CHANGES IN STATE SPECIAL SUPPLEMENTAL NUTRITION PROGRAM FOR WOMEN, INFANTS AND CHILDREN PARTICIPATION AND STATE IMPLEMENTATION OF FEDERAL POLICY

by
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Abstract

The Special Supplemental Nutrition Program for Women, Infants and Children (WIC) is a federally funded program that provides healthy foods, nutrition education, and breastfeeding support to eligible low-income women and children in the United States. Over 50% of infants, 25% of children under 5 years old, and 25% of pregnant and postpartum women receive WIC benefits. Despite the WIC program's reach, participation began to decline in 2009 for unknown reasons.

In this observational study, the objective was to examine if state implementation of three Federal policies, the 2009 WIC Food Package Changes, WIC Electronic Benefit Transfer (EBT), and REAL ID, were associated with changes in state WIC participation from 2005-2017. The study database was comprised of annual state-level measures of WIC participation in 50 states and Washington DC and covariates obtained from publicly available government sources. Two quasi-experimental statistical methods, interrupted time-series (ITS) and difference-in-differences (DID), were employed in analysis.

Compared to pre-policy WIC participation, ITS analysis revealed the immediate change in participation after the 2009 Food Package changes was not significant in most states. Two of the ten states whose models displayed negative level trends, or in other words the immediate change in the number of WIC participants post-policy was less than predicted by pre-policy trends. A positive level change was observed in the null ITS models of the remaining 41 states, but only five states displayed significant coefficients ($p < 0.05$). Participation trends were less than expected in 50 states (38/50 states $p<0.05$) and more than expected, though not significantly different, in 1 state ($p>0.05$).

The average treatment effect (ATT) calculated in DID analysis indicated a possible positive but not significant effect of WIC EBT implementation on state WIC participation. The WIC EBT ATT was 8,447 participants (p=0.19) in the null model, and 6,973 participants (p=0.32) in the extended model. State REAL ID implementation exhibited a possible positive, but not significant, effect on state WIC participation. The REAL ID ATT was 8,020 participants (p=0.32) in the null model, and 924 participants (p=0.80) in the extended model.

Few researchers have examined if state implementation of Federal policy is associated with changes in state WIC participation. This novel study revealed the 2009 WIC Food Package changes were associated with long-term participation changes in the majority of states. State WIC EBT and REAL ID implementation appeared to have a positive impact on WIC participation, but study results were not significant.

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Chapter 1. Introduction, Specific Aims, and Dissertation Overview

1.1 Introduction

The Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) is a federally funded program under the auspices of the United States Department of Agriculture (USDA) Food and Nutrition Services (FNS). States receive grants from FNS to administer the WIC program and deliver benefits to eligible women, infants, and children. WIC program benefits include supplemental healthy food, nutrition education, breastfeeding support, and referrals to health and community organizations ("Revisions in the WIC Food Packages, Interim Rule.," 2007). WIC participation is associated with numerous positive health, nutrition, and birth outcomes of program recipients (Besharov & Germanis, 2000; Caulfield et al., 2022; Colman et al., 2012; Fingar et al., 2017; Hamad et al., 2019; Pati et al., 2014; Pulvera et al., 2022; Schultz et al., 2015; Sonchak, 2016). The benefits of the WIC program extend to non-participants, by improving the food environment and supporting grocers and farmers in the community in which the WIC participants live (Cobb et al., 2015; Lu et al., 2016; Rose et al., 2014; Rossin-Slater, 2013).

Despite the advantages of the WIC Program, the number of WIC participants nationwide has declined each year since 2009 for unclear reasons (Gray et al., 2019). Some researchers have attributed the downward trend in WIC participation to a concurrent decline in the number of eligible individuals, a stronger economy, and declines in the birth rate (Carlson et al., 2017; Hanson & Oliveira, 2012). USDA administrative data, however, refute this; the number of individuals eligible for WIC has increased since 2009 (Gray et al., 2019).

The majority of research examining WIC participation focuses on individual and community level factors (Jacknowitz & Tiehen, 2010; Singleton et al., 2021; Weber et al., 2018;

Weber et al., 2019; Woelfel et al., 2004). Moreover, much of the research examining national or state level factors is descriptive or limited to a single factor (Carlson et al., 2017; Hanson & Oliveira, 2012). State specific trends in WIC participation over time also are not well characterized. Strong evidence supports that WIC-eligible individuals in some states are more likely to participate in WIC than their eligible counterparts in other states (Elster & Nakiryowa, 2019; Gray et al., 2019; Johnson et al., 2017; Pelletier et al., 2017; Trippe et al., 2018, 2019). State-level demographic and economic factors and the number of WIC eligible individuals do not fully account for declines in state WIC participation, suggesting other state-level factors may be responsible (Daepp et al., 2019; Gray et al., 2019).

A potential factor associated with changes in WIC participation, warranting further investigation, is state implementation of Federal policy (Mozaffarian et al., 2018; Pelletier et al., 2017; Seligman & Berkowitz, 2019; Seligman & Hamad, 2021). Due to the emphasis on state rights in the U.S., considerable heterogeneity exists in whether, when, and how states implement Federal policy (Goodman-Bacon & Marcus, 2020; Mozaffarian et al., 2018). In the context of WIC, state WIC agencies are largely responsible for the diversity of foods available and how food benefits are delivered to participants. State policies that alter the availability, acceptability, and accessibility of program benefits are associated with changes in WIC participation (Chauvenet et al., 2019; Lu et al., 2016; Peck et al., 2013; Pelletier et al., 2017; Weber et al., 2018; Weber et al., 2019). However, little is known about whether and how state policies that alter public benefits or alter enrollment procedures are associated with changes in WIC participation across the United States (Daepp et al., 2019; Hanson & Oliveira, 2012; Seligman & Berkowitz, 2019; Seligman & Hamad, 2021; Zimmer et al., 2021).

1.2 Specific Aims

Aim 1: Examine whether state implementation of the 2009 WIC Food Package Changes was associated with changes in state WIC participation.

Aim 2: Examine whether state implementation of the WIC electronic benefit transfer system is associated with changes in state WIC participation.

Aim 3: Examine whether state implementation of the REAL ID act is associated with changes in state WIC participation.

The overarching objective of this thesis is to examine if state implementation of Federal policies is associated with changes in state WIC participation. The three study aims focus on policies shown to be associated with participation in other public benefit programs including changes in program benefits or enrollment procedures. The first policy (Aim One), the 2009 Federal WIC food packages changes, mandated all state WIC programs modify participant food benefits (WIC, 2007). In contrast, states WIC agencies had discretion in whether to adopt the second policy for WIC electronic benefit transfer (EBT) system (Aim Two); using EBT to deliver food benefits instead of issuing paper vouchers, may have rendered benefit redemption easier ("Healthy, Hunger-Free Kids Act of 2010," 2010; Vasan, Kenyon, Feudtner, et al., 2021; Zimmer et al., 2021). The REAL ID Act of 2005, the third policy (Aim Three), may have indirectly made WIC enrollment more difficult. WIC requires proof of identity to enroll in the program; the REAL ID Act set more stringent requirements for state-issued driver's licenses and identification (Lanese et al., 2018; LeBron et al., 2018; "REAL ID Act of 2005," 2005; Sanders et al., 2020; Stuber & Kronebusch, 2004).

1.3 Dissertation Overview

The thesis is organized into five chapters. The current chapter, chapter one, introduces the study, presents the specific aims, and describes the overall thesis organization. Chapter two provides background information on the WIC program, factors associated with program participation, the theoretical basis for the study aims, and a conceptual framework for WIC participation. The study design and methods comprise chapter three, while study results for each aim constitute chapter four. Chapter five synthesizes the study results, details study strengths and limitations, and discusses the public health implications.

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Chapter 2. Background and Conceptual Framework

2.1 Overview

Chapter 2 includes background information on the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC), introduces the WIC participation conceptual framework, and concludes with the study aims, hypotheses, and rationale. The background section is divided into several subsections: the history and administration of the WIC program, a summary of the evidence base that supports WIC as an effective nutrition program, a description of the recent trends in national and state WIC participation, and then a review of multi-level factors associated with WIC participation. The next section describes the WIC participation conceptual framework that illustrates the potential relationships among factors. The chapter concludes by introducing the three dissertation aims, aim-specific hypotheses and study rationale. Throughout this chapter and the rest of the dissertation, WIC participation is defined as the average monthly number of individuals receiving WIC program benefits in a calendar year (Gray et al., 2019).

2.2 The WIC Program

The WIC program was established through an amendment to the Child Nutrition Act of 1966 and placed under the direction of the Food and Nutrition Service branch of the United States Department of Agriculture (Oliveira et al., 2002). The catalyst for the formation of WIC was likely twofold. First, the consequences of poverty, such as a high prevalence of malnutrition and hunger among women and children in the U.S., entered public consciousness. Second, pilot studies demonstrated how the provision of healthy food could prevent adverse nutrition-related health conditions in pregnant and postpartum women, infants and young children (Oliveira et al., 2002). The greater public awareness paired with positive pilot study results helped garner bipartisan support, and the Congress officially established the WIC program in 1974 (Oliveira et al., 2002).

WIC is a discretionary program and does not guarantee funding for all deemed eligible, unlike entitlement programs such as the Supplemental Nutrition Assistance Program (SNAP) or Medicaid (C.B.P.P., 2022; Oliveira et al., 2002). Each fiscal year, Congress determines the budgetary amount allocated to the USDA Food and Nutrition Service to fund WIC. The Food and Nutrition service then distributes the federal funds as grants to state WIC programs, known as state agencies (C.B.P.P., 2022; "Special Supplemental Nutrition Program for Women, Infants and Children ", 2017). State agencies are charged with program administration and implementation of WIC policies (C.B.P.P., 2022; "Special Supplemental Nutrition Program for Women, Infants and Children ", 2017).

All state agencies must abide by the same Federal WIC eligibility guidelines; an applicant must meet categorical, income, residential and nutritional risk requirements in order to participate (C.B.P.P., 2022; "Special Supplemental Nutrition Program for Women, Infants and Children ", 2017). Categorical eligibility refers to the applicant's status as a pregnant, postpartum (up to six months) or breastfeeding (up to one year) woman; an infant; or a child under five years of age. The potential participant must reside in the state in which they are applying to satisfy residential requirements. Income requirements can be satisfied in two ways, either through demonstration of a household income less than or equal to 185% of the federal poverty level (FPL), or by adjunctive eligibility documentation of participation in programs such as the Supplemental Nutrition Assistance Program (SNAP), Temporary Assistance for Needy Families (TANF), or Medicaid. The last eligibility parameter, nutritional risk, can either be medical or diet-related, and is determined by WIC nutritionists or through documentations by an individual's health care provider ("Special Supplemental Nutrition Program for Women, Infants and Children ", 2017) .

2.3 Outcomes Associated with WIC Participation

The WIC program is associated with numerous favorable health, nutrition, and developmental outcomes among participants, and credited with positive impacts on local communities and the greater economy. The outcomes highlighted in this section are not exhaustive, and instead focus on factors with the most robust evidence base.

Pregnant, postpartum, and breastfeeding women, and infants who participate in WIC are more likely to experience several positive health outcomes when compared to eligible non-participants (Angley et al., 2018; Blakeney et al., 2020; Fingar et al., 2017; Sonchak, 2016; Soneji & Beltran-Sanchez, 2019).[1] Pregnant women who participate in WIC are more likely to receive prenatal care and experience more favorable birth outcomes. These outcomes include a lower risk for stillbirth, and a decreased likelihood of delivering a low-birth weight or premature infant. Infants born to WIC participants are more likely to survive their first year of life (Angley et al., 2018; Fingar et al., 2017; Sonchak, 2016; Soneji & Beltran-Sanchez, 2019).

Children who participate in WIC are more likely to experience various positive health, nutrition, and developmental outcomes when compared to WIC-eligible non-participants, Children participating in WIC are more likely to receive regular preventive health care, such as immunizations and dental care (Buescher et al., 2003; Hunter et al., 2016; Lee et al., 2004;

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[1] Unless otherwise stated, the individual outcomes associated with WIC participation described in this section represent a comparison between WIC participants and WIC-eligible non-participants.

Thomas et al., 2014). The diets of child WIC participants are more likely to be high in critical micronutrients such as iron and vitamin C (Andreyeva & Tripp, 2016; Chiasson et al., 2013; Guthrie et al., 2020; Guthrie et al., 2018; Schultz et al., 2015). Cognitive testing of WIC-eligible children has revealed that children who participate in WIC exhibit more extensive vocabularies, higher reading scores and greater numerical recall than their eligible non-participant peers (Jackson, 2015).

The community and local economy also benefit from the WIC program. All retailers authorized to accept WIC benefits are required to maintain a certain amount of WIC foods, which increases the availability and accessibility of healthy foods available to all shoppers in the community (Campbell et al., 2017; Havens et al., 2012; Pelletier et al., 2017). The improvements in the food environment are especially advantageous in urban and rural areas without large supermarkets (Campbell et al., 2017; Cobb et al., 2015; Havens et al., 2012; Lu et al., 2016). WIC also strengthens the local economy by authorizing a diverse network of small grocers, local businesses, and farmers to accept WIC benefits (Oliveira & Frazão, 2015).

Despite this broad array of benefits for participants and communities, WIC outcomes research presents several challenges; eligible individuals self-select to participate, the characteristics of the participant population are different than those of eligible non-participants, and a randomized controlled study of WIC participation is neither ethical nor feasible. Participants may experience more favorable health outcomes than eligible non-participants because they are healthier and more motivated prior to WIC enrollment. Multiple studies have demonstrated that demographic, economic, and other population characteristics of WIC participants are different than those of eligible non-participants. WIC-eligible non-participants are more likely than WIC participants to be white, non-Hispanic, have higher incomes, live above the Federal poverty Level, and experience lower rates of household food insecurity (Gray et al., 2019; Johnson et al., 2017; Thorn et al., 2018; Thorn et al., 2015; Trippe et al., 2018, 2019). Unmeasured differences between WIC-eligible non participants and WIC participants may lead to spurious conclusions about WIC benefits. Despite the methodological challenges, the abundance of well-executed research on WIC participation and health has led multiple professional organizations, including the American Academy of Pediatrics, the American Academy of Sciences, Engineering, Medicine, and Health, and the American Academy of Nutrition and Dietetics, to identify WIC to be an effective nutrition program (A.A.P., 2015; N.A.S, 2017; Roy & Stretch, 2018).

2.4 Trends in WIC Participation

Since its inception, the number of WIC participants increased nationwide in parallel to government investment, until Congress allocated enough money to fully fund the program in 1997 (i.e., adequate funding to serve all WIC-eligible individuals) (C.B.P.P., 2022; Hanson & Oliveira, 2012) (Figure 2.1). From that year forward, WIC participation became more sensitive to external factors. With the exception of a small drop in the late 1990s, WIC participation continued on an upward trajectory until 2009, when the number of participants reached approximately 9.2 million individuals (Hanson & Oliveira, 2012; U.S.D.A., 2023). Starting in 2009, WIC participation declined each subsequent year, falling to 7.2 million participants in 2017 (Gray et al., 2019). Recent FNS estimates indicate that 6.2 million individuals participated in WIC in 2021 (U.S.D.A., 2023a).

WIC participation trends within states are not as well-characterized as at the national level but there are some commonalities across states. The number of WIC participants in each state increased until 2009-2011 and declined thereafter. Coinciding with decreases in participation, many states also experienced a decline in the percent of eligible individuals who participate in WIC (number of participants/estimated number of WIC-eligible individuals). The downward trend reflected both declines in annual WIC participation as well as increases in the estimated number of WIC- eligible individuals (Gray et al., 2019; Johnson et al., 2017; Thorn et al., 2018; Thorn et al., 2015; Trippe et al., 2018, 2019). FNS estimates the number of WIC eligible individuals by applying a series of adjustment factors to demographic survey data (Gray et al., 2019). The reasons for this trend are unclear, but are likely multi-factorial and include individual, state, and national level factors.

Even though states experience some similarities in the overall trends in WIC participation, USDA annual reports on state WIC participation from 2005-2017 have consistently demonstrated that the percent of eligible individuals that participate in WIC varies by state (Elster & Nakiryowa, 2019; Gray et al., 2019; Huynh, 2013). In 2017, for example, the percentage of eligible individuals who participated in WIC, ranged from 35.6% in Montana to 64.3% in Maryland. (Figure 2.2). Not surprisingly, states with large populations, such as California and Texas, have the largest number of WIC-eligible individuals and the largest number of WIC participants. The subset of states that exhibit either the lowest or highest percentage of eligible individuals participating in WIC has remained consistent over the study period (Gray et al., 2019; Johnson et al., 2017; Thorn et al., 2018; Thorn et al., 2015; Trippe et al., 2018, 2019).

2.5 Factors Associated with WIC Participation

Factors associated with WIC participation manifest in two ways; factors either change the number of eligible individuals or influence the number of eligible individuals who choose to participate (Hanson & Oliveira, 2012; McLeroy et al., 1988). In this section, factors are categorized as individual and community level, or state and national level. Extensive research has already been conducted on community and individual factors associated with WIC participation, so these more proximate determinants are only briefly discussed here.

In the state and national level subsection, demographic, economic, other population, and policy characteristics, as well as the political climate, are described. Factors such as race or Hispanic status, constitute individual characteristics but for this dissertation, will be considered in aggregate through a national or state level lens.

2.5.1 Individual and Community Level Factors

Qualitative and survey-based research of WIC participants, eligible non-participants, WIC employees, and other stakeholders (e.g., retailors that accept WIC benefits) have identified multiple individual and community level factors associated with an eligible individual's decision to participate in the WIC program. Individual and community level factors can be labeled as predisposing, need-based, or enabling (Aday & Andersen, 1974; Andersen, 1995). One predisposing factor associated with WIC participation is the individual's WIC eligibility category (pregnant, postpartum, infant, or child). Among the five WIC participant categories, infants comprise the group most likely to participate in WIC among those eligible, followed by postpartum and pregnant women (Pati et al., 2014; Whaley et al., 2020). About half of eligible infants participate in WIC (Gray et al., 2019). Children are the least likely to participate, and the likelihood declines with each year of age (Gray et al., 2019; Jackson & Mayne, 2016; Pati et al., 2014). Not all WIC-eligible individuals participate in WIC, and one reason eligible individuals may elect to not is because they do not perceive a need for services (i.e., need-based factor).

Some non-participants report hesitancy because they do not want to take away benefits from those in greater need (Gago et al., 2022). Localities with accessible and reliable transportation, WIC clinics and stores that accept WIC benefits in convenient locations, or localities that offer extended clinic hours, and/or provide instructional materials in the applicant's native language, are all examples of enabling factors (Liu & Liu, 2016; Peck et al., 2013; Weber et al., 2018; Weber et al., 2019; Woelfel et al., 2004).

2.5.2 State and National Level Factors

The birth rate is associated with changes in the number of WIC participants because it may alter the number of WIC-eligible infants; an eligible population most likely to participate (Pati et al., 2014; Whaley et al., 2020). For example, in 2007, an uptick in the national birth rate to 14.3 births per 1,000 population paralleled an increase in the number of WIC participants for the following two years. The national birth rate began a downward trajectory in 2008, the year before national WIC participation began to decline (Hanson & Oliveira, 2012; Oliveira & Frazão, 2015).

When the association of WIC participation and the birth rate is considered at the state level, the relationship is less clear. From 2005-2017, Utah consistently had the highest birthrates among all states in the U.S., whereas Maine, New Hampshire, and Vermont ranked as the three states with the lowest birthrates throughout the study period (Martin et al., 2018). However, contrary to what might be expected, the percentage of WIC-eligible individuals that participate in Utah has been among the lowest through the same time period. In 2017, only 38.1% of WIC-eligible individuals in Utah participated in WIC, compared to the national level of 51.0%. Yet, further muddying any conclusions, that same year the percentages of eligible individuals in

Maine, New Hampshire, and Vermont, were 50.2%, 36.7%, and 51.3%, respectively (Gray et al., 2019).

National level evidence has consistently shown that race and Hispanic status of WIC-eligible individuals moderates the association between WIC-eligibility and participation status. Among eligible individuals, white, non-Hispanic women and their children comprise the racial group that is the least likely to participate in WIC. Pregnant, black, non-Hispanic women and their infants are more likely to participate in WIC than eligible individuals of other races. WIC-eligible Hispanic children are more likely to participate than eligible non-Hispanic children (Gray et al., 2019; Jackson & Mayne, 2016; Pati et al., 2014). There are a few aberrations from national level associations between race/ethnicity and WIC participation at the state level but these need to be interpreted with caution due to the small population size of some states. The USDA has reported multiple times in annual reports that non-Hispanic whites are more likely to participate in WIC than eligible Hispanics of all races in South Dakota, Vermont and West Virginia (Gray et al., 2019). Variable participation by race/ethnicity is not fully understood. Possible explanations include disproportionately higher rates of poverty and food insecurity in black and Hispanic eligible individuals compared to white eligible individuals, chilling effects brought on by an anti-immigrant political climate, stigma, and cultural beliefs about receipt of government benefits (Bovell-Ammon et al., 2019; Jackson & Mayne, 2016; Pelto et al., 2020; Stuber & Kronebusch, 2004).

Unlike public benefit programs such as SNAP or Medicaid, WIC does not require U.S. citizenship. State agencies are not required to keep records on a participant's place of birth or immigration status, and therefore, less is known about how these factors relate to WIC participation (Thorn et al., 2018; Thorn et al., 2015).[2] Some researchers have investigated if an association exists between the immigration status of the eligible individual or their family and WIC participation (Bovell-Ammon et al., 2019; Jackson & Mayne, 2016; Pelto et al., 2020). In a study published in 2016, Jackson and Mayne found Hispanic children born to foreign-born mothers were 3.5 times more likely to participate in WIC than children of U.S. born non-Hispanic white women. The authors also reported that WIC-eligible children of immigrant families are more likely to participate than eligible children in non-immigrant families and the association was most pronounced in Hispanic families. Emerging research suggests a reversal in this trend starting in 2016; a disproportionate percentage of eligible immigrant and mixed-status Hispanic families no longer participate in WIC (Bovell-Ammon et al., 2019; Jackson & Mayne, 2016; Pelto et al., 2020).

WIC is an income-based program, so changes in the prevalence of poverty or unemployment may change the number of individuals who are eligible for WIC. Compared to WIC-eligible non-participants, participants tend to have lower household incomes and are more likely to live below the Federal Poverty Level (FPL) (Gray et al., 2019; Jackson & Mayne, 2016; Pati et al., 2014; Thorn et al., 2018; Thorn et al., 2015). Households with incomes above the FPL represent the WIC-eligible population least likely to participate. The likelihood of program participation becomes progressively less likely as household income approaches 185% of the FPL, the income threshold for WIC eligibility (Jackson & Mayne, 2016). Macroeconomic events, such as the Great Recession (2007-2009), may alter the number of WIC-eligible individuals who participate in WIC. Researchers examined WIC participation prior to, during, and after the recession. They observed that eligible families living just above the FPL, most

[2] State agencies are not required, but may elect, to document a participant's immigration status. Only one state, Indiana, exercises this option.

notably children in those households, were more likely to participate during the recession than they were in the years leading up to, or the years after the recession (Hanson & Oliveira, 2012; Jackson & Mayne, 2016).

The unemployment rate is also associated with WIC participation. WIC participation appears to respond almost immediately to economic downturns (Hanson & Oliveira, 2012). During the Great Recession, WIC participation reached a record high, a time period when nationwide unemployment rose to 9.6% (Hanson & Oliveira, 2012; Jackson & Mayne, 2016). Although the high unemployment rate did increase the number of WIC-eligible individuals, the change was modest (Jackson & Mayne, 2016; Oliveira & Frazão, 2015). Similar to other income-based public benefit programs, WIC participation declined at a slower rate during the recovery period (i.e., unemployment rate declines), a phenomenon known as the lag effect. The lag effect was likely a result of delays in the resumption of low-wage/low-skill jobs (Hanson & Oliveira, 2012).

U.S. Census Bureau survey data have shown that economic characteristics vary across states and across years, but states with high rates or poverty and/or unemployment do not necessarily translate to higher participation numbers. The association between these factors and state WIC participation is not well researched, and harder to discern.

Due to adjunctive eligibility, a change in the caseload of programs such as Medicaid, TANF, and/or SNAP may change the number of individuals eligible for WIC (Gray et al., 2019; Johnson et al., 2017; Lanese et al., 2018; Trippe et al., 2018, 2019; Yang et al., 2019). An estimated 75% of WIC participants report concurrent enrollment in Medicaid, SNAP, and/or TANF, with Medicaid being the most common. In 2016, 71% of WIC participants disclosed they received Medicaid (Thorn et al., 2018; Thorn et al., 2015). Studies assessing how changes in

Medicaid, TANF, and/or SNAP participation influence the number of WIC-eligible individuals who choose to participate have yielded mixed results, reflecting different data sources, time periods, populations, and analytic approaches (Coleman-Jensen et al., 2018; Lanese et al., 2018; Panzera et al., 2017; Yang et al., 2019).

Eligible individuals are more likely to seek WIC services if they reside in a food insecure household. New WIC participants report food insecurity, or a limited access to adequate food, more often than eligible non-participants. Participants do report the food security status of their household improves when they start to receive WIC benefits (Coleman-Jensen et al., 2018).

Policy changes in public benefit programs have the potential to attenuate or exacerbate barriers to participation (Gilbert et al., 2014; Hanson & Oliveira, 2012; Stuber & Kronebusch, 2004). While numerous characteristics of policies may be at play, in this dissertation three policy characteristics are examined; policies that may, directly or indirectly, change benefits, eligibility requirements, or enrollment procedures (Hanson & Oliveira, 2012; Jackson & Mayne, 2016; Stuber & Kronebusch, 2004).

State agencies exert a strong influence on the acceptability, availability, and accessibility of foods in states' authorized WIC food packages; these factors, in turn, are associated with WIC participation (Chauvenet et al., 2019; Lu et al., 2016). In 2009, FNS required all state agencies to implement new WIC food packages as part of the 2009 Food Package Changes Interim rule ("Revisions in the WIC Food Packages, Interim Rule.," 2007). The objectives of the food package changes were to increase the variety and cultural diversity of the WIC foods, and better align the food packages with national nutrition and feeding guidelines ("Revisions in the WIC Food Packages, Interim Rule.," 2007). FNS aimed to meet these objectives without imposing undue administrative burden on state agencies, authorized vendors, and food manufacturers. The changes included a cash benefit for fruits and vegetables, expanded whole grains options such as whole wheat bread, brown rice, and tortillas, and reduced amounts of cheese and juice ("Revisions in the WIC Food Packages, Interim Rule.," 2007). (Figure 2.3).

