**
	(0.016)	(0.021)	(0.023)
ITO	0.005	-0.005	0.000
	(0.011)	(0.015)	(0.017)
Delta	-0.034*	-0.006	0.039
	(0.016)	(0.019)	(0.022)
Diabetes Belt	-0.050***	-0.035*	0.085***
	(0.011)	(0.014)	(0.016)

Standard errors in parentheses

Significant level: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table IV-5 Logistic Regression for Initiation Choices

VARIABLES	(1) Coefficient Estimates	(2) Odds ratio	(3) Marginal Effects
Post	0.112***	1.119***	0.0129***
	(0.0406)	(0.0455)	(0.00469)
Rural	0.0266	1.027	0.00306
	(0.0581)	(0.0597)	(0.00671)
Age of Caregivers	-0.0145***	0.986***	-0.00167***
	(0.00330)	(0.00325)	(0.000381)
Female Infant	-0.0524	0.949	-0.00605
	(0.0406)	(0.0385)	(0.00468)
Education: High school or GED	0.327***	1.386***	0.0377***
	(0.0514)	(0.0713)	(0.00593)
Education: Some college	0.737***	2.090***	0.0851***
	(0.0549)	(0.115)	(0.00634)
Education: College+	1.513***	4.541***	0.175***
	(0.124)	(0.563)	(0.0143)
Race: Hispanic	-0.00898	0.991	-0.00104
	(0.0805)	(0.0798)	(0.00929)
Race: white	-0.117	0.889	-0.0136
	(0.0789)	(0.0701)	(0.00910)
Race: black	-0.407***	0.666***	-0.0469***
	(0.0874)	(0.0582)	(0.0101)
Food Desert	0.120	1.128	0.0139
	(0.0907)	(0.102)	(0.0105)
Border	-0.00685	0.993	-0.000790
	(0.0497)	(0.0493)	(0.00573)
ARC	-0.177	0.838	-0.0204
	(0.139)	(0.116)	(0.0160)
ITO	-0.319***	0.727***	-0.0369***
	(0.0894)	(0.0650)	(0.0103)
Delta	-0.617***	0.539***	-0.0712***
	(0.104)	(0.0560)	(0.0120)
Diabetes Belt	-0.444***	0.641***	-0.0513***
	(0.0791)	(0.0508)	(0.00913)
Constant	1.946***	7.003***	
	(0.115)	(0.804)	
Observations	21,060	21,060	21,060

Standard errors in parentheses

Significant level: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Compared with other percipients of other races, black participants are 4.69% less likely to initiate breastfeeding.

Discussion

Previous studies have found that WIC food package revisions in 2009 slightly improved breastfeeding outcomes, increasing both FBP use and prevalence of breastfeeding initiation (Whaley et al. 2012; Chiasson et al. 2013; Los Angeles County (Langellier et al. 2014). Moreover, the breastfeeding and initiation rates in low-income mothers are lower relative to high-income mothers. This study adds to the existing literature by using national-level survey data to evaluate the changes in WIC participants' breastfeeding behaviors in high-poverty regions due to revisions in WIC food packages.

In the current study, we find that WIC revision's goal to promote breastfeeding is achieved after the WIC food package revision in some high-poverty regions. Overall, caregivers are more likely to use FBP and less likely to use PBP after WIC revisions. Given that the in FFP use is relatively small, this phenomenon implies that some participants switched from PBP to FBP. The participants who are white or living in rural areas are more likely to use FBP than PBP or FFP. Older caregivers are more likely to use FBP or PBP than FFP. Relative to the participants with education levels lower than high school, more educated participants are more likely to use FBP than PBP or FFP. Overall, the participants in disadvantaged regions are less likely to use FBP. Participants who are black or living in the Delta region are less likely to use FBP than PBP or FFP. The participants living in ARC and the Diabetes Belt regions are more likely to use FFP than

FBP or PBP. Hispanic participants are more likely to use FFP than PBP. No significant changes in food package usage are found in the food desert, border region, and ITOs.

In general, the breastfeeding initiation rates are significantly improved after the policy is revised. However, the results are not consistent among high-poverty regions. Before the policy revision, the initiation rates are relatively higher in the border region and ITOs and lower in the Delta region. The breastfeeding initiation rates increase significantly in the food desert and decrease significantly in ITO regions after the policy revision. In the border region, ARC region, Delta region, and Diabetes Belt, the initiation conditions are improved, but the changes are not significant.