Another objective of the revised benefits was to increase the perceived value of the WIC foods and promote healthy behaviors in WIC participants. However, participants and their families had varied perceptions of the 2009 WIC Food Package changes (Ritchie et al., 2014; Weber et al., 2018; Weber et al., 2019). Participants viewed the increased variety of foods and expanded choices, especially the cash value fruit and vegetable voucher, favorably (Chauvenet et al., 2019; Okeke et al., 2017; Ritchie et al., 2014; Weber et al., 2019). The increased support, longer certification periods, and enhanced food packages for breastfeeding women appeared to have a positive impact on participation by breastfeeding women (Joyce & Reeder, 2015; Langellier et al., 2014; Li et al., 2019; Weber et al., 2019; Wilde et al., 2012). In contrast, some participants viewed the new requirements as too stringent, and noted that the reductions of certain foods (e.g., cheese, juice), or introduction of new foods did not meet their needs (Peck et al., 2013; Ritchie et al., 2014; Weber et al., 2018). Caregivers of infant participants disclosed dissatisfaction with the new infant food packages. Common grievances included the removal of infant juice, decreases in the amount of formula, and a delay in the provision of solid foods to six months (previously supplied at four months). Caregivers also expressed a preference for a fruit and vegetable cash voucher over jarred baby food, a benefit only afforded to women and child participants (Hurley & Black, 2010; Kim et al., 2013; Weber et al., 2018). The difficulties with the new food packages experienced by some participants and their families prompted an early exit from WIC because they believed WIC benefits were not worth the hassle (Chauvenet et al., 2019; Jacknowitz & Tiehen, 2010; Peck et al., 2013; Weber et al., 2018).

State agencies provide food benefits to WIC participants through two different delivery mechanisms, paper vouchers or electronic benefit transfer cards ("Healthy, Hunger-Free Kids Act of 2010," 2010)[3]. In qualitative interviews, participants report a preference for EBT over paper vouchers. Study participants have described EBT as more discreet, flexible, time efficient and a less stigmatizing benefit redemption process than paper vouchers (Chauvenet et al., 2019; Phillips et al., 2014; Vasan, Kenyon, Roberto, et al., 2021; Zimmer et al., 2021). However, WIC vendors authorized to accept paper vouchers, especially small grocers, have not viewed the transition to EBT as advantageous. The technical requirements, financial investment, and the staff training often exceeded their technical capacity, and some elected to no longer redeem WIC benefits. As a consequence, the accessibility and availability of WIC foods may be reduced if fewer vendors are authorized to accept WIC (Hanks et al., 2019; Phillips et al., 2014).

WIC requires proof of identity for participation; therefore, driver's license or identification card (ID) policies may indirectly impact program participation by rendering enrollment procedures more difficult (Ross, 2007; Sanders et al., 2020; Stuber & Kronebusch, 2004; Woelfel et al., 2004). An illustrative example of how stricter documentation requirements impact public program participation is the Deficit Reduction Act (DRA) of 2006. The DRA mandated states to enact stricter enrollment guidelines for Medicaid. Applicants could no longer self-report their identity and/or citizenship and needed to provide written documentation. After implementation of the DRA guidelines, Medicaid participation declined nationwide. Child applicants were disproportionately affected by the policy changes, as they were more likely to lack the required documents (Ross, 2007).

[3] All state agencies were required by HHFKA to switch to an electronic benefit delivery system by October 2020, although some states implemented EBT as early as 2002 (U.S. Congress, 2010; USDA FNS, 2016; USDA FNS, 2019)

The Real ID Act of 2005 set minimum security standards, exceeding previous requirements, for state-issued driver's licenses and identification cards ("REAL ID Act of 2005," 2005) (Figure 2.4). Those least likely to have ID include the populations most likely to participate in WIC -- Hispanics, African Americans, low-income households, and women (BCJ, 2006; Sanders et al., 2020). These groups are more likely to face economic barriers (e.g., cost of documents), structural barriers (e.g., transportation), and lack the key documents needed to apply for an ID (BCJ, 2006; LeBron et al., 2018; Sanders et al., 2020; Stuber & Kronebusch, 2004).

States with policies that expand eligibility requirements for public benefit programs have higher rates of participation than states with less generous requirements because the number of individuals in the eligible pool increases. Increases in the number of individuals eligible for a program is associated with increases in program participation (Stuber & Kronebusch, 2004). For example, under the Patient Protection and Affordable Care Act (ACA) of 2010, states had the option to expand Medicaid eligibility to include individuals >133 percent of the FPL. States that expanded Medicaid had larger increases in Medicaid participation post-ACA relative to non-expansion states (Lanese et al., 2018).

Political climate may directly or indirectly alter WIC participation because it is a government program (Mozaffarian et al., 2018). The political climate is defined as "the aggregate mood or opinions of a population about current political issues that affect said population in some way" (Bozorgmehr et al., 2023). The Trump administration expressed nationalist views and enacted immigration policies punitive to immigrants of certain religious, ethnic, and racial backgrounds (Callaghan et al., 2019; Nienhusser & Oshio, 2018). The anti-immigrant political climate cultivated a chilling effect. WIC-eligible individuals living in immigrant households elected to not participate in WIC because they feared participation increased their risk of deportation (Bovell-Ammon et al., 2019; Vargas & Pirog, 2016). One study found 81% of WIC-eligible households reported hearing at least one rumor that participation in WIC increased family members' risk of deportation. Hearing one or more rumors was associated with a 15% decrease in WIC participation among eligible families (Pelto et al., 2020).

2.6 Conceptual Framework

The WIC Participation Conceptual Framework (hereafter, the framework) draws on aspects from the ecological model for health promotion and the behavioral model of health service use (Aday & Andersen, 1974; Andersen, 1995; Lanese et al., 2018) (Figure 2.5). Adapted from the McLeroy et. al (1988) ecological model for health promotion, the framework recognizes that national, state, and individual factors influence health behavior. At a more granular level, Aday and Anderson's framework for access to medical care provides a succinct representation of individual and community level factors (Aday & Andersen, 1974; Andersen, 1995). The WIC Participation Framework acknowledges, similar to Aday and Andersen's, the decision to participate in WIC is an individual health behavior. Predisposing, need, and enabling factors can encompass individual characteristics and community level attributes, and therefore community is not a distinct level in the WIC Participation Conceptual Framework.

The WIC Participation Conceptual Framework consists of three levels, and the outcome of interest, WIC participation, lies at the bottom of the framework. Each level contains three domains with bidirectional arrows to describe how the domains are interconnected. One-directional downward arrows between the national, state, and individual levels display one pathway that may influence WIC participation. National level or state levels factors may also influence WIC participation directly and are represented in the framework with a connected arrow from each of the two levels straight to WIC participation. The political climate is also important, as the desired health outcome is more likely if the climate supports policies that facilitate or enable the individual health behavior, in this case WIC participation (Sallis & Owen, 2015). Factors beyond the scope of the proposed study are shown with dotted lines.

2.7 Aims, Hypotheses, and Study Rationale

Aim 1: Examine whether state implementation of the 2009 WIC Food Package Change was associated with changes in state WIC participation.

Hypothesis 1: The 2009 WIC food package changes were not consistently associated with changes in state WIC participation from 2010-2013, after adjustment for state-level demographic, economic, and other population characteristics.

This study expects to find varied associations across states between the 2009 food packages changes and state WIC participation because implementation differed by state (Daepp et al., 2019; Hanson & Oliveira, 2012; Pelletier et al., 2017). WIC participation varies across states (Cole et al., 2011; Gray et al., 2019; Thorn et al., 2018; Thorn et al., 2015). State agencies were charged with implementing the 2009 Food Packages changes including selecting WIC approved foods and authorizing vendors in their state (Cole et al., 2011; Gray et al., 2019; Thorn et al., 2018; Thorn et al., 2015). The USDA reported substantial variation among state agencies in the variety and the diversity of WIC foods offered, and adoption of optional provisions when implementing the WIC Food Package changes. Changes that alter the acceptability, accessibility, and availability of WIC benefits are factors associated with changes in WIC participation.

Aim 2: Examine whether state implementation of the WIC electronic benefit transfer system was associated with changes in state WIC participation.

Hypothesis 1: State implementation of the WIC electronic benefit transfer system is associated with increases in state WIC participation, after adjustment for state-level demographic, economic, and other population characteristics.

The study expects to find an increase in WIC participation after EBT implementation because the policy provides more flexibility in benefit redemption than paper vouchers. Qualitative research has provided a potential mechanism for this anticipated association. Multiple studies report that participants view paper vouchers as a barrier to participation due to the stigma and the lengthy process to redeem benefits (Bai & Ciecierski, 2023; Chauvenet et al., 2019; Phillips et al., 2014; Vasan, Kenyon, Feudtner, et al., 2021; Zimmer et al., 2021).

Aim 3: Examine whether state enactment of the REAL ID Act is associated with changes in state WIC participation.

Hypothesis 1: State enactment of the REAL ID Act is associated with declines in state WIC participation, after adjustment for state-level demographic, economic, and other population characteristics.

This study expects to find that state REAL ID implementation is associated with declines in state WIC participation by indirectly complicating WIC enrollment. The REAL ID act mandated that states increase the documentation requirements for obtaining identification ("REAL ID Act of 2005," 2005). WIC-eligible non-participants have cited difficulty obtaining an ID as a barrier to WIC participation (Ross, 2007; Woelfel et al., 2004). The stricter ID requirements could increase the number of WIC-eligible individuals who experience difficulty obtaining ID in enactment states and render enrollment more difficult (LeBron et al., 2018; Sanders et al., 2020; Sobel, 2014).

2.8 Figures

Figure 2.1 Examples of 2009 WIC Food Package Policy Options (Cole et al., 2011)

1. Allowing frozen, canned, and dried fruits and vegetables as alternatives to fresh
2. Redemption of multiple CVVs in a single transaction
3. Redemption of CVVs in a combination tender transaction whereby participants “pay the difference” when the fruits and/or vegetables exceed the value of the CVV
4. Redemption of CVVs at farmers’ markets
5. Allowing soy beverages and/or tofu as milk substitutes
6. Allowing specific Federally authorized whole grains (brown rice, bulgur, barley, oatmeal, and soft corn or whole-wheat tortillas) as alternatives to 100% whole-wheat bread
7. Allowing at least two different types of canned fish (SAs may can choose from tuna, salmon, sardines, and mackerel.
8. Package tailoring with different combinations of dry beans and peanut butter
9. Package tailoring with infant formula in the first month after birth
10. Food package adjustments to accommodate the special needs of homeless participants
11. “Rounding up” of infant formula and infant food container sizes.

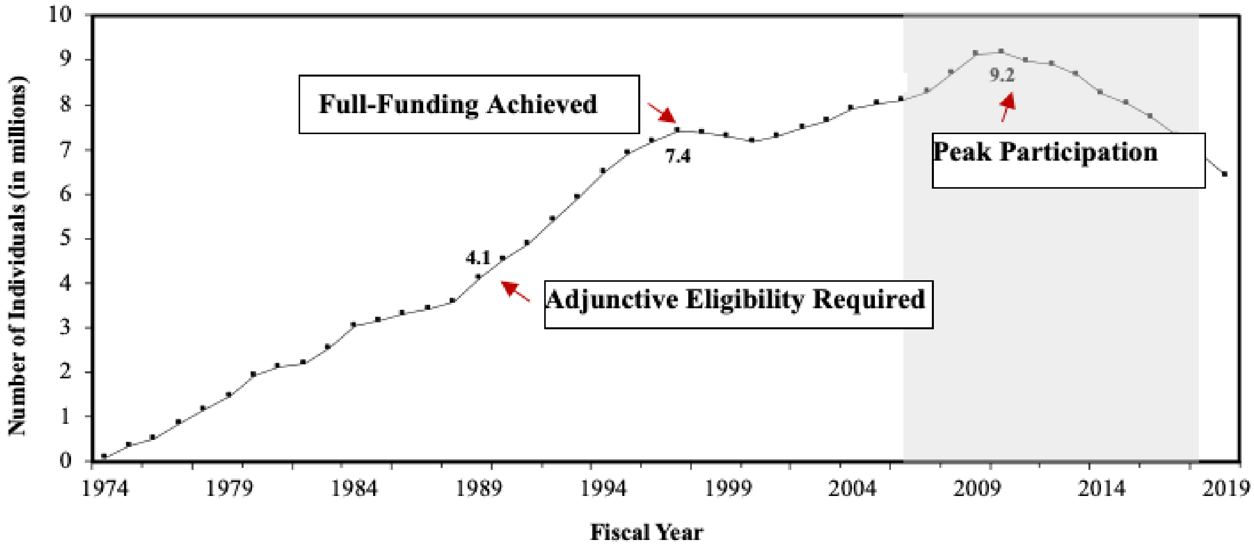
Data Source: Cole, N., Jacobson, J., Nichols-Barrer, I., & Fox, M. K. (2011). *WIC Food Packages Policy Options Study I.* Alexandria, VA: U.S. Department of Agriculture, Food and Nutrition Service, Office of Research and Analysis

Figure 2.2 U.S. Department of Homeland Security REAL ID Act Compliance Requirements ("REAL ID Act of 2005," 2005)

1. Photo identity document (except that a non-photo identity document is acceptable if it includes both the applicant's full legal name and date of birth).
2. Documentation showing the applicant's date of birth.
3. Proof of the person's Social Security Number (SSN) or verification that the applicant is not eligible for an SSN.
4. Documentation showing the applicant's name and address of principal residence.
5. Proof of lawful status in the US.

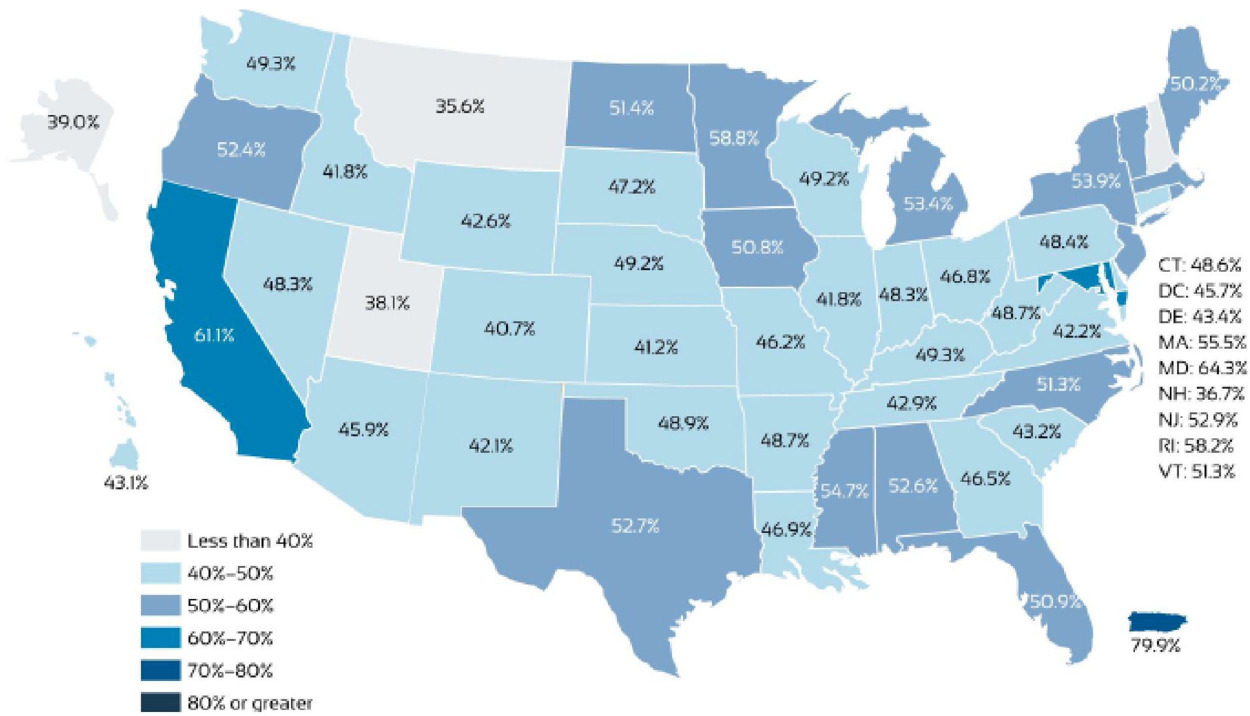
Data Source: REAL ID Act of 2005, 8 U.S.C. §§ 1101 – 1252 (2005).

Figure 2.3 Total Number of WIC Participants, 1974-2019 (U.S.D.A., 2023)



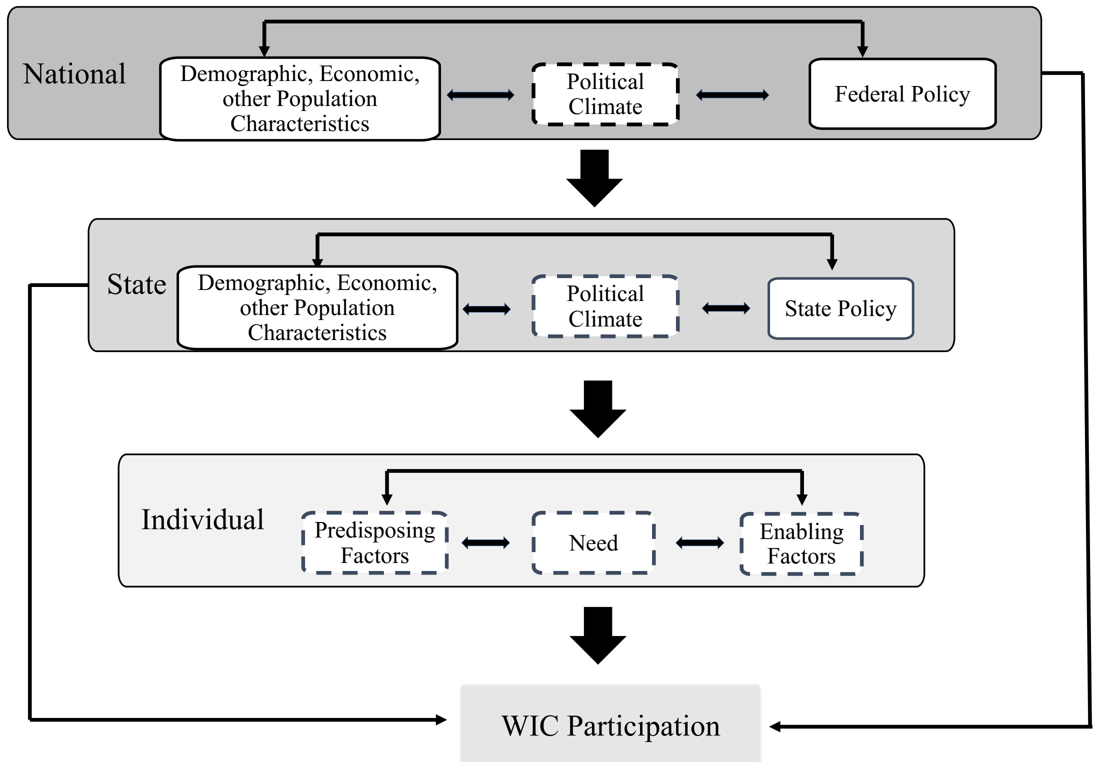
Data Source: U.S.D.A. (2023). *National Level Annual Summary: 1974-2022*. United States Department of Agriculture, Food and Nutrition Services. Retrieved March 20, 2023 from https://www.fns.usda.gov/pd/wic-program

Figure 2.4 Percent of Eligible Individuals Participating in WIC by State, 2017 (Gray et al., 2019)



Data Source: Gray, K., Trippe, C., Tadler, C., Perry, C., Johnson, P., & Betson, D. (2019). *National- and State-Level Estimates of WIC Eligibility and WIC Program Reach in 2017.* Food and Nutrition Services, U.S. Department of Agriculture, Office of Policy Support.

Figure 2.5 WIC Participation Conceptual Framework (Aday & Andersen, 1974; Andersen, 1995; McLeroy et al., 1988)



Data Sources: Aday, L. A., & Andersen, R. (1974). A framework for the study of access to medical care. *Health Serv Res*, *9*(3), 208-220. Andersen, R. M. (1995). Revisiting the behavioral model and access to medical care: does it matter? *J Health Soc Behav*, *36*(1), 1-10.

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Chapter 3. Study Design and Methods

3.1 Overview

The study design and methods chapter present the study design, data sources, variables, human subjects, general analytic methods, and aim-specific analytic approaches.

3.2 Study Design

This observational study using secondary data from existing federal data sets evaluated if state implementation of three Federal policies was associated with changes in state WIC participation. The three Federal policies investigated were the 2009 WIC Food Packages Changes, Electronic Benefit Transfer (EBT) of WIC benefits, and the REAL ID Act. Study variables were annual measures from 2005-2017, aggregated at the state level, and obtained from publicly available government sources.

3.3 Data Sources

This study used data from nine publicly available U.S. Federal government data sources (reports and websites). (Table 3.1). The average number of WIC participants and estimated average number of WIC eligible individuals in each state were obtained from the annual U.S. Department of Agriculture, Food and Nutrition Service (USDA, FNS) report "National- and State-Level Estimates of Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) Eligibles and Program Reach" (Gray et al., 2019; Johnson et al., 2017; Trippe et al., 2018, 2019). The USDA FNS website supplied information on the 2009 WIC food package changes and state WIC EBT implementation status. The U.S. Department of Homeland Security published REAL ID status by state on their publicly available website (U.S. Department of

Homeland Security, 2023). The Centers for Disease Control and Prevention supplied annual birth rate data for each state (U.S. Centers for Disease Control and Prevention, 2023). Two U.S. Census Bureau surveys, the American Community Survey (ACS) and the Community Population Survey (CPS), provided annual national and state data for Hispanic status, nativity, and race (U.S. Census Bureau, 2021). Three CPS supplements (Labor Statistics, Income and Poverty, and Food Security) provided annual estimates of unemployment (U.S. Bureau of Labor Statistics, 2020), poverty, and food insecurity measures for each state (U.S. Census Bureau, 2021).

3.4 Variables

This study included one dependent variable, three independent variables, and nine potential covariates. (Table 3.1). Table 3.1, Variable Definitions and Data Sources, summarizes the definition, aim, operational definition, and data source for each study variable. The dependent variable examined in Aim 1, Aim 2, and Aim 3, WIC participants[4], was defined as the average annual number of individuals enrolled in WIC who claimed benefits in an average month[5] (Gray et al., 2019). The three independent variables, one for each aim, included the 2009 WIC Food Package Changes, WIC EBT, and the REAL ID Act ("Healthy, Hunger-Free Kids Act of 2010," 2010; "REAL ID Act of 2005," 2005; "Revisions in the WIC Food Packages, Interim Rule.," 2007). A further description of how each independent variable was operationalized is discussed below in each aim-specific analysis section.

Nine state-specific, time-varying variables were considered as potential covariates due to demonstrated associations between covariate measures and changes in state WIC participation in prior literature (Bovell-Ammon et al., 2019; Carlson et al., 2017; Hanson & Oliveira, 2012;

[4] Includes total number of participants in all participant categories (e.g. pregnant, infant).
[5] Individuals may be enrolled in WIC but not pick up benefits.

Jackson & Mayne, 2016). All covariates were coded for each state-year observation. The variables included four demographic and two economic characteristics: birthrate, race, Hispanic origin, nativity, unemployment, and poverty. The prevalence of food insecurity, the number of WIC-eligible individuals, and if states opted to expand Medicaid under the Affordable Care Act were also investigated (Coleman-Jensen et al., 2018; Gray et al., 2019; Lanese et al., 2018). The number of WIC-eligible individuals is an FNS estimate of the average monthly number of individuals eligible for WIC each year. FNS uses state-level ACS data subjected to a series of adjustment factors (e.g. state differences in WIC certifications periods, seasonal trends in income) to estimate the number eligible in each state (Ploeg & Betson, 2003).[6] The number of eligible infants in each state is then used as the starting point to estimate the number of eligible pregnant and eligible post-partum women (Gray et al., 2019).[7] The definitions of all potential covariates, with the exception of race, were consistent with government data sources from which the measures were obtained. The ACS changed how race was recorded in 2010, therefore certain race categories were combined in order for race data prior to 2010 to be directly comparable to data after 2010.

3.5 Human Subjects

The Johns Hopkins Bloomberg School of Public Health Institutional Review Board Office determined this study did not qualify as human subjects research on September 1, 2021. (Appendix 1).

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[6] CPS-ASEC data, not ACS, is used to estimate the number of WIC-eligible individuals at the national level.
[7] Data for those eligible for WIC through Indian Tribal Organizations (ITO) are included in the data for the State where the ITO is located.

3.6 General Analytic Plan

This section provides a basic overview of the analysis plan, including formation of the study period, finalization of the study sample, data collection, and a brief summary of methods common to all three aims. The broad rationale for the use of interrupted time series (Aim 1) and difference-in-differences (DID) analysis (Aims 2 and 3) is also described. A more detailed account of analytic decisions is provided in the aim-specific analysis sections.

The study time period, 2005-2017, was curated to minimize the risk that changes in WIC participation could be explained by events other than the independent variables of interest. For Aim 1 (2009 WIC food package changes), the study period spanned from 2005-2013 to capture any pre-existing trends prior to the onset of the Great Recession (2007-2009) and ended before the Patient Protection and Affordable Care Act Medicaid expansion, as research has shown associations between these two phenomena and changes in state WIC participation (Hanson & Oliveira, 2012; Lanese et al., 2018). The study period for Aim 2 (WIC EBT) and Aim 3 (REAL ID) was constructed similarly. The timeframe started in 2010, the year after the 2009 WIC food package changes, and ended in 2017, prior to the public charge executive order leak in 2018 (Torres-Ardila et al., 2018). The latter event was associated with declines in WIC participation among specific minority groups (Bovell-Ammon et al., 2019; Pelto et al., 2020; Vargas & Pirog, 2016).

All study data were obtained from publicly accessible U.S. Federal government websites. Information on outcome measures, independent variables, and covariates for all U.S. states and the District of Columbia from 2005-2017 was merged to create a master database in Microsoft Excel. The database was cleaned; for example, binary and categorial variables were recoded from string to numeric measures (e.g., Alaska was designated as state 1) and then organized by state, year, and aim. (Table 3.2).

The master dataset was imported into Stata version 17® for univariate, bivariate, and regression analyses. To identify outliers, pinpoint errors, and examine missing data, descriptive statistics (e.g., mean, median, inter-quartile range) were calculated for each study variable. Potential outliers were identified using Tukey criteria (Keselman & Rogan, 1977). Only states with WIC participation (number of WIC participants) that met or exceeded Tukey criteria for the entirety of the study period were deemed outliers. Due to multicollinearity and small sample size in some states, race was condensed into three categories: white, black, and other race in initial analyses.