The breastfeeding initiation rates and breastfeeding packages usage rates are significantly increased after the revision in the food desert areas. Both PBP and FFP declined after and balanced by the increase of FBP. In the border region, even though the usage of FBP is low before the revision, the initiation rate is relatively higher than in other regions. Considering the use of FBP significantly increases by 5.6 percentage points after the revision, this evidence shows that most of the participants in border regions have an awareness of breastfeeding before the revision and intend to breastfeed more after the revision. In ARC, Delta region, and Diabetes Belt, all outcomes change in the expected direction. Even though some of the changes are not significant, the trend suggests that participants are more willing to breastfeed. The decrease in breastfeeding initiation in ITOs is unexpected and might have reflected the limited sample of participants in ITOs.

We also use two models to evaluate the effect of WIC food package changes. From the regression results for breastfeeding outcomes, we have several sets of findings. One of the most important findings is that caregivers are more likely to use FBP and less likely to use PBP after the WIC revision, which is consistent with the findings from previous regional studies (Whaley et al., 2012; Langellier et al., 2014; Chiasson et al. 2013; Thornton et al. 2014). Considering that breastfeeding initiation level in all regions exceeded 70 percent, the increase in breastfeeding initiation brought by the policy change is small but still significant. These findings suggest that the food package revisions achieved the goal of promoting breastfeeding nationwide after accounting for education, race, and caregivers age in the analysis.

Findings differed regionally. Overall, the breastfeeding practices of participants living in high-poverty regions are less favored. The participants' choice of packages residing in the food desert or non-food desert and living in the border region or non-border region has no significant difference, neither does the breastfeeding initiation condition. The participants in WIC ITOs show no preference for breastfeeding packages (FBP or PBP) and are less likely to initiate breastfeeding. Participants living in the ARC region are more likely to use FFP by 6.6 percentage points. The participants living in Diabetes Belt are more likely to choose FFP and less likely to choose FBP, and less likely to initiate breastfeeding by 5.13 percentage points. By analyzing each region in high poverty, we can provide some insight into the effects of WIC revision on different regions separately.

The participants living in rural areas are more likely to use FBP and less likely to use PBP compared with the participants living in non-rural areas. Older caregivers are more likely to use FBP or PBP than FFP, but less likely to initiate breastfeeding. Education and race also play essential roles in the caregivers' feeding practices. Participants who have a high school or higher education are more likely to use FBP and to initiate breastfeeding. Participants who have a college or higher education are 16.3 percentage points more likely to choose FBP and are 17.5 percentage points more likely to initiate breastfeeding. The magnitude of the differences suggests the importance of education on people's feeding practice. Hispanic participants are more likely to use PBP and less likely to use FFP. White participants are more likely to use FBP and less likely to use PBP. Black participants preferred to use FFP rather than FBP and are less likely to initiate breastfeeding.

Our study has several important limitations that cannot be avoided. First, we only have the data of the WIC participants and do not have a comparison group of non-WIC participants. Thus, we cannot distinguish that the changes in breastfeeding outcomes are caused by policy change or by other policies implemented in the same period. However, as the survey we used is designed specifically for WIC participants, it is impossible for us to find a comparison group that could measure the same set of breastfeeding outcomes. Another limitation of our study is that the sample size of participants in some high-poverty regions, such as ITOs, is relatively small. This problem may make our data a less representative sample of the national WIC participants. To address this issue, we check the representativeness of NATFAN data by comparing the regional distribution and races of the caregivers and infants in the reports of "WIC Participant and Program Characteristics 2010" (USDA, FNS 2010). From the report, the percentage of participants in ITOs is around 0.6% of nationwide WIC participants. In NATFAN data, participants identified in WIC ITOs count more than 2%. This summary result partially solved our concern.