The models chosen for aim-specific analysis were guided by whether a natural control group existed, and the timing of policy implementation (i.e., one year or multiple years). In Aim 1, an interrupted time series was used, and in Aims 2 and 3 a difference-in-differences approach was employed. Data exploration and assumption testing narrowed down the particular application of the two respective methods.

For Aim 1, an interrupted time series (ITS) design was used to examine if the 2009 WIC food package changes were associated with changes in state WIC participation for several reasons. First, the dataset met key ITS criteria, as it was comprised of annual time-series measures, had more than the minimum of two outcome measures before and after the policy of interest, and the implementation period was clearly demarcated (Kontopantelis et al., 2015; Linden, 2015; Wagner et al., 2002). Second, ITS is a quasi-experimental approach that does not require a natural control group, which is advantageous in investigating the effect of a policy that is implemented in all states at the same time, like the 2009 WIC food package changes (Wing et al., 2018). ITS analysis uses the multiple outcome measures available prior to the intervention to create the counterfactual (i.e., the trend in outcome if the policy was not implemented). The underlying assumption of ITS is the outcome would continue on the same trajectory in the absence of the policy "interruption" (Kontopantelis et al., 2015; Linden, 2015, 2021; Wagner et al., 2002). In Aim 1 analysis, the change in the number of WIC participants over time prior to the 2009 WIC food package changes was projected into the post-policy period, serving as a synthetic control group. The difference between the observed trend in the number of WIC participants following the 2009 Food Package changes and the predicted trend in the synthetic control group was compared and evaluated for significance in Aim 1 (Linden, 2015, 2021).

A difference-in-differences (DID) approach was used in Aims 2 and 3 analyses instead of ITS because a natural control group existed and because states that implemented the policy of interest did so at different times. To illustrate, in Aim 2, 27 states never implemented WIC EBT (the control group), but 19 states did between 2010-2017: one state in 2011, one state in 2013, three states in 2014, two states in 2015, eight states in 2016, and three states in 2017 (U.S.D.A., 2023b). The intended result of DID analysis is to estimate an average treatment effect (ATT) of the intervention (Callaway & Sant'Anna, 2021; Goodman-Bacon, 2018, 2021). In the study context for Aims 2 and 3, DID was used to estimate the average treatment effect of state implementation of WIC EBT or REAL ID on the change in the number of WIC participants in each state. Estimation of an average treatment effect by DID is based on two differences. The first difference is the change in outcome from the pre-policy period to post-policy period, and the second is the difference between the change in outcome between the intervention and control group. The average treatment effect is then estimated by subtracting the potential outcomes with no treatment to the observed outcomes in the treated group. In the multiple groups, multiple intervention period application, an ATT is calculated for each group, and then aggregated to approximate the overall treatment effect (Callaway & Sant'Anna, 2021; Goodman-Bacon, 2021).

The underlying assumptions of DID are that baseline differences between the intervention and control groups do not change over time and time-varying differences do not vary over groups, referred to as the parallel trends (Goodman-Bacon, 2021; Hansen et al., 2017; Harper et al., 2012). Evidence suggests that strict adherence to the parallel trends assumption may not be ideal for DID analysis in this situation (Callaway & Sant'Anna, 2021). A more flexible interpretation, conditional parallel trends, may be better suited to incorporate treatment anticipation behavior or dynamic treatment effects (Callaway & Sant'Anna, 2021; Chaisemartin & D'Haultfœuille, 2022). Therefore, both unconditional and conditional parallel trends approaches were used to calculate ATT in Aims 2 and 3 analyses.

To inform covariate selection, least absolute shrinkage and selection operator (lasso) regression was used, as this method offers several advantages when compared to traditional covariate selection approaches. Lasso is a type of regularized regression (a machine-learning technique) that has been utilized in economic and biomedical studies due to its efficiency and decreased susceptibility to research bias (Ahrens et al., 2020; Drukker & Liu, 2019; StataCorp, 2021b). The sparsity requirement for Lasso, met by the current study, is that the number of covariates in the "true model" (s) divided by the quotient of the square root of the number of observations in the data (N) and the natural log of the number of potential covariates (p) is small (StataCorp, 2021b). (Figure 3.1). Lasso is particularly advantageous because it can regress datasets with a high degree of multicollinearity among variables, and with a relatively high number of variables compared to the sample size (even if the number of variables exceed the number in the sample). Instead of the researcher, the machine learning technique chooses the optimal ordering of covariates (and/or groups of covariates) to be added to the model (Ahrens et al., 2020; Drukker & Liu, 2019; StataCorp, 2021b).

3.7 Aim 1 Analysis

Aim 1: Examine whether state implementation of the 2009 WIC Food Package Change was associated with changes in state WIC participation.

In Aim 1 analysis, an interrupted time series (ITS) design was used to examine if state implementation of the 2009 WIC food packages changes was associated with changes in state WIC participation, using data from 2005-2013. A separate ITS model was estimated for each state as a univariate time series. The number of WIC participants in a state prior to the 2009 WIC Food Package Changes was projected into the post-policy period to create a counterfactual. Each state's counterfactual trend was then compared to the observed state WIC participation in the post-policy time period.

The observed relationship of state WIC participation over time was approximately linear in all states, once segmented into the pre-policy (2005-2008) and post-policy (2010-2013) periods, so ITS with segmented linear regression was used (Bernal et al., 2017; Linden, 2015; Linden & Adams, 2011; Turner et al., 2020).

The null model in Aim 1 analysis used to estimate all 51 ITS equations—one for each state and the District of Columbia—was comprised of an outcome term (Y_t) that represented the number of WIC participants at time *t*, a constant, terms for time, policy period, and interaction of time and policy period, and an error term (Linden, 2015; Linden & Adams, 2011). (Figure 3.2). The constant (β_0) represented the number of state WIC participants in 2005, the year the study period began. Time (T_t) was defined as the number of years since 2005, and policy period (X_t)

indicated if the year was in the pre-policy period (before the 2009 WIC food package changes), or otherwise (2009 or after). An interaction term of the two variables was denoted as X_tT_t (Linden, 2015; Linden & Adams, 2011). Excluding the constant (β_0) and error term (ε_t), regression coefficients (β_1, β_2, β_3) accompanied the (T_t, X_t, X_tT_t) variables. The term (β_1) quantified the change in the number of WIC participants each year in the study period prior to the 2009 WIC Food Package Changes. The difference between the number of WIC participants immediately following the 2009 WIC Food Packages changes and the counterfactual was represented by β_2. The interaction coefficient, β_3, described the change in the trend in the number of WIC participants each year from the pre-policy period to post-policy period (Linden, 2015; Linden & Adams, 2011). ITS regressions with p-value < 0.05 for the β_2 and/or β_3 regression coefficients indicated a significant immediate intervention effect and/or intervention effect over time, respectively (Linden, 2015; Linden & Adams, 2011).

The estimation of ITS regression coefficients for each state was accomplished through three iterations of ordinary-least squared regression (OLS) with Newey-West standard errors. Newey West is a method to adjust standard errors to account for autocorrelation in time-series analysis (Linden, 2015, 2021). However, the degree of autocorrelation must be determined post-estimation. Therefore, in the first iteration, the null ITS model was estimated under the assumption that no autocorrelation was present (Linden, 2015, 2021). After the first equation was estimated, the Cumby-Huizinga general test was applied to ascertain if autocorrelation was present, and if so, to determine to what degree (Baum & Schaffer, 2015; Cumby & Huizinga, 1992; Linden, 2015, 2021). The p-values produced by the Cumby-Huizinga test for each lag were reviewed for significance. If autocorrelation was found, the highest significant lag order (0-8, 8 being the highest lag order) was recorded. In the second iteration of OLS regression with

Newey-West standard errors, the highest significant lag order was specified to inform the adjustment of standard errors (Baum & Schaffer, 2015; Cumby & Huizinga, 1992; Linden, 2015).

Lasso aided in the selection of covariates after evaluation revealed that Aim 1 data met the sparsity requirement (Ahrens et al., 2020; StataCorp, 2021b). The lasso-identified knot was added to each respective state's null ITS model to create an extended model. A third iteration of OLS with Newey-West standard errors (with the number of lags specified) and the lasso-identified covariates was then re-estimated for each state (Linden, 2015, 2021). The significance of the regression coefficients and adjusted r^2 were reviewed postestimation to choose a final ITS model (Ahrens et al., 2020; StataCorp, 2021b).

3.8 Aim 2 Analysis

Aim 2: Examine whether state implementation of the WIC electronic benefit transfer system was associated with changes in state WIC participation.

A difference-in-differences (DID) approach was utilized to examine if state implementation of WIC EBT was associated with changes in state WIC participation through secondary data analysis of time-series panel data of 2010-2017 annual measures. Because pre-EBT implementation data is required to calculate the treatment effect in DID analysis, states that implemented EBT prior to 2010 were excluded from analysis (Callaway & Sant'Anna, 2021; Goodman-Bacon, 2018, 2021; Fernando Rios-Avila et al., 2021; F. Rios-Avila et al., 2021; StataCorp, 2021a). The states removed from the study sample were Wyoming (2002), New Mexico (2007), Michigan (2009), Texas (2009), and Nevada (2009). The final sample contained 8 time points for 46 states, for a total of 368 observations (U.S.D.A., 2023b). (Table 3.3).

Two measures were used to categorize each state's EBT implementation status in DID analysis: WIC EBT Group and WIC EBT Time. (Table 3.1). The WIC EBT Group variable indicated each state's baseline (2010) WIC EBT policy implementation status. States were either categorized as 0 to signify they never-implemented WIC EBT (n=27) or coded as 1 to indicate the state implemented WIC EBT during the study period but had not-yet-implemented at baseline (n=19) (U.S.D.A., 2023b). The WIC EBT Time variable was an extension of the WIC EBT Group variable. The not-yet-implemented WIC EBT Group at baseline states were indexed by year of WIC EBT implementation; 2011 (n=1), 2013 (n=1), 2014 (n=3), 2015 (n=2), 2016 (n=8), and 2017 (n=3) (U.S.D.A., 2023b). Similar to the WIC EBT Group variable, the 27 states that never implemented WIC EBT were assigned a value of zero for WIC EBT Time.

The main objectives of DID analysis in this study were to test the parallel trends assumption under both unconditional and conditional criteria, and then estimate a series of DID models to best approximate the average treatment effect of WIC EBT implementation. First, the parallel trend assumption was evaluated. The baseline characteristics of the two WIC EBT Groups (never implemented and not-yet implemented) were compared to identify if any significant differences between the two groups would violate one of the two tenants of the parallel trends assumption (e.g., unrelated changes due to Medicaid expansion). (Table 3.5). After assessment of unconditional parallel trends, the null DID model was estimated.

The two-way fixed-effects DID model estimated in Aim 2 analysis included terms for group-fixed effects (α_g), time-fixed effects (b_t), WIC EBT policy implementation status (D_{gt}), a treatment effect parameter called the global treatment effect (δ), and error (ε_{gt}). (Figure 3.3). The group fixed effect, α_g, represents variables that may differ among groups but not across time. Variables that vary over time but not across groups make up the time-fixed effects and were denoted by b_t . WIC EBT policy implementation status is a dummy variable, D_{gt}, to indicate the policy implementation status of group g at time t. The global treatment effect is a weighted average of all 2x2 DID estimators (Chaisemartin & D'Haultfœuille, 2022; Goodman-Bacon, 2018, 2021). Table 3.4 displays all the difference-in-differences 2 x 2 estimator combinations used to calculate the global treatment effect in Aim 2.

An event-study was then used to detect the presence of intervention anticipation effects and determine if the treatment effect differed by length of time in states that were exposed to WIC EBT (Callaway & Sant'Anna, 2021; Chaisemartin & D'Haultfœuille, 2022). The Cumby-Huizinga general test for autocorrelation was applied to DID regression post estimation to evaluate the presence of autocorrelation. The highest order of statistically significant lags was specified in the next DID model iteration ($p < 0.05$). Corrections were made for clustering at the state level (Callaway & Sant'Anna, 2021; Linden, 2015, 2021). In Aim 2 covariate selection, lasso was used to identify the most predictive set of covariates (Ahrens et al., 2020; StataCorp, 2021b).

3.9 Aim 3 Analysis

Aim 3: Examine whether state implementation of the REAL ID act was associated with changes in state WIC participation.

A DID model was used to assess if state implementation of the REAL ID act was associated with changes in state WIC participation from 2010-2017. Two measures were created to define the study groups: REAL ID group and REAL ID Time. (Table 3.1) REAL ID Group is a binary variable to indicate if the state implemented REAL ID during the 2010-2017 study period: 0=Never Implemented 1= Not yet implemented at baseline. The group measure sorted each state into one of the two baseline characteristics comparison groups. The REAL ID Time variable was modeled as an independent variable and indexed each REAL ID state by year of implementation. The never implemented group included 24 states and were denoted by 0. The remaining 27 states that implemented REAL ID were stratified into 5 groups; the 2012 group (n=14), 2013 group (n=8), 2014 group (n=2), 2016 group (n=3), and 2017 group (n=2). (Table 3.6) No states implemented REAL ID in 2010, 2011, or 2015 (U.S. Department of Homeland Security, 2021). No states implemented the REAL ID act and expanded Medicaid in the same year (U.S. Department of Homeland Security, 2021; Center for Medicaid and Medicare, 2021). (Table 3.5).

The DID analytic methods used in Aim 3 were similar to those used in Aim 2. Baseline characteristics for the REAL ID never implemented and not yet implemented group were computed and compared. Parallel trends were examined through the lens of unconditional and conditional modalities, and several DID models were employed to estimate the average treatment effect of REAL ID act implementation on state WIC participation (Callaway & Sant'Anna, 2021; Goodman-Bacon, 2021).

A two-way fixed effect DID model was calculated in Aim 3 analysis. (Figure 3.4). Similar to Aim 2, the model included terms for group-fixed effects (α_g), time-fixed effects (b_t), REAL ID Act policy implementation status (D_{gt}), a global treatment effect (δ), and error (ε_{gt}) (Chaisemartin & D'Haultfœuille, 2022; Goodman-Bacon, 2018, 2021). Table 3.7 displays all the difference-in-differences 2 x 2 estimator combinations used to calculate the global treatment effect. Standard errors were corrected to account for clustering at the state level, autocorrelation was identified by the Cumby- Huizinga general test, and lasso was used to identify covariates (Ahrens et al., 2020; Callaway & Sant'Anna, 2021; Linden, 2021; StataCorp, 2021b).

3.10 Tables

Table 3.1 Variable Definitions and Data Sources

Variable	Aim	Definition	Operational Definition	Data Source
Subject Identification				
State Number	1, 2, 3	Number assigned to identify each state	Categorical: 1= AK 2= AL…51=WV	See Table 2
Dependent Variable				
WIC Participants	1, 2, 3	Number of individuals enrolled in WIC that claimed benefits in average month in a year	Continuous: Average	USDA, National- and State-Level Estimates of WIC Eligibles and Program Reach
Independent Variables				
2009 WIC Food Package Change	1	If the time period falls before the 2009 WIC food packages	Binary: 0= Before Food Packages Changes 1= Otherwise	USDA, FNS Interim Rule
WIC EBT Group[1]	2, 3	Whether state WIC agencies delivered WIC benefits by Electronic Benefit Transfer (EBT) during the study period	Binary 0= Never Implemented EBT 1= Not yet Implemented EBT	USDA, WIC EBT Detail Status Report
WIC EBT Time	2, 3	If implemented, the year a state agency implemented EBT	Categorical: 0= Never Implemented EBT 2010+ = Year Implemented EBT	
REAL ID Group[1]	2, 3	Whether states implemented the REAL ID Act during the study period	Binary: 0= Never Implemented REAL ID 1= Not yet Implemented REAL ID	U.S. DHS. REAL ID Act: Federal Enforcement; State Compliance, Extensions and Implementation
REAL ID Time	2, 3	If implemented, the year a state implemented the REAL ID Act	Categorical: 0= Never Implemented REAL ID 2010+ = Year REAL ID Implemented	
Covariates				
Medicaid Expansion Group	2, 3	Whether state expanded Medicaid eligibility during the study period	Binary: 0= Did not expand 1= Did expand	U.S. Centers for Medicare and Medicaid
Medicaid Expansion Time	2, 3	If expanded, the year state expanded Medicaid	Categorical: 0= Did not expand 2014+ = Year Expanded	U.S. Centers for Medicare and Medicaid
Birth Rate	1, 2, 3	Number of births per 1,000 women aged 15–44	Continuous: Number	CDC, National Vital Statistics System
Food insecurity [2]	1, 2, 3	Prevalence of food insecure households (three-year rolling average)	Continuous: Percentage	U.S. Census Bureau, CPS-Food Security Supplement
Foreign Born [3]	1, 2, 3	Percent of population born outside of the U.S.	Continuous: Percentage	U.S. Census Bureau, American Community Survey
Hispanic Origin [3]	1, 2, 3	Percent of population that report Hispanic origin	Continuous: Percentage	
Poverty Rate [4]	1, 2, 3	Percent of individuals earning below 100% of the FPL	Continuous: Percentage	
Race [3, 5]	1, 2, 3	Percent of population that identify with each race	Continuous: Percentage	
Unemployment Rate [6]	1, 2, 3	Percentage of labor force not employed	Continuous: Percentage	U.S. Census Bureau, CPS Labor Statistics
WIC-Eligible	1, 2, 3	Estimated number of individuals eligible for WIC in an average month in a year	Continuous: Average	USDA, National- and State-Level Estimates of WIC Eligibles and Program Reach

Footnotes:
[1] Group variables were also utilized as covariates.
[2] Household consists of all people (adults and children) who occupy a housing unit (U.S. Bureau of Labor Statistics, 2021).
[3] Population includes all the civilian noninstitutional of U.S. and members of the Armed Forces in the U.S. living off post or with families on post but excludes all other members of Armed Forces, in U.S. states and District of Columbia (adults and children,)
[4] Poverty status is determined for individuals in housing units and noninstitutional group quarters except people living in college dormitories or military barracks, or unrelated individuals under 15 years old
[5] Other race includes American Indian or Alaskan Native, Asian, Native Hawaiian and other Pacific Islander, Some other race, two or more races). (U.S. Census Bureau, American Community Survey)
[6] Workforce includes employed persons, those that report not being employed and actively looking for work (U.S. Bureau of Labor Statistics, 2021).

Data Sources: U.S. Department of Agriculture. (2023). *WIC EBT Activities*. U.S. Department of Agriculture, Food and Nutrition Services. Retrieved April 3, 2023 from https://www.fns.usda.gov/wic/wic-ebt-activities; U.S. Department of Homeland Security. (2021). REAL ID Act: Federal Enforcement; State Compliance, Extensions and Implementation. Retrieved April 1, 2021 from https://www.dhs.gov/real-id. Johnson, et al. (2017). *National- and State-Level Estimates of Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) Eligibles and Program Reach in 2014, and Updated Estimates for 2005–2013.* U.S. Department of Agriculture, Food and Nutrition Service, Office of Policy Support. Trippe, C., Tadler, C., Johnson, P., Giannarelli, L., & Betson, D. (2018). *National- and State-Level Estimates of Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) Eligibles and Program Reach in 2015*. Alexandria, VA: U.S. Department of Agriculture, Food and Nutrition Service, Office of Policy Support. Trippe, C., Tadler, C., Johnson, P., Giannarelli, L., & Betson, D. (2019). *National- and State-Level Estimates of Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) Eligibility and Program Reach in 2016*. Alexandria, VA: U.S. Department of Agriculture, Food and Nutrition Service, Office of Policy Support. Gray, K., Trippe, C., Tadler, C., Perry, C., Johnson, P., & Betson, D. (2019). *National- and State-Level Estimates of WIC Eligibility and WIC Program Reach in 2017.* Alexandria, VA: U.S. Department of Agriculture, Food and Nutrition Service, Office of Policy Support. U.S. Centers for Disease Control and Prevention. (2019). Births: Final data for 2005-2017. *National Vital Statistics Reports*, *56*(6); National Center for Health Statistics. U.S. Bureau of Labor Statistics, (2023). *Labor Force Statistics including the National Unemployment Rate. Current Population Survey.* U.S. Bureau of Labor Statistics. Retrieved September 6 from https://www.bls.gov/data/#unemployment; U.S. Census Bureau, (2023c). *Annual Social and Economic Supplement. Current Population Survey Data.* U.S. Census Bureau. Retrieved September 6, 2023 from https://www.census.gov/data/datasets/time-series/demo/cps/cps-asec.html; U.S. Census Bureau, U. S. (2023d). *Food Security Supplement. Current Population Survey.* U.S. Department of Agriculture, Food and Nutrition Services. Retrieved 6, 2023 from https://www.census.gov/programs-surveys/cps/data.html. Centers for Medicare and Medicaid. (2023). Resources for States: State Medicaid and CHIP Profiles. Retrieved March 9, 2023 from https://www.medicaid.gov/resources-for-states/index.html

Table 3.2 State Identification Numbers, Abbreviations, and Names

State ID	Abbreviation	Name
1	AK	Alaska
2	AL	Alabama
3	AR	Arkansas
4	AZ	Arizona
5	CA	California
6	CO	Colorado
7	CT	Connecticut
8	DC	District of Columbia
9	DE	Delaware
10	FL	Florida
11	GA	Georgia
12	HI	Hawaii
13	IA	Iowa
14	ID	Idaho
15	IL	Illinois
16	IN	Indiana
17	KS	Kansas
18	KY	Kentucky
19	LA	Louisiana
20	MA	Massachusetts
21	MD	Maryland
22	ME	Maine
23	MI	Michigan
24	MN	Minnesota
25	MO	Missouri
26	MS	Mississippi

State ID	Abbreviation	Name
27	MT	Montana
28	NC	North Carolina
29	ND	North Dakota
30	NE	Nebraska
31	NH	New Hampshire
32	NJ	New Jersey
33	NM	New Mexico
34	NV	Nevada
35	NY	New York
36	OH	Ohio
37	OK	Oklahoma
38	OR	Oregon
39	PA	Pennsylvania
40	RI	Rhode Island
41	SC	South Carolina
42	SD	South Dakota
43	TN	Tennessee
44	TX	Texas
45	UT	Utah
46	VA	Virginia
47	VT	Vermont
48	WA	Washington
49	WI	Wisconsin
50	WV	West Virginia
51	WY	Wyoming

Table 3.3 State WIC Electronic Benefit Transfer Implementation Status by Year, 2005-2017 (U.S.D.A., 2023b)

Year	**State(s) Implementing EBT**
2005[1] (n=0)	--
2006 (n=0)	--
2007 (n=1)	New Mexico
2008 (n=0)	--
2009 (n=3)	Michigan, Nevada, Texas
2010 (n=0)	--
2011 (n=1)	Kentucky
2012 (n=0)	---
2013 (n=1)	West Virginia
2014 (n=3)	Florida, Massachusetts, Virginia
2015 (n=2)	Ohio, Wisconsin
2016 (n=8)	Colorado, Connecticut, Delaware, Indiana, Iowa, Oklahoma, Oregon, Vermont
2017 (n=3)	Arizona, Maryland, Montana
Did not implement: (n=27) Alabama, Alaska, Arkansas, California, District of Columbia, Georgia, Hawaii, Idaho, Illinois, Kansas, Louisiana, Maine, Minnesota, Mississippi, Missouri, Nebraska, New Hampshire, North Carolina, New Jersey, New York, North Dakota, Pennsylvania, Rhode Island, South Carolina, Tennessee, Utah, Washington	

[1] Wyoming Implemented EBT in 2002

Data Source: U.S. Department of Agriculture. (2023). *WIC EBT Activities*. U.S. Department of Agriculture, Food and Nutrition Services. Retrieved April 3, 2023 from https://www.fns.usda.gov/wic/wic-ebt-activities.

Table 3.4 WIC EBT 2x2 Difference-in Differences Estimators (U.S.D.A., 2023b)

	Group 2											
	Never Implemented	Not-yet implemented WIC EBT						Implemented WIC EBT				
Group 1	(n=27)	2010 (n=17)	2011 (n=17)	2013 (n=16)	2014 (n=13)	2015 (n=11)	2016 (n=3)	2013 (n=1)	2014 (n=3)	2015 (n=2)	2016 (n=8)	2017 (n=3)
2013 (n=1)	1	2	3						4	5	6	7
2014 (n=3)	8	9	10	11						12	13	14
2015 (n=2)	15	16	17	18	19						20	21
2016 (n=8)	22	23	24	25	26	27						28
2017 (n=3)	29	30	31	32	33	34	35					

No WIC EBT implementation in 2012

Data Source: U.S. Department of Agriculture. (2023). *WIC EBT Activities*. U.S. Department of Agriculture, Food and Nutrition Services. Retrieved April 3, 2023 from https://www.fns.usda.gov/wic/wic-ebt-activities.

Table 3.5 State Medicaid Expansion Status by Year, 2014-2017 (C.M.S., 2023)

Year	States
2014 (n=27)	Arizona, Arkansas, California, Colorado, Connecticut, Delaware, District of Columbia, Hawaii, Illinois, Idaho, Kentucky, Maryland, Massachusetts, Michigan, Minnesota, New Hampshire, Nevada, New Jersey, New Mexico, New York, North Dakota, Ohio, Oregon, Rhode Island, Vermont, Washington, West Virginia.
2015 (n=3)	Alaska, Pennsylvania, Indiana
2016 (n=2)	Montana, Louisiana
2017 (n=0)	--
Did not implement: (n=28) Alabama, Florida, Georgia, Idaho, Kansas, Maine, Mississippi, Missouri, Nebraska, North Carolina, Oklahoma, South Carolina, South Dakota, Tennessee, Texas, Virginia, Utah, Wisconsin, Wyoming	

Data Source: Centers for Medicare and Medicaid. (2023). Resources for States: State Medicaid and CHIP Profile. Retrieved March 9, 2023 from https://www.medicaid.gov/resources-for-states/index.html

Table 3.6 State REAL ID Implementation Status by Year, 2012-2017 (D.H.S., 2023)

Year	States
2012 (n=13)	Colorado, Connecticut, Delaware, Georgia, Indiana, Iowa, Maryland, Ohio, South Dakota, Tennessee, West Virginia, Wisconsin, Wyoming
2013 (n=8)	Alabama, Florida, Hawaii, Kansas, Mississippi, Nebraska, Utah, Vermont
2014 (n=2)	District of Columbia, Nevada
2015 (n=0)	---
2016 (n=3)	Arizona, Arkansas, New Mexico
2017 (n=2)	North Carolina, Texas
Did not implement: (n= 23) Alaska, California, Idaho, Illinois, Kentucky, Louisiana, Maine, Massachusetts, Michigan, Minnesota, Missouri, Montana, New Hampshire, New Jersey, New York, North Dakota, Oklahoma, Oregon, Pennsylvania, Rhode Island, South Carolina, Virginia, Washington	

Data Source: U.S. Department of Homeland Security. (2023). REAL ID Act: Federal Enforcement; State Compliance, Extensions and Implementation. Retrieved August 28, 2023 from https://www.dhs.gov/real-id.

Table 3.7 REAL ID 2x 2 Difference-in Differences Estimators (D.H.S., 2023)

		Group 2											
		Never Implemented	Not-yet implemented REAL ID						Implemented REAL ID				
		(n=23)	2010 (n=29)	2011 (n=29)	2012 (n=16)	2013 (n=8)	2014 (n=6)	2016 (n=3)	2012 (n=13)	2013 (n=8)	2014 (n=2)	2016 (n=3)	2017 (n=2)
Group 1	2012 (n=13)	1	2	3						4	5	6	7
	2013 (n=8)	8	9	10	11						12	13	14
	2014 (n=2)	15	16	17	18	19						20	21
	2016 (n=3)	22	23	24	25	26	27						28
	2017 (n=2)	29	30	31	32	33	34	35					

No REAL ID implementation in 2015

Data Source: U.S. Department of Homeland Security. (2023). REAL ID Act: Federal Enforcement; State Compliance, Extensions and Implementation. Retrieved August 28, 2023 from https://www.dhs.gov/real-id.

3.11 Figures

Figure 3.1. Sparsity Requirement for Lasso (StataCorp, 2021b)

$$\frac{s}{\sqrt{N}/\ln p}$$

s: number of covariates in the true model,
N: number of observations in the data,
p: number of potential covariates.

Data Source: StataCorp. (2021). Lasso Reference Manual. In Stata Reference Manual (17 ed.). StataCorp LLC.

Figure 3.2. Null Interrupted Time Series Model (Linden, 2015; Linden & Adams, 2011)

$Y_t = \beta_0 + \beta_1 T_t + \beta_2 X_t + \beta_3 X_t T_t + \varepsilon_t$

Y_t: number of WIC participants at time, t.
T_t: time variable, number of years since the start of the study, years from 2005.
X_t: policy period variable, Indicator variable for pre-policy period (0) or (1) if otherwise
$X_t T_t$: interaction term of time and policy period variables
β_0: the number of WIC participants in 2005
β_1: Change in the number of WIC participants each year in the pre-policy period
β_2: Change in the number of WIC participants that occurs immediately following policy implementation compared with the counterfactual (level change/indicate an immediate treatment effect)
β_3: Difference between pre-policy and post-policy slopes in the number of WIC participants over time (trend change/indicate a treatment effect over time)
ε_t: Error term

Data Sources: Linden, A. (2015). Conducting interrupted time-series analysis for single- and multiple-group comparisons. *The Stata Journal*, 15(2), 480–500. Linden, A., & Adams, J. L. (2011). Applying a propensity score-based weighting model to interrupted time series data: improving causal inference in programme evaluation. *J Eval Clin Pract*, 17(6), 1231-1238. https://doi.org/10.1111/j.1365-2753.2010.01504.x

Figure 3.3 Null Two-way Fixed Effects Difference-in-differences WIC EBT Model (Dettmann et al., 2021; Goodman-Bacon, 2018, 2021; Wing et al., 2018)

$Y_{gt} = a_g + b_t + \delta D_{gt} + \varepsilon_{gt}$

Y: The number of WIC participants in group *g* at time *t*
g: Group
t: Time period
D_{gt}: WIC EBT policy implementation status of group *g* at time *t*
α_g: Group-fixed effect
b_t: Time-fixed effect
δ: Global treatment effect
ε_{gt}: Error term

Data Sources: Dettmann, et al. (2021). flexpaneldid: A Stata toolbox for causal analysis with varying treatment time and duration. https://doi.org/http://dx.doi.org/10.2139/ssrn.3692458. Goodman-Bacon, A. (2018). Difference-in-Differences With Variation in Treatment Timing. Working Paper 25018. *NBER WORKING PAPER SERIES*. http://www.nber.org/papers/w25018. Goodman-Bacon, A. (2021). Difference-in-differences with variation in treatment timing. *Journal of Econometrics*, 225(2), 254-277. https://doi.org/10.1016/j.jeconom.2021.03.014. Wing, et al. (2018). Designing Difference in Difference Studies: Best Practices for Public Health Policy Research. *Annu Rev Public Health*, *39*, 453-469. https://doi.org/10.1146/annurev-publhealth- U.S. Department of Agriculture. (2023). *WIC EBT Activities*. U.S. Department of Agriculture, Food and Nutrition Services. Retrieved April 3, 2023 from https://www.fns.usda.gov/wic/wic-ebt-activities.

Figure 3.4 Null Two-way Fixed Effects Difference-in-differences REAL ID Model (Dettmann et al., 2021; Goodman-Bacon, 2018, 2021; Wing et al., 2018)

$Y_{gt} = a_g + b_t + \delta D_{gt} + \varepsilon_{gt}$

Y: The number of WIC participants in group *g* at time *t*
g: Group
t: Time period
$D_{gt:}$ REAL ID policy implementation status of group *g* at time *t*
$\alpha_{g:}$ Group-fixed effect
$b_{t\,:}$ Time-fixed effect
δ: Global treatment effect
$\varepsilon_{gt:}$ Error term

Data Sources: Dettmann, et al. (2021). flexpaneldid: A Stata toolbox for causal analysis with varying treatment time and duration. https://doi.org/http://dx.doi.org/10.2139/ssrn.3692458. Goodman-Bacon, A. (2018). Difference-in-Differences With Variation in Treatment Timing. Working Paper 25018. *NBER WORKING PAPER SERIES*. http://www.nber.org/papers/w25018. Goodman-Bacon, A. (2021). Difference-in-differences with variation in treatment timing. *Journal of Econometrics*, 225(2), 254-277. https://doi.org/10.1016/j.jeconom.2021.03.014. Wing, et al. (2018). Designing Difference in Difference Studies: Best Practices for Public Health Policy Research. *Annu Rev Public Health*, *39*, 453-469. https://doi.org/10.1146/annurev-publhealth- U.S. Department of Homeland Security. (2023). REAL ID Act: Federal Enforcement; State Compliance, Extensions and Implementation. Retrieved August 28, 2023 from https://www.dhs.gov/real-id.

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Chapter 4. Study Results

4.1 Overview

In this chapter, the results of population trend analyses and aim-specific results are presented. All sections start with a statement of the study aim, and a description of the demographic, economic, and other population characteristics of the study sample. Next, the results from in time-series regressions, autocorrelation tests, and sensitivity and additional analyses are reported and constitute the rest of each aim-specific section.

4.2 Aim 1 Results

Aim 1: Examine whether state implementation of the 2009 WIC Food Package Change was associated with changes in state WIC participation.

The results of Aim 1 analysis are presented in this section. First, state-level demographic, economic, and other population characteristics in 2005 (e.g., baseline, the first year of the study period) are described and compared and highlight the pre-existing differences among states. Next, the univariate interrupted time series (ITS) and post-estimation autocorrelation tests are reported by the type of ITS model, null followed by extended. The results of additional analyses, such as sensitivity and robustness tests, are reviewed at the end of the section.

In 2005, the beginning of the Aim 1 study period, the annual average number of WIC participants was 153,084 and the median was 108,816 individuals per state (Johnson et al., 2017). High populous states such as California, New York, and Texas contributed to a right skewed distribution of WIC participation, but most states had participation numbers concentrated close to the median (Johnson et al., 2017). In absolute numbers, California had the highest number of WIC participants at 1,320,859, and Wyoming had the least at 12,777 participants (Johnson et al., 2017).

State demographic characteristics were heterogenous in 2005. (Table 4.1). Utah had the highest birth rate with 21.0 births per 1,000 population, and Vermont had the lowest at 10.1 births per 1,000 population (Martin et al., 2007). Approximately 97% of the Vermont population identified as white, the highest among all states (U.S. Census Bureau, 2023a, 2023b). Similarly, the population of West Virginia was predominantly white, (94.9%), and one of the least racially and ethnically diverse states (U.S. Census Bureau, 2023a). West Virginia had the lowest percent of foreign-born (1.2%), percent identifying as a race other than black or white (2.1%), and the smallest percent of Hispanics at less than a half percent (U.S. Census Bureau, 2023a, 2023b). On the other end of the spectrum, California had the highest percent foreign born at 27.3%, and New Mexico the highest percent of Hispanics at 43.9% (U.S. Census Bureau, 2023a, 2023b). The Hawaiian population was also diverse, with the lowest percent of its population reporting as white, and the highest percent identifying as other race at 73.7% (U.S. Census Bureau, 2023a). The District of Columbia had the highest percentage of its population identifying as black (57.5%), and Montana had the lowest at approximately 0.2% of its population (U.S. Census Bureau, 2023a).

Two economic characteristics explored in this study– poverty and unemployment—differed substantially among states in 2005 (U.S. Bureau of Labor Statistics, 2023; U.S. Census Bureau, 2023c). New Hampshire had the lowest poverty rate with 7.5% of individuals living below 100% of the FPL, whereas in Missouri, 21.3% were living in poverty (U.S. Census Bureau, 2023c). Mississippi experienced a 7.5% unemployment rate in 2005, and represented the highest level of unemployment in the U.S. By contrast, Hawaii had the lowest unemployment rate of 2.9% (U.S. Bureau of Labor Statistics, 2023).

Analogous to demographic and economic measures, two other population characteristics, the number of WIC-eligible individuals and the prevalence of food insecurity, varied among states (Johnson et al., 2017; U.S. Census Bureau, 2023d). Similar to the number of WIC participants, Wyoming and California also represented the two extremes (minimum and maximum) in the number of WIC-eligible individuals. Wyoming had the smallest number of WIC eligible individuals and California had the highest (Johnson et al., 2017). The prevalence of food insecurity ranged from 6.4% of households in North Dakota to 16.8% of households in New Mexico (U.S. Census Bureau, 2023d).

Fifty-one null ITS models were estimated, one for each state and DC (null refers to the null model for ITS, not the null for autocorrelation tests). The null ITS model included a term for time in years (β_1), a term for policy period ($\beta_{2,}$ 0 if pre-2009 food package changes or 1 if otherwise), and an interaction term for time and policy period, (β_3). (Figure 4.1). The first estimation of the 51 null ITS models was conducted under the assumption that no autocorrelation was present (the null hypothesis of the autocorrelation test applied, Cumby-Huizinga) (Baum & Schaffer, 2015; Cumby & Huizinga, 1992). The Cumby-Huizinga autocorrelation tests revealed that 16 of the 51 states' null ITS models had significant lags ($p < 0.05$) indicating the presence of autocorrelation (Baum & Schaffer, 2015). (Table 4.2). The null ITS models were recalculated only for the 16 states with significant autocorrelative lags, and the Newey-West method was applied to adjust the standard errors to correct for the degree of autocorrelation (number of lags) (Linden, 2015; Linden & Adams, 2011).

The final null ITS models by state are displayed in Table 4.3. Each row represents a state (and DC) (n=51), and each column corresponds to an ITS regression term. Within each cell is the state-specific regression coefficient and associated p-value for the column term. There is a column for the constant (β_0), and for each model coefficient: year (β_1), policy period (β_2), and interaction of year and policy period (β_3). The post-policy trend is displayed in the last column.

The first column in Table 4.3 contains the number of WIC participants by state in 2005 (constant, β_0). All 51 states had positive and significant values, as expected. All state agencies had WIC participants in 2005, and the number of WIC participants in each state in 2005 was a known quantity.

The average change in the number of WIC participants each year throughout the entire study period (2005-2013) was significant in 75% of states' (39/51) null ITS models (β_1). Four states had negative coefficients for year, indicative of a decline in the average number of WIC participants every year in the study period, however, no coefficients were significant. The majority of states had an average increase in the number of WIC participants each year (i.e., a positive β_1), and among those, 39 of the 47 states (83%) had statistical significance ($p < 0.05$).

The immediate change in the number of WIC participants observed in the year after the 2009 WIC Food Package Changes, referred to as a level change, was significantly different than expected based on pre-policy participation trends in the null ITS models of 7 states (denoted by β_2, the coefficient for policy period). (Table 4.4). Two of the ten states whose models displayed negative level trends, or in other words the immediate change in the number of WIC participants post-policy was less than predicted by pre-policy trends, were significant: Minnesota ($p < 0.001$) and Rhode Island ($p = 0.04$). A positive level change was observed in the null ITS models of the remaining 41 states, but only five states displayed significant coefficients ($p < 0.05$). The observed number of WIC participants in the year after the policy was implemented was significantly higher than predicted in the null ITS models for Kansas ($p < 0.01$), Michigan ($p = 0.01$), Oklahoma ($p = 0.02$), Texas ($p = 0.02$), and Utah ($p = 0.03$).

The trend change, the difference between the slope of WIC participation over time in the post-policy period estimated based on pre-policy trends and the actual slope of the number of WIC participants observed in the time period after the 2009 WIC Food Package Changes (referred to as a trend change), was less than predicted in the null ITS models of 50 states, and more than predicted in the model of 1 state. Among the 50 states with negative trend changes, 42 state null ITS models (84%) demonstrated significant trends ($p < 0.05$). (Table 4.4). Montana was the only state model that exhibited a positive trend change but was not significant ($p > 0.05$) (Linden, 2015; Linden & Adams, 2011).

The null ITS models of states with different combinations of significant ITS regression terms, are illustrated in Figures 4.2-4.5. Each figure is a graph of the number of WIC participants each year from 2005-2013, includes at red solid vertical line at 2009 (the interruption), and after 2009 a blue dashed line to show the counterfactual trendline. The actual number of WIC participants are marked with black circles, and the predicted (or expected) number of participants are represented with a solid black line. Blue arrows and text are used to label the direction and type of change. The figure number, state, and significant ITS regression term are as follows: Figure 4.2 - Utah (positive level change); Figure 4.3 - West Virginia (negative trend change); Figure 4.4 - Minnesota (negative level and negative trend change); and Figure 4.5 - Michigan (positive level change and negative trend change).

The extended ITS models ($n = 51$) included the same four regression terms in the null ITS models (constant, time, policy-period, and interaction of time and policy period), and two additional terms for covariates. Lasso selected the most predictive combination of covariates among the potential variables (i.e. knot), the number of WIC-eligible individuals (β_4), and percent foreign born (β_5), which were incorporated into the ITS models (Chen & Chen, 2008). (Table A.4). The Cumby-Huizinga general test for autocorrelation revealed significant lags in 43 of the 51 states (84%). (Table A.4). The standard errors were adjusted by the Newey-West method in the extended models of states with significant levels of autocorrelation (Linden, 2015, 2021). The extended ITS models for each state are displayed in Table 4.6. Each row represents a state, and each column represents a regression term in the extended ITS model: a term for the number of WIC participants in 2005 (β_0), time in years (β_1), policy period (β_2), interaction of time and policy period (β_3), the number of WIC eligible individuals (β_4), the percent foreign born (β_5), and the post-trend. Within each cell is the state-specific regression coefficient and associated p-value for the column term.

Approximately half of state extended ITS models had significant and positive constants and coefficients for time. Only two states exhibited negative intercepts, Colorado, and Hawaii, though both were not significant (each $p>0.55$). The number of WIC participants in 2005 was positive in the extended ITS models of 49 states, lending for a more intuitive interpretation with almost half (24 states) producing significant p-values ($p<0.05$). The average increase in the number of WIC participants over time was positive in the models of 46 states, and 30 had significant values (65.2% $p<0.05$), indicating an overall increase in the number of WIC participants each year. Only five states displayed a negative coefficient for year in their respective extended ITS models, but none were significant.

The proportion of significant level and/or trend changes in the extended ITS models were similar to what was observed in the null ITS models. (Table 4.7). The models of 13 states demonstrated negative level changes, and 38 displayed positive trend changes, once adjusted for the number of WIC-eligible individuals and percent foreign born. Only two of the thirteen states with negative level changes were significant, Minnesota (p=0.03) and Mississippi (p=0.03). Over 18% of states with positive level changes (7/38) had significant values: Colorado (p=0.02); District of Columbia (p<0.05), Maine (p<0.01), Michigan (p=0.01), Oklahoma (p=0.04); West Virginia (p=0.04), Wyoming (p=0.02). The change in the number of WIC participants expected based on pre-food package change trends, compared to what was observed in the years following implementation was less than predicted in 50 states, and more than predicted in 1 state. Significant values were observed only in 38 of the 50 state ITS models with negative trend changes.

Adjustment for the number of WIC-eligible individuals and percent foreign-born in extended ITS models revealed that at least one of the two variables was a significant confounder of the association between the food package changes and WIC participation in 14 states. The association between the number of WIC eligible individuals and the number of WIC participants was negative in 19 states, and positive in 32. Three of the nineteen states with negative coefficients for the number of WIC eligible individuals were significant; Maine (p=0.02), Michigan (p<0.05), and Rhode Island (p=0.03). The extended ITS models for Ohio (p<0.01) and Hawaii (p=0.03), displayed significant positive coefficients for the number of WIC eligible individuals. The change in the percent of the state population born outside the U.S. and the number of WIC participants displayed a negative association (i.e., negative coefficient) in 32 state models, 3 of which were significant: New Mexico (p=0.02), Ohio (p=0.03), and Wyoming (p=0.03). The District of Columbia (p<0.01), Delaware (p=0.04), Hawaii (p<0.01), Montana (p<

0.01), Nebraska (p=0.04), and West Virginia (p=0.03) displayed significant positive coefficients for percent foreign born in their respective extended ITS models.

The extended ITS models of states with different combinations of significant ITS regression terms, are illustrated in Figures 4.6-4.9. Each figure is a graph of the number of WIC participants each year from 2005-2013, and includes a red solid vertical line at 2009. The actual number of WIC participants are marked with black circles, and the predicted (or expected) number of participants are represented with a solid black line. [Figures 4.6-Michigan (positive level change), 4.7 Minnesota (negative level change and negative trend change), 4.8 Ohio (negative trend change), and 4.9 Maine (positive level change and negative trend change).]

Additional analyses were performed to evaluate the sensitivity and the robustness of the results. To evaluate if the Newey-West standard error autocorrelation adjustments were appropriate, an alternative univariate ITS method, Prais-Winsten, was explored. The Prais-Winsten method is appropriate for first-order autocorrelation (i.e. one lag) but autocorrelation tests revealed a range of lags (0-7) (Linden, 2015). Newey-West method was determined to be a better fit due to its flexibility in the level of autocorrelative adjustment. Hausman specification tests established that fixed effects rather than random effects, were more appropriate for the ITS models so fixed-effects models were used ($p < 0.0001$). (Table A.5).

4.3 Aim 2 Results

Aim 2: Examine whether state implementation of the WIC electronic benefit transfer (EBT) system was associated with changes in state WIC participation.

The results of Aim 2 analysis are presented in this section. First, the rationale and criteria used to determine the states in the final study sample are described. A comparison of 2010 (baseline first year of the study period) demographic, economic, and other population characteristics of the study sample are summarized next. The models created by difference-in-differences (DID) estimation, and supplementary analysis comprise the last two parts of the section.

The final study sample for Aim 2 was comprised of 45 states' annual measures for the 2010-2017 study period (n=360). It is recommended in DID estimation to have a minimum of two pre-intervention measures, so six states were excluded due to early EBT implementation; Wyoming (2002), New Mexico (2007), Michigan (2009), Texas (2009), Nevada (2009), and Kentucky (2011) (U.S.D.A., 2023b). The high volume of WIC participants in the states of California, Florida, and New York met outlier criteria (Gray et al., 2019; Johnson et al., 2017; Keselman & Rogan, 1977). However, since the pre-implementation differences between the control (never-implemented WIC EBT) and intervention (not-yet implemented WIC EBT) groups produced the same results with or without outliers, the three states were included in the final study sample.

The number of WIC participants, the number of WIC-eligible individuals, and the percent of eligible individuals that participated in WIC in 2010 varied substantially (Johnson et al., 2017). (Table 4.8). Among states in the final study sample, California had the largest number of WIC participants, WIC-eligible individuals, and the highest percent of eligible individuals participating in WIC (78%) (Johnson et al., 2017). North Dakota had the smallest number of WIC participants, D.C. had the lowest number of WIC-eligible individuals, and WIC-eligible individuals in Utah were the least likely to participate (45.4%) (Johnson et al., 2017).

California, North Dakota, D.C., and Utah also represented the extremes of several other demographic, economic, and other population statistics. In California, 38% of population identified as Hispanic, and 27.2% reported foreign nativity, the maximum values observed among states in the sample (U.S. Census Bureau, 2023a, 2023b). California also had the highest unemployment rate in 2010 at 12% (U.S. Bureau of Labor Statistics, 2023) . North Dakota had both the lowest unemployment rate (3.8%) and level of household food insecurity (7.1%) (U.S. Bureau of Labor Statistics, 2023; U.S. Census Bureau, 2023d). D.C was home to the highest percent of black residents (51.2%) (U.S. Census Bureau, 2023a). The highest birth rate was observed in Utah 18.9 births per 1,000 population (Martin et al., 2012).

The lowest values of several state-level characteristics in 2010 were predominantly observed in states located on the eastern side of the United States. West Virginia had the lowest proportion of foreign born (1.2%), and shared the lowest percent Hispanic population among states with New Hampshire (1.2%) (U.S. Census Bureau, 2023a, 2023b). New Hampshire had the smallest percent of people living in poverty (8.3%), and shared the lowest birth rate in the U.S. (9.8 births per 1,000 population) with Maine (Martin et al., 2012; U.S. Census Bureau, 2023c). Vermont had the highest proportion of white individuals among all states at 95.4%, in stark contrast to Hawaii's 24.6% (U.S. Census Bureau, 2023a). Mississippi experienced the highest prevalence of poverty (19.4%) and food insecurity (22.4%) in 2010 (U.S. Census Bureau, 2023c, 2023d).

The 2010 state-level outcome measures, demographic, economic, and other population characteristics were aggregated by WIC EBT Group, the never-implemented WIC EBT group (n=27), and not-yet-implemented WIC EBT group (n=18), in order to evaluate if the dataset met DID parallel trends assumptions. Baseline differences in the group characteristics of the never-implemented WIC EBT group and not-yet-implemented WIC EBT were not significant. (Table 4.9). Prior to WIC EBT implementation by any state in the study sample, the trends in the number of WIC participants over time per group were approximately parallel (2010-2012). (Figure 4.10).

The null DID model was calculated under the assumption that data met parallel trends, or in other words, baseline differences between groups did not vary over time, and both groups were exposed to the same time-specific events. (Figure 4.11). The null model was then used to estimate average treatment effects (ATT) of state WIC EBT implementation on state WIC participation. Four types of DID estimators were used to predict the ATT, a global treatment effect (overall weighted average), group specific (grouped by the WIC EBT Time variable), calendar year, and event-study post-trend (Callaway & Sant'Anna, 2021; Goodman-Bacon, 2021). (Table 4.10).

All four DID estimator types revealed positive ATTs, though none were significant, suggesting a possible increase in the number of WIC participants in the not-yet implemented WIC EBT states, compared to never-implemented states. (Table 4.10). EBT implementation was associated with a non-significant increase in 8,447 WIC participants in the post-implementation period (p=0.19). The group-specific ATT of 7,856 participants (p= 0.16), and ATT by calendar period of 6,787 participants (p=0.18) displayed smaller effects of WIC EBT on WIC participation compared to the global treatment effect estimate. In the event-study ATT calculations, the post-trend ATT was 13,643 WIC participants (p=0.15). This finding suggested an increase in the treatment effect of WIC EBT as length of exposure increased but was not significant at p<0.05 and therefore, not considered to indicate evidence of heterogenous intervention effects. Event-study pre-trends revealed that WIC participation did not change in anticipation of WIC EBT implementation, referred to as intervention anticipatory behavior, because the average pre-event ATT of 1,226 participants and was not statistically significant (p=0.36).

Group-specific ATTs were calculated for each of the 5 WIC EBT Time implementation groups (indexed by year of WIC EBT implementation; 2013, 2014, 2015, 2016, 2017). (Figure A.2). Only the group specific ATT for 2013 was significant ($p<0.05$). Figures 4.12-4.16 illustrate the ATT in number of WIC participants by time-period until WIC EBT implementation (1 time-period = 1 year), one figure for each WIC EBT Time implementation group. In all five figures, a solid circle demarcates the estimated average treatment effect in number of WIC participants for each time period until WIC EBT implementation (in years), with a time period of zero equivalent to the year of WIC EBT implementation. Shaded bars encapsulate the ATTs to show the respective 95% confidence intervals, and the fill color of the confidence interval bars indicate the policy period: blue for pre-policy ATTs, and pink for post-policy. Figure 4.12 displays the ATT in number of WIC participants by time-period until WIC EBT implementation for the states that implemented WIC EBT in 2013. Figure 4.13 displays the ATT in number of WIC participants by time-period until WIC EBT implementation for the states that implemented WIC EBT in 2014. The same sequence continues for Figures 4.14-4.16, for WIC EBT Groups 2015-2017, respectively. In the observation of Figures 4.12-4.16, a pattern emerged in the ATTs of each WIC EBT implementation group over time. In the pre-policy time periods, the ATTs centered close to zero and exhibited smaller confidence intervals compared to post-implementation measures. Even though confidence intervals were relatively smaller in pre-policy period, the width of the interval increased as time until WIC EBT implementation approached and expanded more dramatically after implementation. The width of the pre-policy ATT confidence intervals--

relative to the post-policy period-- became less pronounced the later WIC EBT was implemented.

In Figure 4.17, the WIC EBT Event Study for all time implementation groups combined, the ATTs are aggregated by time period until year of WIC EBT implementation, regardless of WIC EBT Time, so the sample size varies by time period. The overall trend in ATTs observed in Figure 4.17 was consistent with the results observed in the series of WIC EBT time figures. The pre-WIC EBT implementation ATTs in the WIC EBT Event Study figure hovered around zero and had relatively small confidence intervals but were not significant. After EBT implementation the ATTs on the event study graph grew larger, and 95% confidence intervals widened.

The 2013 WIC EBT time group displayed significant ATTs when estimated by WIC EBT implementation group, calendar period, and time exposed to WIC EBT. In ATT by group, the 2013 WIC EBT time group had a significant ATT of 16,364 WIC participants, ($p<0.05$). Only one state, West Virginia, implemented WIC EBT in 2013, and when compared to the control states in 2013, the average treatment effect was 5,391 WIC participants ($p=0.01$). Only states exposed to WIC EBT for 4 time periods post implementation had significant average treatment effects ($p<0.05$), which again was West Virginia, the only state in the 2013 WIC EBT Time group.