Conclusions

The findings of our study provide much needed information on the effects of WIC food policy revisions on breastfeeding practices of the participants living in high poverty. We link the geographic information from the NATFAN data with indicators of six regions with a higher poverty rate relative to the federal poverty level. We find that the goal to promote breastfeeding is achieved after the policy revisions, even though some of the changes are not significant. Overall, the WIC food package revision increases the selection of FBP among participants in all regions. Given that the usage of FFP does not change significantly after the revision, the results suggest that the participants shifted from using PBP to using FBP. The change shows an increase in exclusively breastfeeding rates after the revision. Findings differed by region. Participants living in food deserts, ARC, and border regions show significant increases in their use of FBP. However, the food package choices of participants living in ITOs and Delta regions are not significantly influenced by the WIC revision. Furthermore, we find that the WIC participants in the rural area preferred to choose fully breastfeeding packages, compared with the participants in the non-rural area.

We find that female infants are more likely than male infants to receive FBP. One potential explanation is that male infants need more food and caregivers do not have enough breastmilk, even though they try to breastfeed their infants. This suggests that a revision of the packages that take into account infants' gender may help to improve the effectiveness of the program. Our results also suggest that caregivers who are young and less educated are less likely to use FBP. We also find that participants in disadvantaged regions such as ARC, ITOs, and Delta regions preferred FFP over FBP or PBP. Considering the limited effect of WIC revision in these regions, we suggest that a greater and more targeted effort to promote breastfeeding in these areas might provide desired results.

CHAPTER V

CONCLUSIONS

This study examines the effect of the 2009 WIC food package revision on infants' and pre-school children's food consumption and how mothers' nutrition knowledge affects her and children's food choices and consumption.

In Chapter II, we measure the effect of mothers' nutrition knowledge on mother and child dietary patterns using the TEXFAN data. The dataset provides information on food consumption of the mother and child from the same household who participate in the Texas WIC program. Our findings suggest that mothers' higher nutrition knowledge level significantly improved the likelihood of WIC participants practicing healthier dietary habits. Children with mothers who have higher levels of nutrition knowledge consume more variety of fruits and vegetables. They are also more likely to consume vegetables, fruits, and whole-grain products daily and less likely to eat refined grain foods. The amount of milk consumed is not significantly affected by the mother's nutrition knowledge. The probability of the children drinking the type of milk recommended by DGA is positively correlated with the mothers' nutrition knowledge . In addition to the parent-level effect, we also evaluate the impact of revisions in WIC food packages. We find that mothers and children are more likely to consume fruits, vegetables, and whole-grain foods daily after the revisions in WIC.

In Chapter III and Chapter IV, we use NATFAN infant data, which provide information on the mothers' breastfeeding practices and the time they introduce complementary foods to infants, to evaluate the effect of the 2009 WIC policy revision on infant feeding practices. The analysis in Chapter III suggests that mothers are more likely to breastfeed their infants at least once and choose fully breastfeeding packages rather than partially breastfeeding packages after revision. Even though the percentage of participants who prefer to choose fully formula feeding packages do not change significantly, the overall changes suggest an increase in breastfeeding. As for the effect of the revisions in WIC food packages on parents' introduction of complementary foods to infants, we found that parents delayed the introduction of complementary foods, which is more consistent with USDA guidelines. We further separate the sample into non-rural and rural areas using participants' location of residence. We find that WIC participants in rural areas are likely to use fully breastfeeding packages but introduce infants to complementary foods earlier than the recommended age, compared to the participants living in the non-rural area. Overall, the participants in both rural and non-rural regions benefit from WIC food package revisions.

In Chapter IV, we examine the effects of the revised WIC food packages on breastfeeding, including the choice of breastfeeding packages and breastfeeding initiation among WIC participants in areas with high levels of poverty relative to the federal poverty level. Our findings suggest that the revision in WIC packages led to healthier infant feeding behaviors in general. Participants are more likely to choose fully breastfeeding package, and the breastfeeding initiation is significantly improved. However, we find that the observed improvements significantly vary by region.

Overall, we find that the goals of WIC food package revision are achieved to some degree. Mothers are more likely to breastfeed their infants and delay introducing complementary foods to infants. Mothers and the pre-school children's food consumption patterns are also shifted to healthier patterns after the revision. Our analyses also suggest that additional supports to residents in high-poverty regions are necessary. Some more efforts on enhancing nutrition-related education to WIC participants are likely to shift the mothers and young age children’s food consumption to healthier dietary patterns, which could benefit the low-income families in both the short and long run.

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