The extended DID model was estimated based on a conditional approach to the parallel trends assumption, which allows for cofounders to be added to the model to account for differences between the group characteristics of the never implemented and not-yet implemented groups that vary over time. Therefore, only states with similar characteristics will follow the same trend in WIC participation. The significant confounder identified by lasso estimation to include in the extended model was the number of WIC-eligible individuals. (Table A.6). The same four DID estimator types employed in the null DID model to estimate ATTs were used in extended model ATT calculations, and just as observed in the null DID results, all four ATTs were positive in the extended model though none were significant. (Table A.6). The global treatment effect was 6,973 WIC participants (p = 0.32), the ATT by WIC EBT Time group was 4,358 WIC participants (p= 0.26), and the ATT by calendar period was 54,363 WIC participants (p=0.36). The event-study post-trend (length of exposure to EBT) was 7,557 participants (p=0.43). After adjustment for the number of WIC-eligible individuals, the WIC EBT not-yet implementation group compared to the never-implemented EBT group, experienced an increase in the number of WIC participants in the years following WIC EBT implementation though not significant. Overall, in the extended model the ATT p-values were larger compared to that of the ATTs calculated from the null DID model. (Figure A.3).

Among the ATTs calculated separately for each of the 5 WIC EBT time groups, only the 2013 WIC EBT time group ATT was significant (p<0.05). In contrast to the null model ATT, the extended model ATT for the 2013 EBT group time was negative, - 8, 575 WIC participants (p=0.001). This indicated that WIC EBT implementation was associated with a decrease in WIC participation, after adjustment for the number of WIC eligible individuals. By calendar year, the ATT for 2013 was also negative (1,009 fewer participants), but not significant (p=0.25). The event study post-trend ATT was significant at four years post-implementation, with 15,658 fewer WIC participants (p<0.001).

Additional DID analyses were performed with a novel, more robust DID estimation technique than two-way fixed effects methods, entitled “improved doubly robust DID Estimator based on inverse probability of tilting and weighted least squares” (Callaway & Sant'Anna, 2018;

Callaway & Sant’Anna, 2021). (Figure A.4). The method created by Callaway and Sant'Anna in 2021 was specifically designed for DID analysis of time-series panel data with multiple intervention periods. The robust technique produced larger average treatment effects with three of the four DID estimator types, with the exception being the calendar period ATT. (Table 4.11). The p-values of the ATTs did decrease for all four DID estimator types, including calendar period, but the interpretation of the results did not change. Hausman specification tests confirmed that a fixed-effects model was a better fit than a random-effects model, so a fixed-effect model was used ($p<0.001$). (Table A.7).

4.4 Aim 3 Results

Aim 3: Examine whether state implementation of the REAL ID act was associated with changes in state WIC participation.

The Aim 3 results section consists of three main parts. The first part focuses on the determination of the final sample, and the characteristics of the states in the two REAL ID implementation groups. The average treatments effects estimated by DID models are presented in the second part. The section concludes with a review of additional analyses.

The Aim 3 final study sample was comprised of 51 states annual measures from 2010-2017 (n=408). Four states -- California, Florida, New York, and Texas—were identified as outliers due the high numbers of WIC participants compared to other states (Johnson et al., 2017). The baseline difference in the number of WIC participants of the never-implemented REAL ID group and the not-yet implemented REAL ID group were not significantly different, even with the inclusion of outliers, so all states were included in analysis. (Table 4.12). Additionally, as displayed in Figure 4.18, the trend in the number of WIC participants each year of the two REAL ID groups was approximately parallel in the two years prior to any state implementing REAL ID. The baseline characteristics of the not-yet implemented REAL ID group (n=29) and never-implemented REAL ID group (n=22) were not significantly different at p<0.05. (Table 4.12).

The demographic, economic, and other populations characteristics of states in 2010 were previously described in the Aim 2 results section and are summarized in Table 4.8. A few shifts in state rankings occurred, notably in the state with the smallest number of WIC participants, highest percent Hispanic population, and highest unemployment rate because the six states excluded in Aim 2 were included in the study sample for Aim 3. Wyoming, not North Dakota, had the smallest number of WIC-participants (Johnson et al., 2017). In the Aim 3 sample, California was no longer the state with the highest percent Hispanic population (38%), or highest unemployment rate (12%). New Mexico had the highest percent Hispanic population at 46%, and Nevada had the highest unemployment rate, at 13.5% in 2010 (U.S. Bureau of Labor Statistics, 2023; U.S. Census Bureau, 2023a).

The null DID model calculated the average treatment effects of state REAL ID implementation on state WIC participation under the assumption of unconditional parallel trends. (Figure 4.19). All ATTs estimated by the null DID model were positive, indicating REAL ID implementation may be associated with an increase in WIC participation in the post-policy period, but none were significant. The p-values associated with the estimated ATTs were greater than 0.36, whether aggregated globally, by group, by calendar period, or length of exposure to REAL ID. (Table 4.13). The global treatment effect was 8,020 WIC participants (p = 0.37), the group-specific ATT was 7,000 WIC participants (p =0.41), the calendar period ATT was 6,713 WIC participants (p=0.39), and ATT by length of exposure (i.e., event study post-trend) was

8,849 participants (p=0.39). (Figure A.5). The event-study pre-trend ATT was -5,981 (p=0.12), which suggested that WIC participation declined in anticipation of REAL ID implementation but like the other ATTs, was also not significant.

The five REAL ID Time group's ATTs over time are illustrated in Figures 4.20-4.24. Each figure displays the ATTs measured in the number of WIC participants by time-period until REAL ID implementation (1 time-period = 1 year). Figures 4.20-4.24 are similar to the WIC EBT Time figures 4.12-4.16, a solid circle is used to mark the ATT in number of WIC participants for each time period until REAL ID implementation (in years), and blue and pink histogram bars illustrate the 95% confidence intervals for each ATT. Figure 4.20 displays the ATT in number of WIC participants by time-period until REAL ID implementation for the states that implemented REAL ID in 2012. Figure 4.21-4.24 illustrate the same for the REAL ID Time Groups 2014-2017. The graphs of ATTs over time period until REAL ID implementation exhibited increasing variability the later in the study period REAL ID was implemented.

The ATTs estimated in the extended DID model were based on a conditional approach to parallel trends, in that only states with similar covariate values would follow the same trends in WIC participation. In this analysis, percent foreign born and the number of WIC-eligible individuals were identified by lasso. (Table A.8). The estimated global treatment effect, group-specific ATT, calendar year, or length of exposure to REAL ID were all positive but small and had p-values above 0.60, a strong indication the results were more likely to have occurred by chance than due to REAL ID exposure. (Table 4.14). The non-significant global treatment effect was 924 WIC participants (p=0.80). The estimated average treatment effects, also not significant, ranged from 576 WIC participants if calculated by calendar year (p=0.85), to 1,700 (p=0.62) by group. (Figure A.6).

No significant trends emerged with additional analyses. A robust estimator was used to calculate ATTs aggregated by year of implementation (i.e. REAL ID Time), calendar time, and length of exposure, but did not alter results. (Table 4.14; Table A.7). Hausman specification tests rejected that a random effects model adequately described the association between the number of WIC participants and REAL ID implementation, so a fixed-effect model was used. (Table A.9). Event studies of both the null and extended DID models did not reveal any significant anticipation effects, or clear heterogeneity in average treatment effects over time. (Figure 4.25).

4.5 Tables

Table 4.1 Demographic, Economic, and Other Population Characteristics by State, 2005

State	Birth Rate (number of births per 1,000 population)	Foreign Born (%)	White (%)	Hispanic (%)	Food Insecurity (%)	Unemployment (%)	Poverty (%)	WIC Eligible Individuals
Alabama	13.2	2.7	70.5	2.2	12.3	4.5	17.0	233,960
Alaska	15.7	5.4	69.0	4.4	12.2	6.9	11.2	39,940
Arizona	16.5	14.7	76.4	28.9	12.2	4.7	14.2	360,413
Arkansas	14.1	3.9	78.7	4.8	14.7	5.2	17.2	176,458
California	15.3	27.3	60.8	35.5	11.7	5.4	13.3	1,906,011
Colorado	14.9	10.1	83.2	19.7	12.0	5.0	11.1	209,898
Connecticut	11.9	12.3	81.4	11.1	8.2	4.9	8.3	100,053
Delaware	13.8	7.3	73.7	6.1	6.6	4.1	10.4	35,959
District of Columbia	14.1	12.9	31.9	8.6	11.4	6.4	19.0	22,707
Florida	12.7	18.6	76.7	19.8	9.4	3.7	12.8	778,841
Georgia	15.9	9.0	62.6	7.1	12.4	5.3	14.4	491,190
Hawaii	13.9	17.5	24.6	8.2	7.8	2.9	9.8	49,857
Idaho	16.2	6.0	91.2	9.6	14.1	4.0	13.9	92,914
Illinois	14.2	13.7	72.2	14.5	9.1	5.7	12.0	540,394
Indiana	13.9	3.9	86.4	4.5	14.1	5.5	12.2	289,788
Iowa	13.3	3.5	94.1	3.6	10.9	4.3	10.9	124,990
Kansas	14.5	5.5	85.2	8.2	12.3	5.0	11.7	133,336
Kentucky	13.5	2.5	85.2	1.6	12.3	5.9	16.8	206,982
Louisiana	13.3	2.8	63.4	2.9	12.8	7.2	19.8	268,681
Maine	10.7	3.0	96.5	1.0	12.3	4.9	12.6	48,308
Maryland	13.4	11.8	61.2	5.7	9.4	4.1	8.2	182,692
Massachusetts	12.0	14.6	83.5	7.9	7.8	4.8	10.3	174,390
Michigan	12.7	6.2	79.8	3.8	11.5	6.8	13.2	398,167
Minnesota	13.9	6.6	87.9	3.7	7.7	4.1	9.2	179,685
Mississippi	14.6	1.6	60.6	1.7	16.5	7.5	21.3	184,990
Missouri	13.6	3.6	84.7	2.8	11.7	5.4	13.3	267,037
Montana	12.3	2.3	90.9	2.5	11.2	4.4	14.4	41,076
Nebraska	14.8	5.5	88.9	7.3	10.3	3.8	10.9	79,571
Nevada	15.3	17.3	76.0	23.5	8.4	4.1	11.1	113,144
New Hampshire	11.1	5.9	94.9	1.9	6.5	3.6	7.5	37,546
New Jersey	13.2	19.4	69.9	15.4	8.1	4.5	8.7	271,382
New Mexico	14.9	8.8	69.0	43.9	16.8	5.1	18.5	136,494
New York	12.9	21.2	67.2	16.2	10.4	5.0	13.8	761,839
North Carolina	14.1	6.7	71.3	6.5	13.2	5.2	15.1	442,476
North Dakota	13.0	2.3	90.6	1.8	6.4	3.4	11.2	22,783
Ohio	12.9	3.5	84.2	2.3	12.6	5.9	13.0	490,580
Oklahoma	14.6	4.5	75.7	6.4	14.6	4.5	16.5	216,019
Oregon	12.7	9.7	86.8	10.1	11.9	6.2	14.1	164,674
Pennsylvania	11.7	5.2	84.7	4.1	9.8	5.0	11.9	442,189
Rhode Island	11.9	12.4	83.3	11.0	12.4	5.0	12.3	36,459
South Carolina	13.5	4.2	67.3	3.3	15.5	6.7	15.6	207,322
South Dakota	14.8	2.6	88.3	1.6	9.5	3.8	13.6	43,275
Tennessee	13.6	3.7	79.6	3.0	13.0	5.6	15.5	291,992
Texas	16.9	16.0	71.8	35.4	16.0	5.4	17.6	1,555,753
Utah	21.0	7.8	89.8	10.8	14.5	4.1	10.2	155,723
Vermont	10.1	3.4	96.8	0.7	9.5	3.5	11.5	25,375
Virginia	13.8	9.9	71.9	6.0	8.4	3.6	10.0	264,468
Washington	13.2	12.3	81.0	8.9	9.5	5.6	11.9	283,740
West Virginia	11.5	1.2	94.9	0.6	8.9	5.1	18.0	86,067
Wisconsin	12.8	4.1	88.3	4.3	9.5	4.7	10.2	207,296
Wyoming	14.1	2.3	91.7	7.4	11.1	3.6	9.5	23,842
Total	14.0	12.6	74.3	14.4	11.0	5.1	13.3	14,220,718

Data Sources: Martin, J. A., Hamilton, B. E., Sutton, P. D., Ventura, S. J., Menacker, F., Kirmeyer, S., & Munson, M. L. (2007). Centers for Disease Control and Prevention, National Center for Health Statistics, National Vital Statistics System. Births: Final

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Table 4.2 Autocorrelation Tests Results for each State by Number of Significant Lags, Null Interrupted Time Series Model (Baum & Schaffer, 2015; Linden, 2015)

Number of Significant Lags (number of states)	**States**
0 (n=35)	AK, AL, AZ, D.C., DE, FL, GA, HI, IA, ID, IL, IN, LA, MD, ME, MI, MO, MT, NC, ND, NE, NH, NJ, NV, OH, OR, RI, SC, TX, UT, VA, WA, WI, WV, WY
1 (n=4)	AR, CO, OK, PA
2 (n=7)	CT, MA, MS, NM, NY, TN, VT
3 (n=0)	0
4 (n=0)	0
5 (n=0)	0
6 (n=3)	KS, KY, MN
7 (n=2)	CA, SD

Data Source : Johnson, et al. (2017). *National- and State-Level Estimates of Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) Eligibles and Program Reach in 2014, and Updated Estimates for 2005–2013.* U.S. Department of Agriculture, Food and Nutrition Service, Office of Policy Support. Linden, A. (2015). Conducting interrupted time-series analysis for single- and multiple-group comparisons. *The Stata Journal*, 15(2), 480–500. Baum, C., & Schaffer, M. (2015). *ACTEST: Stata module to perform Cumby-Huizinga general test for autocorrelation in time series*. In https://EconPapers.repec.org/RePEc:boc:bocode:s457668

Table 4.3 Null Interrupted Time Series Model Coefficients by State, 2005-2013
* Statistically significant, p <0.05

State	Constant β_0	Year β_1	Policy Period β_2	Interaction β_3	Post-trend $\beta_1 + \beta_3$
Alaska	26,037.2 (< 0.001)*	-349.8 (0.11)	2,700.2 (0.05)	-714.2 (0.16)	-1,064 (0.04)*
Alabama	117,999.6 (< 0.001)*	5,814.6 (< 0.01)*	3,479.8 (0.34)	-7,360 (0.02)*	-1,546 (0.18)
Arkansas	86,999.2 (< 0.001)*	668.7 (0.51)	7,923.6 (0.09)	-2,711.4 (0.04)*	-2,042.7 (0.03)*
Arizona	174,234.5 (< 0.001)*	8,189.5 (< 0.01)*	4,701.1 (0.26)	-15,838.5 (0.00)*	-7,649 (< 0.001)*
California	1,320,885 (< 0.001)*	33,055.1 (< 0.001)*	9667.9 (0.44)	-39,337.2 (< 0.01)*	-6282.1 (0.31)
Colorado	82,796.8 (< 0.001)*	5,659.8 (< 0.001)*	5,467.4 (0.10)	-9,215.6 (< 0.001)*	-3,555.8 (< 0.01)*
Connecticut	50,726 (< 0.001)*	1,926.5 (< 0.01)*	1,141.6 (0.32)	-3,333(< 0.01)*	-1,406.5 (< 0.01)*
District of Columbia	15,305.7 (< 0.001)*	315.2 (0.41)	833.5 (0.40)	-764.6 (0.08)	-449.4 (< 0.001)*
Delaware	19,209.3 (< 0.001)*	1,029.3 (< 0.01)*	943.7 (0.24)	-1,923.8 (< 0.01)*	-894.5 (< 0.001)*
Florida	365,401.6 (< 0.001)*	34,924.1 (< 0.001)*	6,659.2 (0.52)	-42,887.4 (< 0.001)*	-7,963.3 (< 0.01)*
Georgia	265,544.1 (< 0.001)*	14,201.6 (< 0.01)*	-1,587.5 (0.86)	-22,487.6 (< 0.01)*	-8,286 (< 0.01)*
Hawaii	31,824 (< 0.001)*	789.5 (0.06)	1,961 (0.09)	-914.2 (0.05)	-124.7 (0.49)
Iowa	66,217.1 (< 0.001)*	2,160.6 (< 0.01)*	1,361.7 (0.11)	-4,910.3 (< 0.001)*	-2,749.7 (< 0.001)*
Idaho	36,540.2 (< 0.001)*	1,755.7 (0.07)	3,267 (0.20)	-2,838.2 (0.015)*	-1,082.5 (< 0.001)*
Illinois	271,244.5 (< 0.001)*	8,067.5 (< 0.01)*	8,246.3 (0.23)	-16,755.5 (< 0.001)*	-8,688 (< 0.001)*
Indiana	132,251.2 (< 0.001)*	7,899.7 (< 0.01)*	10,651 (0.16)	-11,788 (< 0.01)*	-3,888.3 (< 0.01)*
Kansas	68,019.8 (< 0.001)*	1,658.8 (< 0.01)*	3,988.8 (0.01)*	-3,739.1 (< 0.001)*	-2,080.3 (< 0.01)*
Kentucky	121,666.2 (< 0.001)*	5,168.7 (< 0.001)*	732 (0.57)	-8582.7 (< 0.001)*	-3,414 (< 0.001)*
Louisiana	129,993.9 (< 0.001)*	2,702.4 (0.53)	14,448.5 (0.20)	-6,713.7 (0.17)	-4,011.3 (0.02)*
Massachusetts	113,373.4 (< 0.001)*	3,645.9 (< 0.01)*	-1,721 (0.32)	-5,541.6 (< 0.01)*	-1,895.7 (0.02)*
Maryland	108,219.9 (< 0.001)*	9,780.4 (< 0.001)*	1,141.1 (0.57)	-10,801.9 (< 0.001)*	-1,021.5 (< 0.01)*
Maine	23,241.8 (< 0.001)*	894.3 (< 0.001)*	487.4 (0.35)	-1,606.3 (< 0.001)*	-712 (< 0.01)*
Michigan	226,964.4 (< 0.001)*	3,618.4 (< 0.001)*	10,336.8 (0.01)*	-2823.5 (0.04)*	794.9 (0.46)
Minnesota	124,616.6 (< 0.001)*	5,933.1 (< 0.001)*	-7,770.4 (< 0.001)*	-10,301 (< 0.001)*	-4,367.9 (< 0.001)*
Missouri	130,063.7 (< 0.001)*	4,374.7 9 (0.01)*	4,112.9 (0.30)	-7,076.9 (< 0.01)*	-2,702.2 (< 0.001)*
Mississippi	97,459.8 (< 0.001)*	3,842.3 (< 0.01)*	-5,369.6 (0.07)	-8,491.4 (< 0.01)*	-4,649.1 (< 0.01)*
Montana	20,509.6 (< 0.001)*	-298.9 (0.33)	1,494 (0.13)	41.2 (0.89)	-257.7 (0.03)*
North Carolina	224,072.6 (< 0.001)*	12,827.6 (< 0.01)*	-907.6 (0.88)	-15,636.3 (< 0.001)*	-2,808.7 (0.02)*
North Dakota	14,259.9 (< 0.001)*	201.4 (< 0.001)*	-360.3 (0.06)	-581.6 (< 0.001)*	-380.2 (< 0.01)*
Nebraska	40,563 (< 0.001)*	1,277 (< 0.01)*	411.8 (0.63)	-2,743.5 (< 0.001)*	-1,466.5 (< 0.001)*
New Hampshire	16,416.1 (< 0.001)*	514.6 (< 0.01)*	-81.1 (0.69)	-1,264.4 (< 0.001)*	-749.8 (< 0.001)*
New Jersey	145,874.6 (< 0.001)*	4,533.1 (< 0.01)*	6,719.4 (0.13)	-5,107.5 (< 0.01)*	-574.4 (0.34)
New Mexico	63,246.3 (< 0.001)*	1,564.8 (0.03)*	-1295.3 (0.41)	-3,484.7 (< 0.01)*	-1,919.9 (< 0.001)*
Nevada	48,008 (< 0.001)*	4,316 (< 0.01)*	6,693 (0.18)	-3,212.4 (0.07)	1,103.6 (0.26)
New York	477,905.3 (< 0.001)*	6,742.8 (< 0.05)*	12,155.3 (0.16)	-7,583.4 (0.05)	-840.6 (0.57)
Ohio	271,667.4 (< 0.001)*	7,367.9 (< 0.01)*	2,843.4 (0.48)	-18,338.1 (< 0.001)*	-10,970.2 (< 0.001)*
Oklahoma	118,756.8 (< 0.001)*	1,472.8 (0.05)	9,121.8 (0.02)	-5,563.4 (< 0.001)*	-4,090.6 (< 0.001)*
Oregon	101,721.2 (< 0.001)*	2,171.7 (< 0.05)*	4,306.8 (0.13)	-3,887.4 (< 0.01)*	-1,715.7 (< 0.01)*
Pennsylvania	239,259.8 (< 0.001)*	4,318.8 (< 0.01)*	5,813.6 (0.07)	-6,985 (< 0.01)*	-2,666.2 (< 0.01)*
Rhode Island	22,368.1 (< 0.001)*	1,146.1 (< 0.01)*	-1,224.7 (0.04)*	-1,763.6 (< 0.001)*	-617.5 (< 0.01)*
South Carolina	105,288.1 (< 0.001)*	7,386.1 (< 0.01)*	1,173.9 (0.82)	-10,493.3 (< 0.01)*	-3,107.2 (0.02)*
South Dakota	21,140.1 (< 0.001)*	468.6 (< 0.01)*	381.7 (0.33)	-1,165.6 (< 0.01)*	-697 (< 0.01)*
Tennessee	153,782.8 (< 0.001)*	5,245.8 (< 0.01)*	-1,946 (0.43)	-9,243. (< 0.01)*	-3,997.5 (< 0.01)*
Texas	882,058.9 (< 0.001)*	17,239.4 (0.03)*	76,935.7 (0.02)*	-37,365.4 (< 0.01)*	-20,126 (< 0.01)*
Utah	67,061.5 (< 0.001)*	-389.5 (0.70)	10,277.5 (0.03)*	-2,004 (0.14)	-2,393.5 (< 0.01)*
Virginia	137,457.8 (< 0.001)*	4,698.3 (< 0.01)*	4,629.8 (0.25)	-6,132.4 (< 0.01)*	-1,434.1 (< 0.01)*
Vermont	16,064.4 (< 0.001)*	233.9 (0.06)	313.6 (0.23)	-912.9 (< 0.001)*	-679 (< 0.001)*
Washington	157,074.1 (< 0.001)*	6,769.1 (0.02)*	10,329.1 (0.12)	-7,569.5 (< 0.01)*	-800.4 (0.33)
Wisconsin	111,204.3 (< 0.001)*	3,682.8 (< 0.01)*	3,010.3 (0.10)	-7,726.6 (< 0.001)*	-4,043.8 (< 0.001)*
West Virginia	49,201.2 (< 0.001)*	816.2 (0.09)	282.4 (0.83)	-2,579.7 (< 0.01)*	-1,763.5 (< 0.001)*
Wyoming	12,591.9 (< 0.001)*	-24.1 (0.84)	1,276.5 (< 0.01)*	-423.2 (0.02)*	-447.3 (< 0.001)*

Data Sources: Johnson, et al. (2017). *National- and State-Level Estimates of Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) Eligibles and Program Reach in 2014, and Updated Estimates for 2005–2013.* U.S. Department of Agriculture, Food and Nutrition Service, Office of Policy Support.

Table 4.4 Summary of Null Interrupted Time Series Model Coefficient Values and Significance by State

Coefficient Value (+/-)	**State Abbreviation** (n=51)
Intercept (β_0)	
Positive (n=51)	AK*, AL*, AR*, AZ*, CA*, CO*, CT*, D.C.*, DE*, FL*, GA*, HI*, IA*, ID*, IL*, IN*, KS*, KY*, LA*, MA*, MD*, ME*, MI*, MO*, MN*, MS*, MT*, NC*, ND*, NE*, NH*, NJ*, NM*, NV*, NY*, OH*, OK*, OR*, PA*, RI*, SC*, SD*, TN*, TX*, UT*, VA*, VT*, WA*, WI*, WV*, WY*
Year (β_1)	
Negative (n=4)	AK, MT, UT, WY
Positive (n=47)	AL*, AR, AZ*, CA*, CO*, CT*, D.C., DE*, FL*, GA*, HI, IA*, ID, IL*, IN*, KS*, KY*, LA, MA*, MD*, ME*, MI*, MO*, MN*, MS*, NC*, ND*, NE*, NH*, NJ*, NM*, NV*, NY*, OH*, OK, OR*, PA*, RI*, SC*, SD*, TN*, TX*, VA*, VT, WA*, WI*, WV (39/47)
Policy Period (β_2)	
Negative (n =10)	GA, MA, MN*, MS, NC, ND, NH, NM, RI*, TN (2/10)
Positive (n =41)	AK, AL, AR, AZ, CA, CO, CT, D.C., DE, FL, HI, IA, ID, IL, IN, KS*, KY, LA, MD, ME, MI*, MO, MT, ND, NE, NJ, NM, NV, NY, OH, OK*, OR, PA, SC, SD, TX*, UT*, VA, VT, WA, WI, WV, WY (5/41)
Interaction (β_3)	
Negative (n =50)	AK*, AL*, AR*, AZ*, CA*, CO*, CT*, D.C., DE*, FL*, GA*, HI, IA*, ID*, IL*, IN*, KS*, KY*, LA, MA*, MD*, ME*, MI*, MO*, MN*, MS*, NC*, ND*, NE*, NH*, NJ*, NM*, NV, NY, OH*, OK*, OR*, PA*, RI*, SC*, SD*, TN*, TX*, UT, VA*, VT*, WA*, WI*, WV*, WY* (42/49)
Positive (n =1)	MT (0/1)
Post-Trend	
Negative (n =49)	AK*, AL, AR*, AZ*, CA, CO*, CT*, D.C.*, DE*, FL*, GA*, HI, IA*, ID*, IL*, IN*, KS*, KY*, LA*, MA*, MD*, ME*, MO*, MN*, MS*, MT*, NC*, ND*, NE*, NH*, NJ, NM*, NY, OH*, OK*, OR*, PA*, RI*, SC*, SD*, TN*, TX*, UT*, VA*, VT*, WA, WI*, WV*, WY* (43/49)
Positive (n =2)	MI, NV (0/2)
	* Statistically significant, $p < 0.05$

Data Source: Johnson, et al. (2017). *National- and State-Level Estimates of Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) Eligibles and Program Reach in 2014, and Updated Estimates for 2005–2013.* U.S. Department of Agriculture, Food and Nutrition Service, Office of Policy Support.

Table 4.5 Autocorrelation Tests Results for each State by Number of Significant Lags, Extended ITS Model (Baum & Schaffer, 2015; Linden, 2015)

Number of Significant Lags (number of states)	**States**
0 (n=8)	D.C., GA, MS, RI, SC, TN, UT, VA
1 (n=21)	AK, AL, AZ, CA, FL, HI, ID, IL, ME, MN, ND, NJ, NV, OH, OK, OR, PA, SD, TX, WV, WY
2 (n=10)	CT, DE, LA, MA, MO, NE, NH, NY, VT, WA
3 (n=1)	NM
4 (n=1)	WI
5 (n=3)	AR, KY, MD
6 (n=2)	IN, MT
7 (n=5)	CO, IA, KS, MI, NC

Data Source : Johnson, et al. (2017). *National- and State-Level Estimates of Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) Eligibles and Program Reach in 2014, and Updated Estimates for 2005–2013.* U.S. Department of Agriculture, Food and Nutrition Service, Office of Policy Support. Linden, A. (2015). Conducting interrupted time-series analysis for single- and multiple-group comparisons. *The Stata Journal*, 15(2), 480–500. Baum, C., & Schaffer, M. (2015). *ACTEST: Stata module to perform Cumby-Huizinga general test for autocorrelation in time series*. In https://EconPapers.repec.org/RePEc:boc:bocode:s457668

Table 4.6 Extended Interrupted Time Series Model Coefficients by State, 2005-2013

* Statistically significant, p <0.05

State	Constant β_0	Year β_1	Policy Period β_2	Interaction β_3	WIC Eligibles β_4	Foreign Born β_5	Post-trend $\beta_1 + \beta_3$
Alaska	19,453.3 (0.07)	-105.1 (0.74)	1,442.5 (0.54)	-706.9 (0.09)	0.20 (0.33)	-22,888.3 (0.41)	-812 (0.13)
Alabama	46,699.3 (0.40)	5,323.8 (<0.01)*	-3,519.4 (0.60)	-6,087.8 (< 0.01)*	0.17 (0.44)	1,152,587 (0.14)	-764 (0.57)
Arkansas	74,116.7 (0.31)	799.1 (0.35)	8,913.8 (0.07)	-1,878 (0.51)	0.15 (0.74)	-339,342.6 (0.62)	-1,078.9 (0.73)
Arizona	259,714.3 (<0.01)*	8,454.6 (<0.01)*	-92.6 (0.97)	-17,503.2 (< 0.01)*	-0.091 (0.13)	-353,569.5 (0.18)	-9,048.5 (< 0.01)*
California	929,748.4 (0.53)	33,649.7(<0.01)*	6,020.7 (0.81)	-38,694.1 (< 0.01)*	-0.26 (0.24)	3,200,984 (0.51)	-5,044.4 (0.40)
Colorado	-34,100.8 (0.56)	5,895.2 (< 0.01)*	9,110.2 (0.02)*	-9,186.2 (< 0.01)*	-0.03 (0.68)	1,216,825 (0.11)	-3,291 (< 0.01)*
Connecticut	88,468 (0.35)	2,724.9 (0.20)	108 (0.98)	-3,580.3 (< 0.01)*	-0.05 (0.75)	-266,478.8 (0.73)	-855.4 (0.58)
District of Columbia	6,152.4 (0.13)	-35.2 (0.49)	2,170.2 (< 0.05)*	-824.7 (0.04)*	-0.24 (0.14)	117,953.6 (< 0.01)*	-860 (0.03)*
Delaware	11,262 (< 0.01)*	992.7 (0.02)*	368.7 (0.55)	-1,887 (< 0.01)*	0.08 (0.20)	70,320.9 (0.04)*	-894.3 (<0.001)*
Florida	676,290 (0.17)	34,833.7 (< 0.01)*	11,801.4 (0.53)	-40,712.5 (<0.01)*	< 0.01 (0.90)	-1,718,806 (0.38)	-58,788 (0.22)
Georgia	261,837.7 (0.32)	14,899.2 (0.05)	425.6 (0.97)	-25,567.7 (<0.01)*	-0.20 (0.33)	1,161,566 (0.70)	-10,668.5 (0.04)*
Hawaii	-1,671.7 (0.79)	563.9 (< 0.01)*	424.9 (0.38)	-860.9 (< 0.01)*	0.19 (0.03)	139,762.4 (<0.01)*	-297.1 (< 0.01)*
Iowa	67,922.3(<0.001)*	2,296.2 (< 0.01)*	1,235.8 (0.06)	1,235.8 (< 0.001)*	0.01 (0.65)	-101,574.4 (0.46)	-2,515.6 (< 0.01)*
Idaho	13,786.03 (0.32)	2,021.9 (< 0.01)*	1,396.2 (0.43)	-2,943.6(< 0.01)*	0.09 (0.53)	251,518.3 (0.24)	-921.8 (0.04)*
Illinois	206,627.2 (0.23)	7,417.5 (< 0.01)*	1,764.8 (0.82)	-13,530.4 (0.02)*	0.15 (0.34)	-118,200.1 (0.89)	-6,112.9 (0.08)
Indiana	51,009.6 (0.44)	7,731 (< 0.001)*	2,256.9 (0.76)	-9,910.7 (< 0.01)*	0.31 (0.13)	-161,091.4 (0.73)	-2,179.6 (0.11)
Kansas	81,857.7 (0.02)*	2,328.2 (0.04)*	3,417.9 (0.23)	-4,168.5 (< 0.01)*	0.02 (0.88)	-286,376.7 (0.23)	-1,840.3 (< 0.01)*
Kentucky	96,748 (< 0.01)*	4,926.9 (< 0.001)*	-32.4 (0.98)	-7,044.6 (0.03)*	0.16 (0.39)	-287,710.1 (0.66)	-2,117.7 (0.27)
Louisiana	48,206.2 (0.46)	3,013 (0.41)	12,916 (0.28)	-4,979.6 (0.28)	0.30 (0.22)	26,180 (0.97)	-1,966.6 (0.43)
Massachusetts	75,016.7 (0.13)	4,188 (< 0.01)*	-1,828.3 (0.30)	-7,045.2 (0.07)	-0.09 (0.05)	369,885.7 (0.28)	-2,857.2 (0.06)
Maryland	103,990.5 (0.03)*	9,766.9 (< 0.001)*	437.9 (0.91)	-10,756.9 (< 0.001)*	0.04 (0.83)	-21,234.8 (0.74)	-990 (0.06)
Maine	35,739.5 (< 0.01)*	686.6 (< 0.01)*	2,153.6 (< 0.01)*	-1,695 (< 0.01)*	-0.22 (0.02)*	-52,294.9 (0.45)	-1,008.4 (< 0.01)*
Michigan	335,716.5 (< 0.01)*	2,675.1 (0.02)*	14,265.3 (< 0.01)*	-1,597.1 (0.18)	-0.07 (< 0.05)*	-1,322,852 (0.11)	1,078.004 (0.09)
Minnesota	149,609.7 (< 0.01)*	6,142.7 (< 0.001)*	-7,170.5 (0.03)*	-10,106.9 (< 0.001)*	-0.02 (0.08)	-322,565.1 (0.26)	-3,964.1 (< 0.01)*
Missouri	100,385.7 (0.08)	4,338.5 (0.02)*	2,003.7 (0.58)	-6,664.6 (< 0.01)*	0.06 (0.61)	410,278.5 (0.37)	-2,326.05 (0.05)
Mississippi	103,908.1 (0.10)	4,671.9 (0.05)	-6,247 (0.03)*	-9,032 (0.02)*	0.03 (0.91)	-680,054.6 (0.26)	-4,360 (0.08)
Montana	18,433.14 (0.03)*	-91.6 (0.29)	1,021.1 (0.15)	20.2 (0.73)	-0.05 (0.70)	199,663.6 (< 0.01)*	-71.4 (0.44)
North Carolina	273,995.7 (< 0.01)*	13,739.2 (< 0.01)*	617.3 (0.89)	-17,180.7 (< 0.01)*	-0.11 (0.10)	3,531 (0.99)	-3,441.5 (0.03)*
North Dakota	15,595.3 (< 0.01)*	186.1 (< 0.01)*	-177.3 (0.58)	-549.9 (< 0.01)*	-0.01 (0.70)	-48,177.7 (0.53)	-363.9 (< 0.01)*
Nebraska	16,983.9 (0.11)	989.6 (0.02)*	-97.8 (0.90)	-2,506(< 0.01)*	0.13 (0.12)	238,075.7 (0.04)*	-1,516.3 (< 0.01)*
New Hampshire	19,191.4 (< 0.01)*	294 (0.37)	547.2 (0.48)	-1,030.7 (0.05)	0.01 (0.80)	-56,203.9 (0.31)	-736.7 (< 0.01)*
New Jersey	305,390.7 (0.59)	5,285.5 (0.10)	10,786.6 (0.57)	-3,708.1 (0.46)	-0.14 (0.86)	-625,809.6 (0.72)	1,577.4 (0.82)
New Mexico	65,355.4 (< 0.01)*	1,864.3 (< 0.01)*	-962 (0.23)	-3,538.1 (< 0.01)*	0.10 (0.40)	-165,168.1 (0.02)*	-1,673.9 (< 0.01)*
Nevada	35,841.7 (0.62)	4,629 (0.07)	1,491 (0.76)	-3,508.3 (0.13)	0.26 (0.34)	-91,135 (0.75)	1,120.7 (0.11)
New York	563,703.3 (0.17)	6,917.8 (0.24)	13,701.2 (0.38)	-6,850.4 (0.15)	-0.07 (0.65)	-153,794.2 (0.93)	67.4 (0.99)
Ohio	250,934.7 (< 0.01)*	12,992.9 (< 0.01)*	-12,964.5 (0.07)	-20,685.1 (< 0.001)*	0.26 (< 0.01)*	-2,980,741 (0.03)*	-7,692.2 (< 0.01)*
Oklahoma	131,860.1 (0.04)*	2,347 (0.15)	9,038.3 (0.04)*	-6,066.9 (< 0.01)*	0.03 (0.85)	-440,077.4 (0.47)	-3,719.8 (0.03)*
Oregon	97,692.5 (0.06)	2,081.1 (0.02)*	2,494.4 (0.11)	-3,440.9 (< 0.01)*	0.17 (0.19)	-236,746.3 (0.30)	-1,359.8 (< 0.01)*
Pennsylvania	150,286.4 (0.10)	3,977.8 (0.02)*	3,988.4 (0.15)	-7,701.7 (< 0.01)*	0.15 (0.28)	44,7021 (0.06)	-3,724 (0.14)
Rhode Island	28,270.1 (< 0.01)*	996.7 (0.02)*	-458.7 (0.40)	-1,693.3 (< 0.01)*	-0.16 (0.03)*	-180.4 (0.99)	-696.6 (< 0.01)*
South Carolina	133,427 (0.38)	7,693.2 (0.09)	2,522.6 (0.78)	-10,364.5 (0.06)	< 0.01 (0.98)	-716,834.4 (0.78)	-2,671.3 (0.22)
South Dakota	16,597.8 (0.03)*	907.1 (0.05)	-1,199.9 (0.39)	-1,860.8 (0.02)*	-0.02 (0.84)	211,326.2 (0.08)	-953.7 (0.02)*
Tennessee	168,390.2 (< 0.01)*	5,856. (< 0.05)*	-741 (0.87)	-9,382.6 (< 0.01)*	0.02 (0.79)	-560,973.9 (0.50)	-3,526.4 (0.02)*
Texas	92,252.4 (0.94)	16,987 (0.06)	66,379.7 (0.09)	-39,414.5 (< 0.01)*	0.05 (0.89)	4,420,799 (0.46)	-22,427.5 (< 0.01)*
Utah	31,781.3 (0.29)	-1,612.8 (0.44)	14,689.5 (0.07)	-1,766 (0.35)	-0.13 (0.54)	707,170 (0.18)	-3,378.8 (0.02)*
Virginia	139,020.6 (< 0.01)*	5,120.2 (0.03)*	2,808.3 (0.58)	-6,034.5 (0.02)*	0.06 (0.54)	-161,784.9 (0.67)	-914.3 (0.49)
Vermont	15,283.9 (<0.001)*	282.5 (0.27)	221.1 (0.64)	-968 (< 0.01)*	0.03 (0.44)	-672.4 (0.99)	-685.5 (< 0.01)*
Washington	190,874.5 (< 0.01)*	6,857 (0.05)	9,844.3 (0.51)	-6,685.2 (0.06)	0.03 (0.94)	-333,079 (0.60)	171.7 (0.94)
Wisconsin	108,569.7 (0.01)*	3,717.6 (< 0.01)*	2,617.1 (0.17)	-7,696.4 (< 0.01)*	0.01 (0.76)	-178.5 (0.99)	-3,978.8 (< 0.001)*
West Virginia	39,352.3 (< 0.001)*	320.1 (0.13)	2,027.5 (0.04)*	-2,873.4 (< 0.001)*	-0.01 (0.38)	963,544 (0.03)*	-2,553.3 (< 0.01)*
Wyoming	13,577.6 (< 0.01)*	-9.4 (0.60)	1,267.8 (0.02)*	-399.7 (< 0.01)*	< 0.01 (0.93)	-43,045.1 (0.03)*	-409.1 (< 0.01)*

Data Sources: Johnson, et al. (2017). *National- and State-Level Estimates of Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) Eligibles and Program Reach in 2014, and Updated Estimates for 2005–2013.* U.S. Department of Agriculture, Food and Nutrition Service, Office of Policy Support. U.S. Census Bureau (2023a). *American Community Survey Data. Demographic and Housing Estimates.* Retrieved Sept 6, 2023 from https://data.census.gov/table?q=DP05; U.S. Census Bureau (2023b). *American Community Survey. Selected Social Characteristics in the United States.* Retrieved Sept 6, 2023 from https://data.census.gov/table?q=DP02

Table 4.7 Summary of Extended Interrupted Time Series Model Coefficient Values and Significance by State

Coefficient Value (+/-)	**State Abbreviation** (n=51)
Intercept (β_0)	
Negative (n=2)	CO, HI (0/2)
Positive (n=49)	AK, AL, AR, AZ*, CA, CT, D.C., DE*, FL, GA, IA*, ID, IL, IN, KS*, KY*, LA, MA, MD, ME*, MI*, MO, MN*, MS, MT*, NC*, ND*, NE, NH*, NJ, NM*, NV, NY, OH*, OK*, OR, PA, RI*, SC, SD*, TN*, TX, UT, VA*, VT*, WA, WI*, WV*, WY* (24/49)
Year (β_1)	
Negative (n =5)	AK, D.C., MT, UT, WY (0/5)
Positive (n =46)	AL*, AR, AZ*, CA*, CO*, CT, DE*, FL*, GA, HI*, IA*, ID, IL*, IN*, KS*, KY*, LA, MA*, MD*, ME*, MI*, MO*, MN*, MS, NC*, ND*, NE*, NH, NJ, NM*, NV, NY, OH*, OK, OR*, PA*, RI*, SC, SD, TN*, TX, VA*, VT, WA, WI*, WV (30/46)
Policy Period (β_2)	
Negative (n =13)	AL, AZ, KY, MA, MN*, MS*, ND, NE, NM, OH, RI, SD, TN (2/13)
Positive (n =38)	AK, AR, CA, CO*, CT, D.C.*, DE, FL, GA, HI, IA, ID, IL, IN, KS, LA, MD, ME*, MI*, MO, MT, NC, NH, NJ, NM, NV, NY, OK*, OR, PA, SC, TX, UT, VA, VT, WA, WI, WV*, WY* (7/38)
Interaction (β_3)	
Negative (n =50)	AK, AL*, AR, AZ*, CA*, CO*, CT*, D.C.*, DE*, FL*, GA*, HI*, IA*, ID*, IL*, IN*, KS*, KY*, LA, MA, MD*, ME*, MI, MO*, MN*, MS*, NC*, ND*, NE*, NH, NJ, NM*, NV, NY, OH*, OK*, OR*, PA*, RI*, SC, SD*, TN*, TX*, UT, VA*, VT*, WA, WI*, WV*, WY* (38/50)
Positive (n =1)	MT (0/1)
WIC Eligibles (β_4)	
Negative (n =19)	AZ, CA, CO, CT, D.C., GA, MA, ME*, MI*, MN, MT, NC, ND, NJ, NY, RI*, SD, UT, WV (3/19)
Positive (n =32)	AK, AL, AR, DE, FL, HI*, IA, ID, IL, IN, KS, KY, LA, MD, MO, MS, NE, NH, NM, NV, OH*, OK OR, PA, SC, TN, TX, VA, VT, WA, WI, WY (2/32)
Foreign Born (β_5)	
Negative (n =32)	AK, AR, AZ, CT, FL, IA, ID, IN, KS, KY, MD, ME, MI, MN, MS, ND, NH, NJ, NM*, NV, NY*, OH*, OK, OR, RI, SC, TN, VA, VT, WA, WI, WY* (3/32)
Positive (n =19)	AL, CA, CO, D.C.*, DE*, GA, HI*, IL, LA, MA, MO, MT*, NC, NE*, PA, SD, TX, UT, WI, WV* (6/19)
Post-Trend	
Negative (n =46)	AK, AL, AR, AZ*, CA, CO*, CT, D.C.*, DE*, FL, GA*, HI*, IA, ID*, IL*, IN, KS*, KY, LA, MA, MD, ME*, MO, MN*, MS, MT, NC*, ND*, NE*, NH*, NM*, OH*, OK*, OR*, PA, RI*, SC, SD*, TN*, TX*, UT*, VA, VT*, WI*, WV*, WY* (28/46)
Positive (n =5)	MI, NJ, NV, NY, WA (0/5)
	* Statistically significant, $p < 0.05$

Data Sources: Johnson, et al. (2017). *National- and State-Level Estimates of Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) Eligibles and Program Reach in 2014, and Updated Estimates for 2005–2013.* U.S. Department of Agriculture, Food and Nutrition Service, Office of Policy Support. U.S. Census Bureau (2023a). *American Community Survey Data. Demographic and Housing Estimates.* Retrieved Sept 6, 2023 from https://data.census.gov/table?q=DP05; U.S. Census Bureau (2023b). *American Community Survey. Selected Social Characteristics in the United States.* Retrieved Sept 6, 2023 from https://data.census.gov/table?q=DP02

Table 4.8 Demographic, Economic, and Other Population Characteristics by State, 2010

State	Birth Rate (number of births per 1,000 population)	Foreign Born (%)	White (%)	Hispanic (%)	Food Insecurity (%)	Unemployment (%)	Poverty (%)	WIC Eligible Individuals
Alaska	16.2	6.5	67.4	3.8	13.6	7.9	9.9	38,972
Alabama	12.6	3.6	69.5	5.7	17.3	10.5	19.0	232,138
Arkansas	13.2	4.6	78.4	6.3	17.3	8.2	18.8	170,731
Arizona	13.7	13.4	79.4	29.8	15.3	10.4	17.4	364,240
California	13.7	27.2	62.4	37.7	15.9	12.2	15.8	1,873,660
Colorado	13.2	9.7	83.3	20.8	13.4	8.7	13.4	201,505
Connecticut	10.6	13.2	78.2	13.5	12.7	9.1	10.1	113,420
District of Columbia	15.2	13.2	40.2	9.1	13.0	9.4	19.2	24,232
Delaware	12.7	7.8	70.7	8.2	9.7	8.4	11.8	38,867
Florida	11.4	19.5	76.5	22.6	16.1	11.1	16.5	823,194
Georgia	13.8	9.7	60.7	8.8	16.9	10.5	17.9	547,352
Hawaii	14.0	17.9	24.6	8.9	13.1	6.9	10.7	59,058
Iowa	12.7	4.6	91.5	5.0	12.1	6.0	12.6	120,416
Idaho	14.8	5.7	92.2	11.3	12.4	9.0	15.7	96,077
Illinois	12.9	13.7	72.5	15.9	12.9	10.4	13.8	582,693
Indiana	13.0	4.6	85.1	6.0	13.0	10.4	15.3	315,548
Kansas	14.3	6.6	85.2	10.5	14.5	7.1	13.6	136,394
Kentucky	12.9	3.4	88.3	3.0	15.6	10.2	19.0	215,991
Louisiana	13.8	3.7	62.8	4.3	12.6	8.0	18.7	269,253
Massachusetts	11.1	14.9	81.1	9.6	10.8	8.3	11.4	194,096
Maryland	12.8	13.9	58.9	8.2	12.5	7.7	9.9	210,285
Maine	9.8	3.6	95.3	1.2	15.4	8.1	12.9	49,267
Michigan	11.6	5.9	79.3	4.4	14.7	12.6	16.8	442,562
Minnesota	12.9	7.1	86.1	4.7	10.3	7.4	11.6	186,402
Missouri	12.8	3.9	83.1	3.6	15.8	9.6	15.3	286,042
Mississippi	13.5	2.1	59.5	2.5	19.4	10.4	22.4	193,849
Montana	12.2	2.0	89.9	2.8	14.1	7.3	14.6	44,458
North Carolina	12.8	7.5	69.7	8.4	15.7	10.9	17.5	491,143
North Dakota	13.5	2.5	90.0	2.1	7.1	3.8	13.0	27,220
Nebraska	14.2	6.0	88.9	9.2	12.7	4.6	12.9	86,560
New Hampshire	9.8	5.4	94.1	2.8	9.6	5.8	8.3	34,434
New Jersey	12.2	21.0	69.3	17.8	12.1	9.5	10.3	281,764
New Mexico	13.5	10.1	73.4	46.4	15.4	8.1	20.4	132,808
Nevada	13.3	18.8	72.9	26.6	14.7	13.5	14.9	130,694
New York	12.6	22.2	65.9	17.7	12.9	8.6	14.9	808,837
Ohio	12.1	4.1	83.0	3.1	16.4	10.3	15.8	512,726
Oklahoma	14.2	5.6	73.5	8.8	16.4	6.8	16.9	222,154
Oregon	11.9	9.8	85.0	11.8	13.7	10.6	15.8	172,266
Pennsylvania	11.3	5.7	82.6	5.7	12.5	8.5	13.4	466,963
Rhode Island	10.6	12.4	81.4	12.5	14.7	11.2	14.0	35,700
South Carolina	12.6	4.6	67.1	5.0	14.8	11.2	18.2	242,943
South Dakota	14.5	2.6	86.0	2.5	12.3	5.0	14.4	40,329
Tennessee	12.5	4.6	78.4	4.5	15.0	9.7	17.7	321,937
Texas	15.4	16.4	74.1	37.7	18.8	8.1	17.9	1,544,504
Utah	18.9	8.3	88.8	13.0	13.0	7.8	13.2	165,043
Virginia	12.9	11.3	69.5	7.9	9.6	7.1	11.1	291,597
Vermont	10.0	4.5	95.4	1.5	13.8	6.1	12.7	24,795
Washington	12.9	13.3	78.7	11.3	14.7	10.0	13.4	316,827
Wisconsin	12.0	4.4	87.0	5.9	11.8	8.7	13.2	229,157
West Virginia	11.1	1.2	93.9	1.2	14.1	8.7	18.1	77,723
Wyoming	13.4	2.9	91.0	9.0	11.6	6.4	11.2	25,888
Total	13.0	12.9	74.2	16.4	14.5	9.6	15.3	14,789,179

Data Sources: Martin, et al. (2007). Centers for Disease Control and Prevention, National Center for Health Statistics, National Vital Statistics System. Births: Final Data for 2005. *National Vital Statistics Reports*, *56*(6); U.S. Bureau of Labor Statistics, (2023). *Labor Force Statistics including the National Unemployment Rate. Current Population Survey.* U.S. Bureau of Labor Statistics. Retrieved September 6 from https://www.bls.gov/data/#unemployment; U.S. Census Bureau, (2023c). *Annual Social and Economic Supplement. Current Population Survey Data.* U.S. Census Bureau. Retrieved September 6, 2023 from https://www.census.gov/data/datasets/time-series/demo/cps/cps-asec.html; U.S. Census Bureau, U. S. (2023d). *Food Security Supplement. Current Population Survey.* U.S. Department of Agriculture, Food and Nutrition Services. Retrieved 6, 2023 from https://www.census.gov/programs-surveys/cps/data.html; Johnson, et al. (2017). *National- and State-Level Estimates of Special*

Supplemental Nutrition Program for Women, Infants, and Children (WIC) Eligibles and Program Reach in 2014, and Updated Estimates for 2005–2013. U.S. Department of Agriculture, Food and Nutrition Service, Office of Policy Support.

Table 4.9 Number of WIC Participants, Demographic, Economic, and Other Characteristics in 2010, by WIC EBT Group (WIC EBT Not-Yet-Implemented and WIC EBT never Implemented)

Characteristics	**WIC EBT Not Yet Implemented Group (n=18)**	**WIC EBT never Implemented Group (n=27)**	**Difference**	**p-value**
WIC Participants (number)	130,173	184,260	-54,087	0.45
Demographic				
Birth Rate (Births per 1,000 population)	12.32	13.23	-0.91	0.07
Foreign born (%)	0.08	0.09	-0.01	0.66
White (%)	0.82	0.74	0.08	0.08
Hispanic (%)	0.09	0.09	0.00	0.88
Economic				
Unemployment (%)	0.08	0.09	0.00	0.48
Poverty (%)	0.14	0.15	-0.01	0.32
Other				
Food Insecure (%)	0.13	0.14	-0.01	0.35
WIC-Eligible Individuals (number)	222,043	297,240	-75,197	0.44

Data Sources: U.S. Department of Agriculture. (2023). *WIC EBT Activities*. U.S. Department of Agriculture, Food and Nutrition Services. Retrieved April 3, 2023 from https://www.fns.usda.gov/wic/wic-ebt-activities. Johnson, et al. (2017). *National- and State-Level Estimates of Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) Eligibles and Program Reach in 2014, and Updated Estimates for 2005–2013.* U.S. Department of Agriculture, Food and Nutrition Service, Office of Policy Support. U.S. Centers for Disease Control and Prevention. (2019). Births: Final data for 2005-2017. *National Vital Statistics Reports*, National Center for Health Statistics. U.S. Census Bureau (2023a). *American Community Survey Data. Demographic and Housing Estimates.* Retrieved Sept 6 from https://data.census.gov/table?q=DP05; U.S. Census Bureau, U. S. (2023b). *American Community Survey. Selected Social Characteristics in the United States.* Retrieved September 6 from https://data.census.gov/table?q=DP02. U.S. Bureau of Labor Statistics. (2023). *Labor Force Statistics including the National Unemployment Rate. Current Population Survey.* U.S. Bureau of Labor Statistics. Retrieved September 6 from https://www.bls.gov/data/#unemployment; U.S. Census Bureau, (2023c). *Annual Social and Economic Supplement. Current Population Survey Data.* U.S. Census Bureau. Retrieved September 6, 2023 from https://www.census.gov/data/datasets/time-series/demo/cps/cps-asec.html; U.S. Census Bureau, U. S. (2023d). *Food Security Supplement. Current Population Survey.* U.S. Department of Agriculture, Food and Nutrition Services. Retrieved 6, 2023 from https://www.census.gov/programs-surveys/cps/data.html.

Table 4.10 WIC EBT Aggregate Average Treatment Effects in Number of WIC Participants by Difference-in-differences Estimator Type, Null Model

DID Estimator	**Average Treatment Effect**	**Standard Error**	**p-value**	**95% CI**	
Global Treatment Effect	8,447	6,427	0.19	-4,150	21,043
Group Specific	7,856	5,592	0.16	-3,105	18,816
Calendar Period	6,787	5,123	0.18	-3,255	16,829
Event Study-pre-trend	1,226	1,343	0.36	-1,405	3,858
Event Study-post-trend	13,643	9,388	0.15	-4,758	32,043

Data Sources: Johnson, et al. (2017). *National- and State-Level Estimates of Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) Eligibles and Program Reach in 2014, and Updated Estimates for 2005–2013.* U.S. Department of Agriculture, Food and Nutrition Service, Office of Policy Support. Trippe, et al. (2018). *National- and State-Level Estimates of Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) Eligibles and Program Reach in 2015*. Alexandria, VA: U.S. Department of Agriculture, Food and Nutrition Service, Office of Policy Support. Trippe, et al. (2019). *National- and State-Level Estimates of Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) Eligibility and Program Reach in 2016.* Alexandria, VA: U.S. Department of Agriculture, Food and Nutrition Service, Office of Policy Support. Gray, et al. (2019). *National- and State-Level Estimates of WIC Eligibility and WIC Program Reach in 2017.* Alexandria, VA: U.S. Department of Agriculture, Food and Nutrition Service, Office of Policy Support. U.S. Department of Agriculture. (2023). *WIC EBT Activities*. U.S. Department of Agriculture, Food and Nutrition Services. Retrieved April 3, 2023 from https://www.fns.usda.gov/wic/wic-ebt-activities

Table 4.11 WIC EBT Aggregate Average Treatment Effects in Number of WIC Participants by Standard Error Estimation Method and Difference-in-differences Estimator Type, Extended Model

	Average Treatment Effect	Standard Error	p-value	95% CI	
Regular Method					
Global Treatment Effect	6,973	7,017	0.32	-6,779	20,725
Group Specific	4,358	3,838	0.26	-3,164	11,882
Calendar Period	54,363	5,921	0.36	-6,141	17,068
Event Study-pre-trend	-388	461	0.40	-1,293	516
Event Study-post-trend	7,557	9,544	0.43	-11,150	26,263
Robust Method					
Global Treatment Effect	9,090	7,424	0.22	-5,460	23,640
Group Specific	6,170	4,090	0.13	-1,845	14,186
Calendar Period	7,315	6,279	0.24	-4,991	19,622
Event Study-pre-trend	-188	401	0.64	-975	598
Event Study-post-trend	12,221	10,282	0.23	-7,930	32,373

Data Sources: Johnson, et al. (2017). *National- and State-Level Estimates of Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) Eligibles and Program Reach in 2014, and Updated Estimates for 2005–2013.* U.S. Department of Agriculture, Food and Nutrition Service, Office of Policy Support. Trippe, et al. (2018). *National- and State-Level Estimates of Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) Eligibles and Program Reach in 2015*. Alexandria, VA: U.S. Department of Agriculture, Food and Nutrition Service, Office of Policy Support. Trippe, et al. (2019). *National- and State-Level Estimates of Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) Eligibility and Program Reach in 2016.* Alexandria, VA: U.S. Department of Agriculture, Food and Nutrition Service, Office of Policy Support. Gray, et al. (2019). *National- and State-Level Estimates of WIC Eligibility and WIC Program Reach in 2017.* Alexandria, VA: U.S. Department of Agriculture, Food and Nutrition Service, Office of Policy Support. U.S. Department of Agriculture. (2023). *WIC EBT Activities*. U.S. Department of Agriculture, Food and Nutrition Services. Retrieved April 3, 2023 from https://www.fns.usda.gov/wic/wic-ebt-activities

Table 4.12 Number of WIC Participants, Demographic, Economic, and Other Characteristics in 2010, by REAL ID Group (REAL ID Not-Yet-Implemented and REAL ID Never Implemented)

Characteristics	**REAL ID Not-yet Implemented Group** (n=29)	**REAL ID never Implemented Group** (n=22)	**Difference**	**p-value**
WIC Participants (number)	159,385	194,045	-34,660	0.63
Demographic				
Birth Rate (births per 1,000 population)	13.21	12.55	0.66	0.15
Foreign Born (%)	0.09	0.09	-0.003	0.84
White (%)	0.76	0.79	-0.035	0.37
Hispanic (%)	0.12	0.09	0.035	0.22
Economic				
Unemployment (%)	0.09	0.09	-0.001	0.81
Poverty (%)	0.15	0.14	0.01	0.20
Other				
Food Insecure (%)	0.14	0.13	0.01	0.12
WIC-Eligible Individuals (number)	273,008	299,886	-26,878	0.79

Data Sources: Johnson, et al. (2017). *National- and State-Level Estimates of Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) Eligibles and Program Reach in 2014, and Updated Estimates for 2005–2013.* U.S. Department of Agriculture, Food and Nutrition Service, Office of Policy Support. U.S. Centers for Disease Control and Prevention. (2019). Births: Final data for 2005-2017. *National Vital Statistics Reports*, National Center for Health Statistics. U.S. Census Bureau (2023a). *American Community Survey Data. Demographic and Housing Estimates.* Retrieved Sept 6 from https://data.census.gov/table?q=DP05; U.S. Census Bureau, U. S. (2023b). *American Community Survey. Selected Social Characteristics in the United States.* Retrieved September 6 from https://data.census.gov/table?q=DP02. U.S. Bureau of Labor Statistics. (2023). *Labor Force Statistics including the National Unemployment Rate. Current Population Survey.* U.S. Bureau of Labor Statistics. Retrieved September 6 from https://www.bls.gov/data/#unemployment; U.S. Census Bureau, (2023c). *Annual Social and Economic Supplement. Current Population Survey Data.* U.S. Census Bureau. Retrieved September 6, 2023 from https://www.census.gov/data/datasets/time-series/demo/cps/cps-asec.html; U.S. Census Bureau, U. S. (2023d). *Food Security Supplement. Current Population Survey.* U.S. Department of Agriculture, Food and Nutrition Services. Retrieved 6, 2023 from https://www.census.gov/programs-surveys/cps/data.html.

Table 4.13 REAL ID Aggregate Average Treatment Effects in Number of WIC Participants by Difference-in-differences Estimator Type, Null Model

DID Estimation Type	Average Treatment Effect	Standard Error	p-value	95% CI	
Global Treatment Effect	8,020	9,044	0.37	-9,706	25,746
Group Specific	7,000	9,179	0.41	-97,921	2,392
Calendar Period	6,713	7,875	0.39	-8,721	22,148
Event Study-pre-trend	-5,981	3,896	0.12	-13,619	1,656
Event Study-post-trend	8,849	10,311	0.39	-1,360	29,059

Data Sources: Johnson, et al. (2017). *National- and State-Level Estimates of Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) Eligibles and Program Reach in 2014, and Updated Estimates for 2005–2013.* U.S. Department of Agriculture, Food and Nutrition Service, Office of Policy Support. Trippe, et al. (2018). *National- and State-Level Estimates of Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) Eligibles and Program Reach in 2015*. Alexandria, VA: U.S. Department of Agriculture, Food and Nutrition Service, Office of Policy Support. Trippe, et al. (2019). *National- and State-Level Estimates of Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) Eligibles and Program Reach in 2016*. Alexandria, VA: U.S. Department of Agriculture, Food and Nutrition Service, Office of Policy Support. Gray, et al. *National- and State-Level Estimates of WIC Eligibility and WIC Program Reach in 2017.* Alexandria, VA: U.S. Department of Agriculture, Food and Nutrition Service, Office of Policy Support. U.S. Department of Homeland Security. (2021). REAL ID Act: Federal Enforcement; State Compliance, Extensions and Implementation. Retrieved on April 1, 2021 from https://www.dhs.gov/real-id

Table 4.14 REAL ID Aggregate Average Treatment Effects in Number of WIC Participants by Standard Error Estimation Method and Difference-in-differences Estimator Type, Extended Model

	Average Treatment Effect	Standard Error	p-value	95% CI	
Regular Method					
Global Treatment Effect	924	3,620	0.80	-6,171	8,019
Group Specific	1,700	3,408	0.62	-4,979	8,380
Calendar Period	576	3,160	0.85	-5,619	6,771
Event Study-pre-trend	-3,027	2,394	0.21	-7,719	1,665
Event Study-post-trend	1,230	3,855	0.75	-6,327	8,787
Robust Method					
Global Treatment Effect	1,908	3,049	0.53	-4,067	7,883
Group Specific	2,843	2,871	0.32	-2,785	8,470
Calendar Period	1,440	2,683	0.59	-3,818	6,698
Event Study-pre-trend	-2,914	2,446	0.23	-7,709	1,881
Event Study-post-trend	2,149	3,258	0.51	-4,237	8,535

Data Sources: Johnson, et al. (2017). *National- and State-Level Estimates of Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) Eligibles and Program Reach in 2014, and Updated Estimates for 2005–2013.* U.S. Department of Agriculture, Food and Nutrition Service, Office of Policy Support. Trippe, et al. (2018). *National- and State-Level Estimates of Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) Eligibles and Program Reach in 2015*. Alexandria, VA: U.S. Department of Agriculture, Food and Nutrition Service, Office of Policy Support. Trippe, et al. (2019). *National- and State-Level Estimates of Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) Eligibles and Program Reach in 2016*. Alexandria, VA: U.S. Department of Agriculture, Food and Nutrition Service, Office of Policy Support. Gray, et al. *National- and State-Level Estimates of WIC Eligibility and WIC Program Reach in 2017.* Alexandria, VA: U.S. Department of Agriculture, Food and Nutrition Service, Office of Policy Support. U.S. Census Bureau (2023a). *American Community Survey Data. Demographic and Housing Estimates.* Retrieved Sept 6 from https://data.census.gov/table?q=DP05. U.S. Department of Homeland Security. (2021). REAL ID Act: Federal Enforcement; State Compliance, Extensions and Implementation. Retrieved on April 1, 2021 from https://www.dhs.gov/real-id

4.6 Figures

Figure 4.1 Null Interrupted Time Series Model (Linden, 2015; Linden & Adams, 2011)

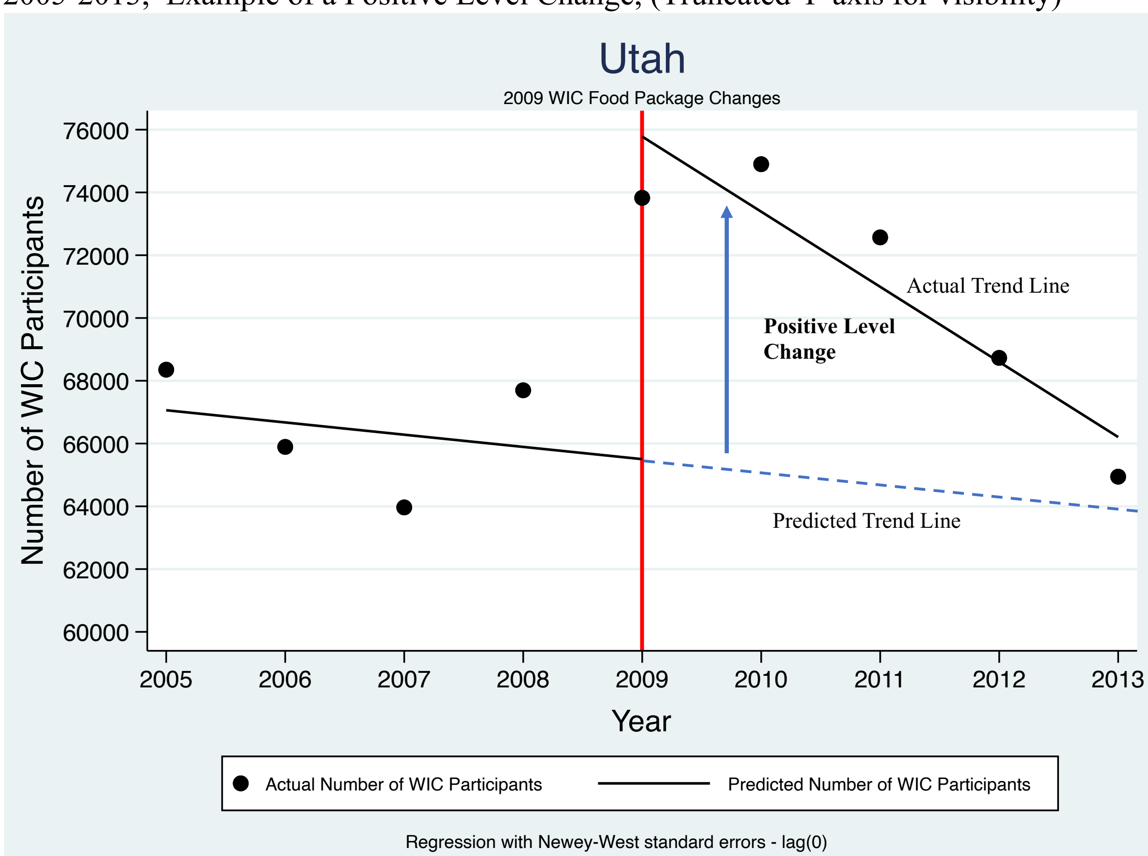
$Y_t = \beta_0 + \beta_1 T_t + \beta_2 X_t + \beta_3 X_t T_t + \varepsilon_t$

Y_t: number of WIC participants at time, t.
T_t: number of years since the start of the study, years from 2005.
X_t: Indicator variable for pre-policy period (0) or (1) if otherwise
$X_t T_t$: interaction term of time and policy period variables

β_0: the number of WIC participants in 2005
β_1: Average change in the number of WIC participants each year
β_2: The difference between the number of WIC participants expected after the 2009 Food Package Changes based on pre-policy trends, and the number of WIC participants actually observed immediately
β_3: Difference between pre-policy and post-policy slopes in the number of WIC participants over time (trend change/indicate a treatment effect over time)
ε_t: Error term

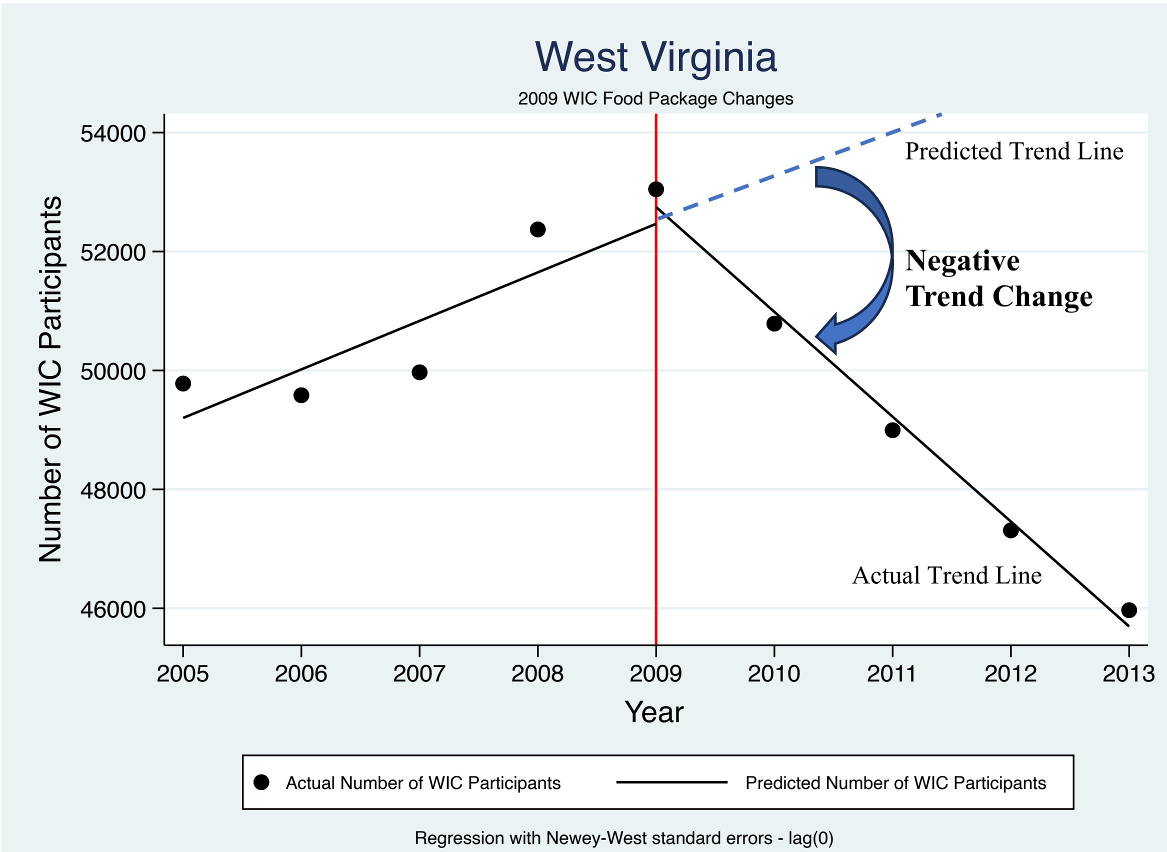
Data Source: Linden, A. (2015). Conducting interrupted time-series analysis for single- and multiple-group comparisons. *The Stata Journal*, 15(2), 480–500. Linden, A., & Adams, J. L. (2011). Applying a propensity score-based weighting model to interrupted time series data: improving causal inference in programme evaluation. *J Eval Clin Pract*, 17(6), 1231-1238. https://doi.org/10.1111/j.1365-2753.2010.01504.x

Figure 4.2 Null Interrupted Time Series Model for Utah, Number of WIC Participants by Year, 2005-2013, Example of a Positive Level Change, (Truncated Y-axis for visibility)



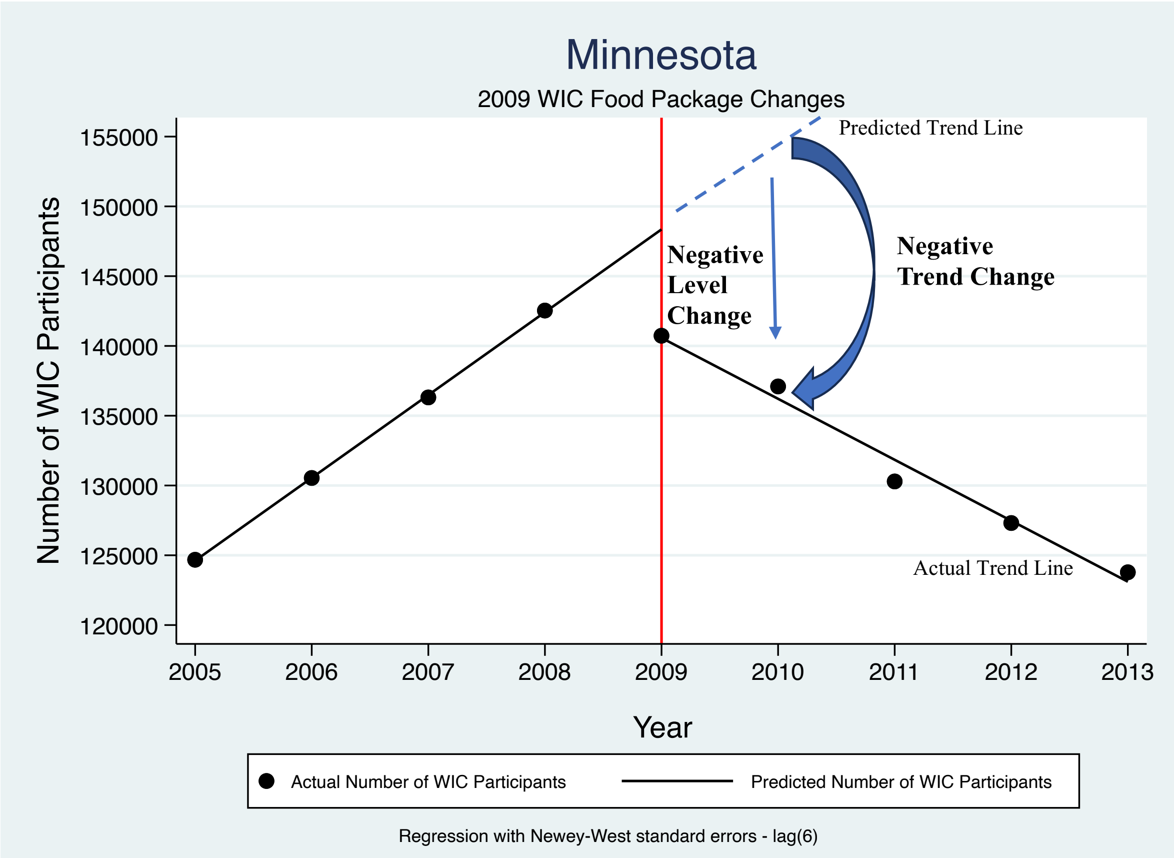
Data Source: Johnson, et al. (2017). *National- and State-Level Estimates of Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) Eligibles and Program Reach in 2014, and Updated Estimates for 2005–2013.* U.S. Department of Agriculture, Food and Nutrition Service, Office of Policy Support.

Figure 4.3 Null Interrupted Time Series Model for West Virginia Number of WIC Participants by Year, 2005-2013, Example of a Negative Trend Change (Truncated Y-axis for visibility)



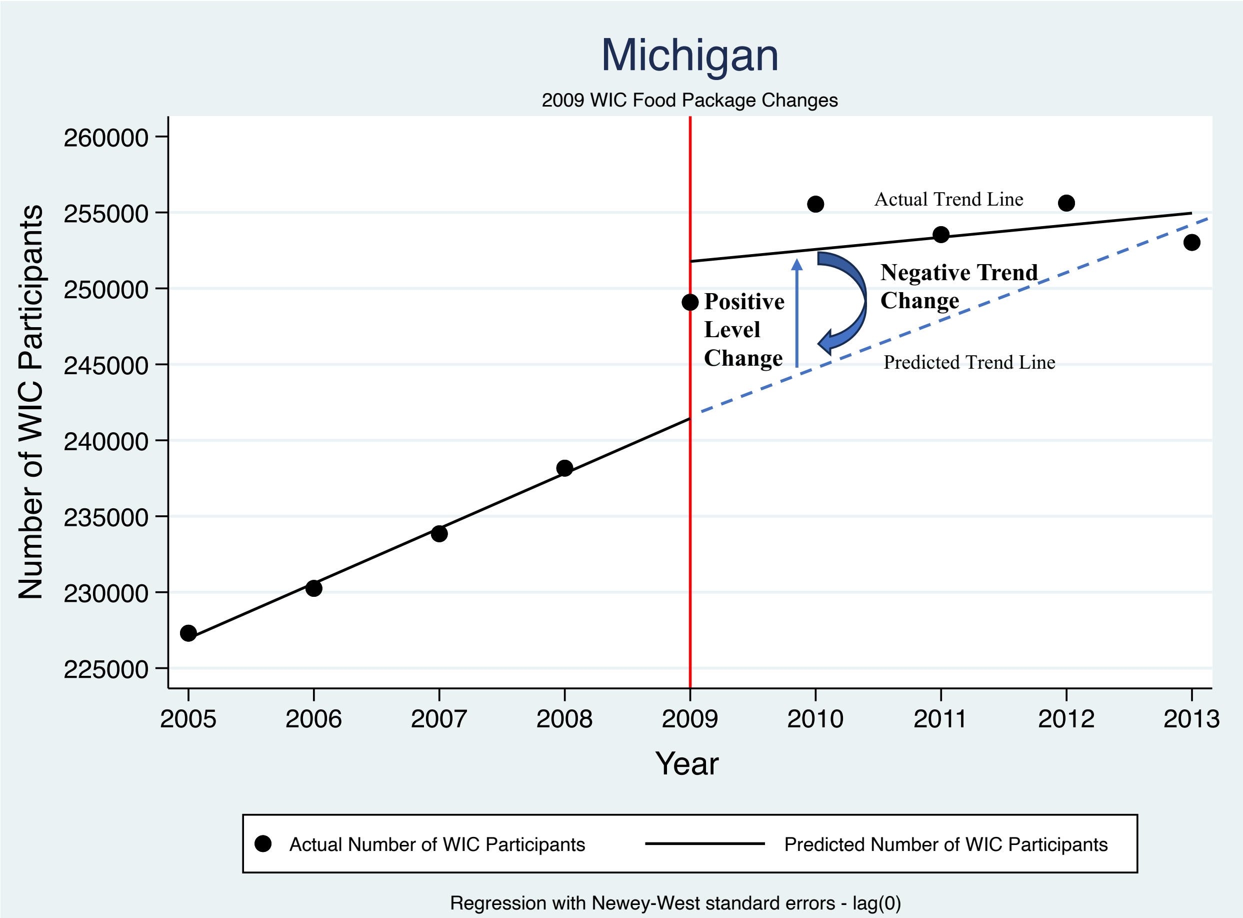
Data Source: Johnson, et al. (2017). *National- and State-Level Estimates of Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) Eligibles and Program Reach in 2014, and Updated Estimates for 2005–2013.* U.S. Department of Agriculture, Food and Nutrition Service, Office of Policy Support

Figure 4.4 Null Interrupted Time Series Model for Minnesota, Number of WIC Participants by Year, 2005-2013, Example of a Negative Level and Negative Trend Change (Truncated Y-axis for visibility)



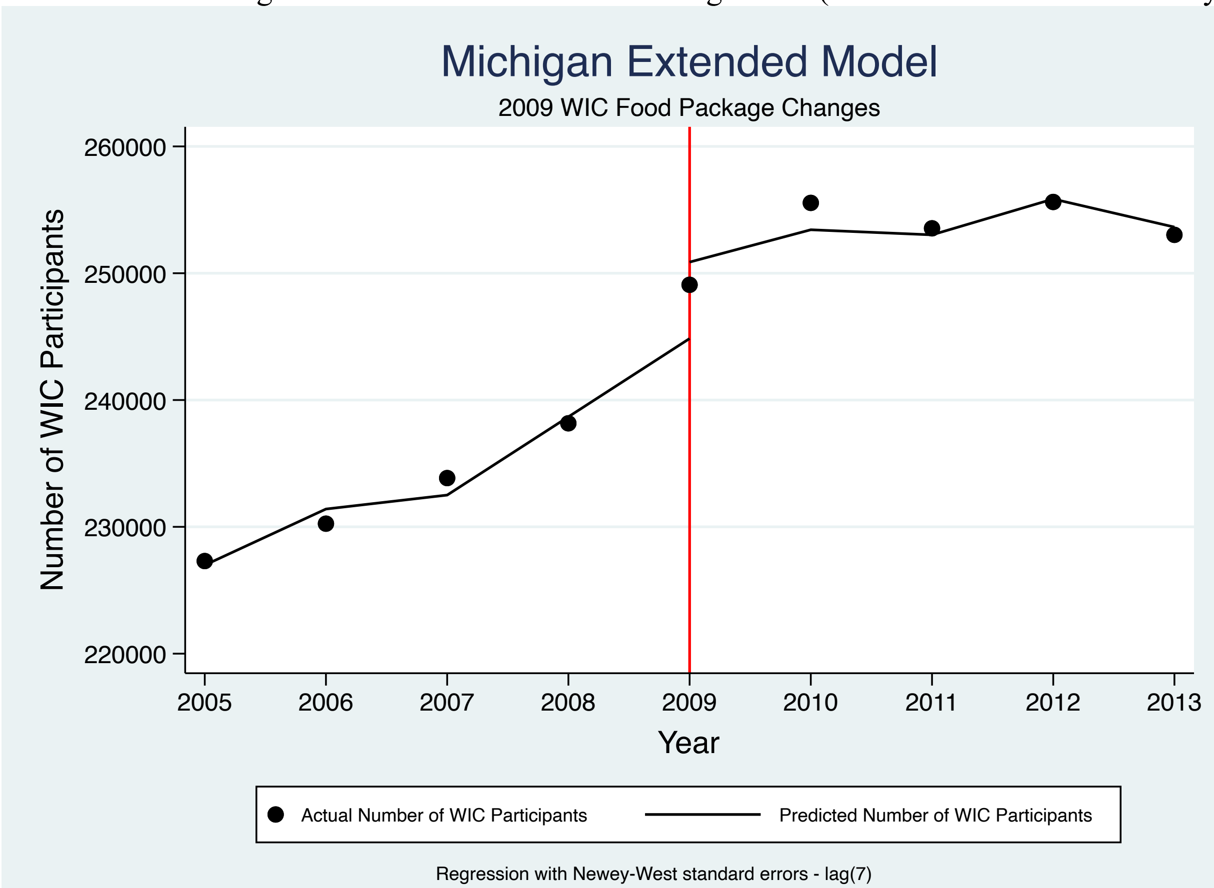
Data Source: Johnson, et al. (2017). *National- and State-Level Estimates of Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) Eligibles and Program Reach in 2014, and Updated Estimates for 2005–2013.* U.S. Department of Agriculture, Food and Nutrition Service, Office of Policy Support

Figure 4.5 Null Interrupted Time Series Model for Michigan, Number of WIC Participants by Year, 2005-2013, Example of a Positive Level Change and Negative Trend Change (Truncated Y-axis for visibility)



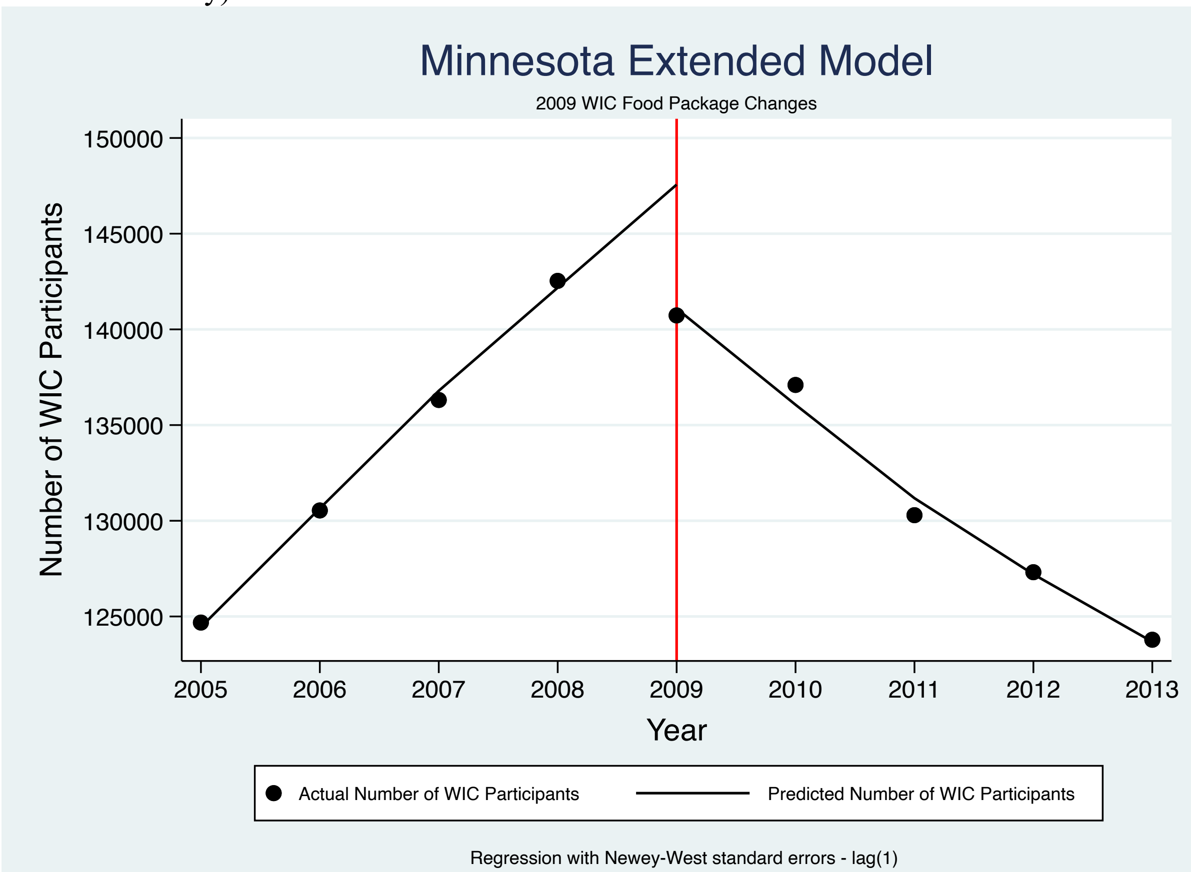
Data Source: Johnson, et al. (2017). *National- and State-Level Estimates of Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) Eligibles and Program Reach in 2014, and Updated Estimates for 2005–2013.* U.S. Department of Agriculture, Food and Nutrition Service, Office of Policy Support

Figure 4.6 Extended Interrupted Time Series Model for Michigan, Number of WIC Participants by Year, 2005-2013, Positive Level Change and Negative Trend Change, Adjusted for the Number of WIC Eligible Individuals and Percent Foreign Born (Truncated Y-axis for visibility)



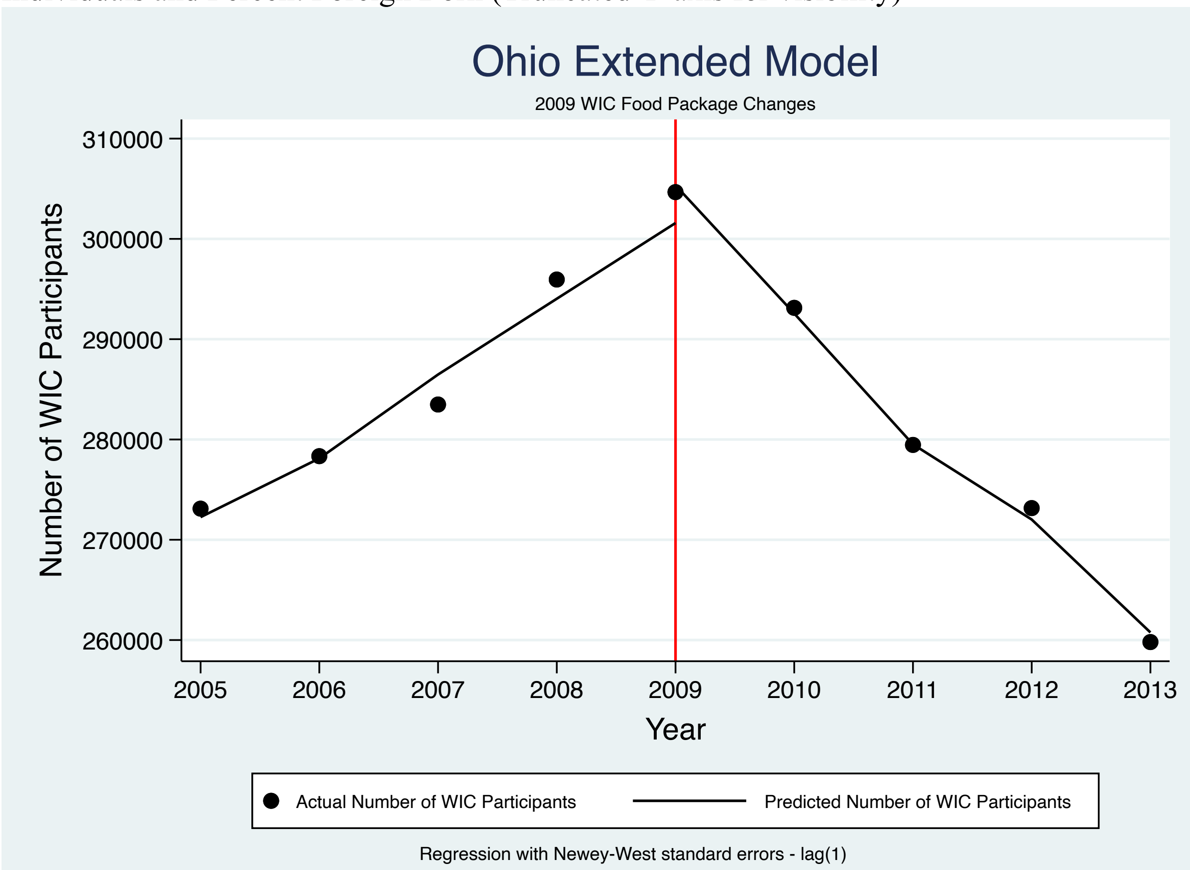
Data Sources: Johnson, et al. (2017). *National- and State-Level Estimates of Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) Eligibles and Program Reach in 2014, and Updated Estimates for 2005–2013.* U.S. Department of Agriculture, Food and Nutrition Service, Office of Policy Support. U.S. Census Bureau (2023b). *American Community Survey. Selected Social Characteristics in the United States.* Retrieved Sept 6, 2023 from https://data.census.gov/table?q=DP02

Figure 4.7 Extended Interrupted Time Series Model for Minnesota, Number of WIC Participants by Year, 2005-2013, Example of a Negative Level Change and Negative Trend Change, Adjusted for the Number of WIC Eligible Individuals and Percent Foreign Born (Truncated Y-axis for visibility)



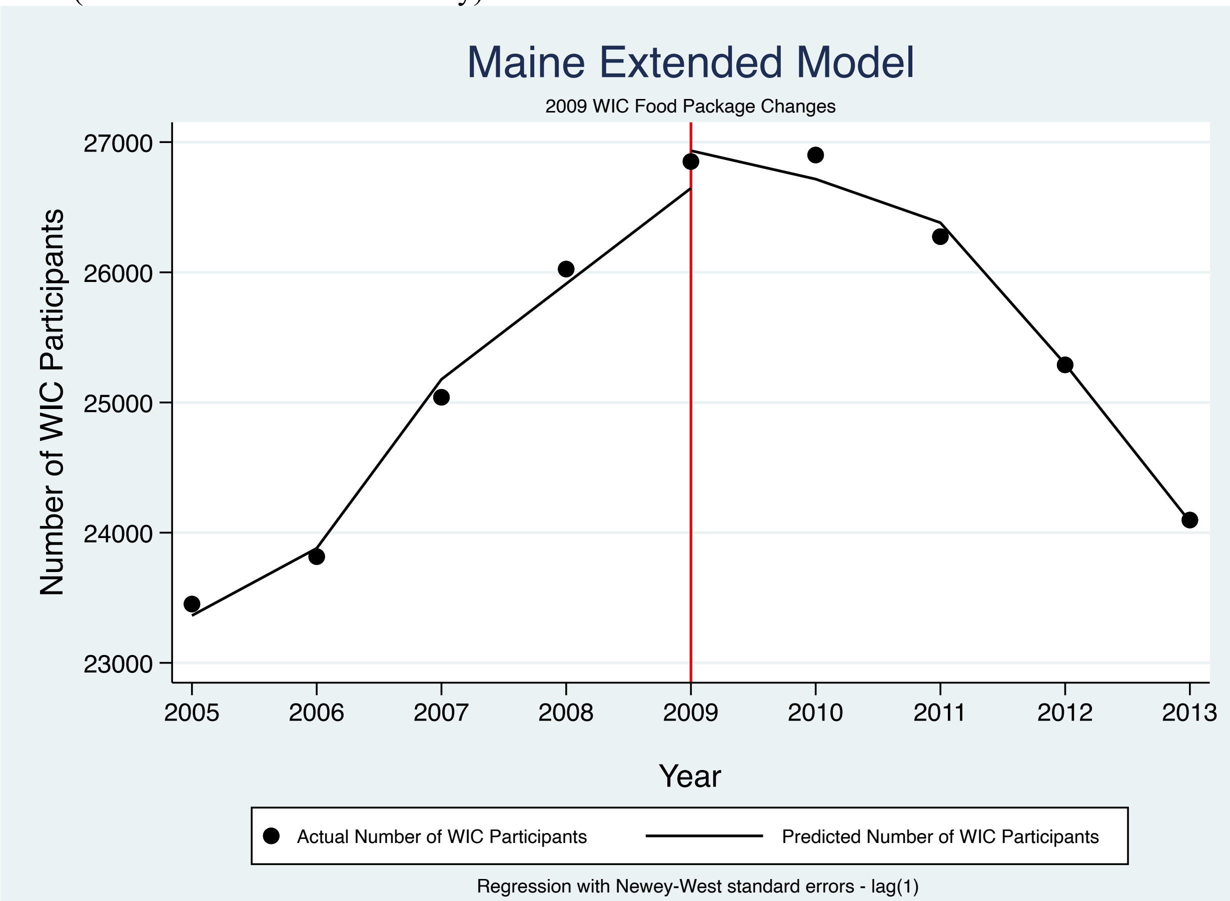
Data Sources: Johnson, et al. (2017). *National- and State-Level Estimates of Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) Eligibles and Program Reach in 2014, and Updated Estimates for 2005–2013.* U.S. Department of Agriculture, Food and Nutrition Service, Office of Policy Support. U.S. Census Bureau (2023b). *American Community Survey. Selected Social Characteristics in the United States.* Retrieved Sept 6, 2023 from https://data.census.gov/table?q=DP02

Figure 4.8 Extended Interrupted Time Series Model for Ohio, Number of WIC Participants by Year, 2005-2013, Example of Negative Trend Change, Adjusted for the Number of WIC Eligible Individuals and Percent Foreign Born (Truncated Y-axis for visibility)



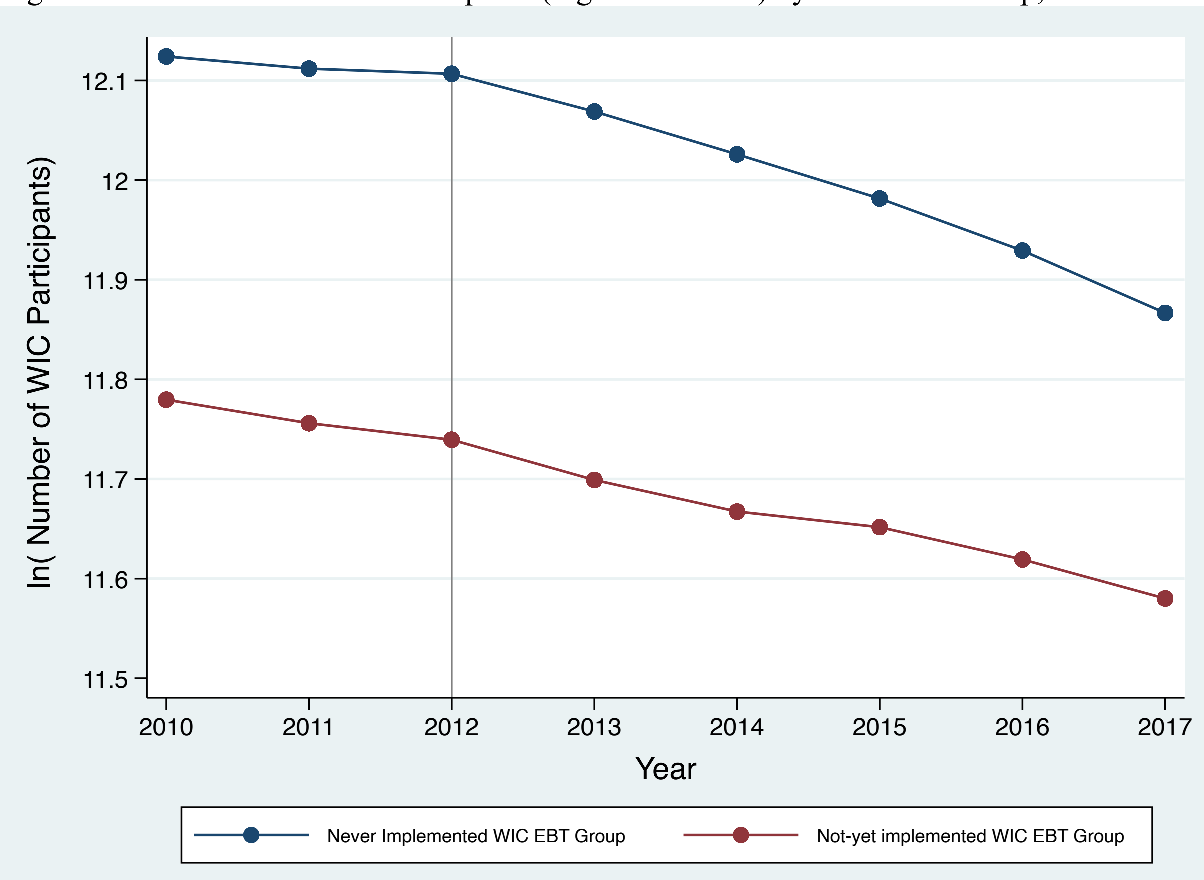
Data Sources: Johnson, et al. (2017). *National- and State-Level Estimates of Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) Eligibles and Program Reach in 2014, and Updated Estimates for 2005–2013.* U.S. Department of Agriculture, Food and Nutrition Service, Office of Policy Support. U.S. Census Bureau (2023b). *American Community Survey. Selected Social Characteristics in the United States.* Retrieved Sept 6, 2023 from https://data.census.gov/table?q=DP02

Figure 4.9 Extended Interrupted Time Series Model for Maine, Number of WIC Participants by Year, 2005-2013, Adjusted for the Number of WIC Eligible Individuals and Percent Foreign Born (Truncated Y-axis for visibility)



Data Sources: Johnson, et al. (2017). *National- and State-Level Estimates of Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) Eligibles and Program Reach in 2014, and Updated Estimates for 2005–2013.* U.S. Department of Agriculture, Food and Nutrition Service, Office of Policy Support. U.S. Census Bureau (2023b). *American Community Survey. Selected Social Characteristics in the United States.* Retrieved Sept 6, 2023 from https://data.census.gov/table?q=DP02

Figure 4.10. Number of WIC Participants (log-transformed) by WIC EBT Group, 2010-2017



Data Sources: U.S. Department of Agriculture. (2023). *WIC EBT Activities*. U.S. Department of Agriculture, Food and Nutrition Services. Retrieved April 3, 2023 from https://www.fns.usda.gov/wic/wic-ebt-activities. Johnson, et al. (2017). *National- and State-Level Estimates of Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) Eligibles and Program Reach in 2014, and Updated Estimates for 2005–2013.* U.S. Department of Agriculture, Food and Nutrition Service, Office of Policy Support. Trippe, et al. (2018). *National- and State-Level Estimates of Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) Eligibles and Program Reach in 2015*. Alexandria, VA: U.S. Department of Agriculture, Food and Nutrition Service, Office of Policy Support. Trippe, et al. (2019). *National- and State-Level Estimates of Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) Eligibles and Program Reach in 2016.* Alexandria, VA: U.S. Department of Agriculture, Food and Nutrition Service, Office of Policy Support. Gray, et al. *National- and State-Level Estimates of WIC Eligibility and WIC Program Reach in 2017.* Alexandria, VA: U.S. Department of Agriculture, Food and Nutrition Service, Office of Policy Support.

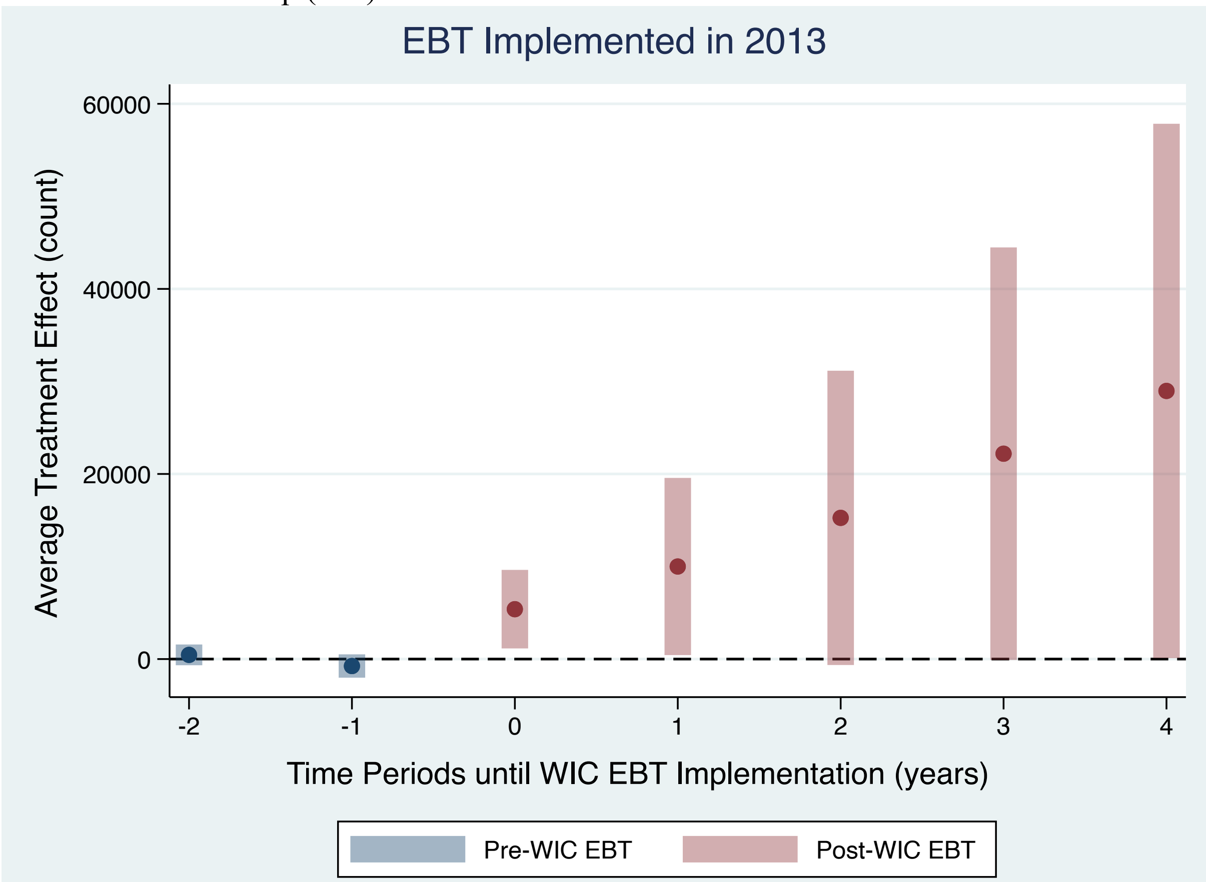
Figure 4.11 Null Difference-in-differences Two-way Fixed Effects Model for WIC EBT (Dettmann et al., 2021; Goodman-Bacon, 2018, 2021; Wing et al., 2018)

$Y_{gt} = a_g + b_t + \delta D_{gt} + \varepsilon_{gt}$

Y: The number of WIC participants in group *g* at time *t*
g: Group
t: Time period
$D_{gt:}$ WIC EBT implementation status of group *g* at time *t*
$\alpha_{g:}$ Group-fixed effect
$b_{t\,:}$ Time-fixed effect
δ: Global treatment effect
$\varepsilon_{gt:}$ Error term

Data Sources: Dettmann, et al. (2021). flexpaneldid: A Stata toolbox for causal analysis with varying treatment time and duration. https://doi.org/http://dx.doi.org/10.2139/ssrn.3692458. Goodman-Bacon, A. (2018). Difference-in-Differences With Variation in Treatment Timing. Working Paper 25018. *NBER Working Paper Series*. http://www.nber.org/papers/w25018. Goodman-Bacon, A. (2021). Difference-in-differences with variation in treatment timing. *Journal of Econometrics*, 225(2), 254-277. https://doi.org/10.1016/j.jeconom.2021.03.014. Wing, et al. (2018). Designing Difference in Difference Studies: Best Practices for Public Health Policy Research. *Annu Rev Public Health*, *39*, 453-469. https://doi.org/10.1146/annurev-publhealth- U.S. Department of Agriculture. (2023). *WIC EBT Activities*. U.S. Department of Agriculture, Food and Nutrition Services. Retrieved April 3, 2023 from https://www.fns.usda.gov/wic/wic-ebt-activities.

Figure 4.12. Average Treatment Effect in Number of WIC Participants by Year for the 2013 WIC EBT Time Group (n=1)



Data Sources: U.S. Department of Agriculture. (2023). *WIC EBT Activities*. U.S. Department of Agriculture, Food and Nutrition Services. Retrieved April 3, 2023 from https://www.fns.usda.gov/wic/wic-ebt-activities. Johnson, et al. (2017). *National- and State-Level Estimates of Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) Eligibles and Program Reach in 2014, and Updated Estimates for 2005–2013.* U.S. Department of Agriculture, Food and Nutrition Service, Office of Policy Support. Trippe, et al. (2018). *National- and State-Level Estimates of Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) Eligibles and Program Reach in 2015*. Alexandria, VA: U.S. Department of Agriculture, Food and Nutrition Service, Office of Policy Support. Trippe, et al. (2019). *National- and State-Level Estimates of Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) Eligibles and Program Reach in 2016.* Alexandria, VA: U.S. Department of Agriculture, Food and Nutrition Service, Office of Policy Support. Gray, et al. *National- and State-Level Estimates of WIC Eligibility and WIC Program Reach in 2017.* Alexandria, VA: U.S. Department of Agriculture, Food and Nutrition Service, Office of Policy Support. Rios-Avila, F., Callaway, B., & Sant'Anna, P. H. C. (2021). csdid: Difference-in-Differences with Multiple Time Periods in Stata [PowerPoint Slides]. Stata Conference, Virtual.
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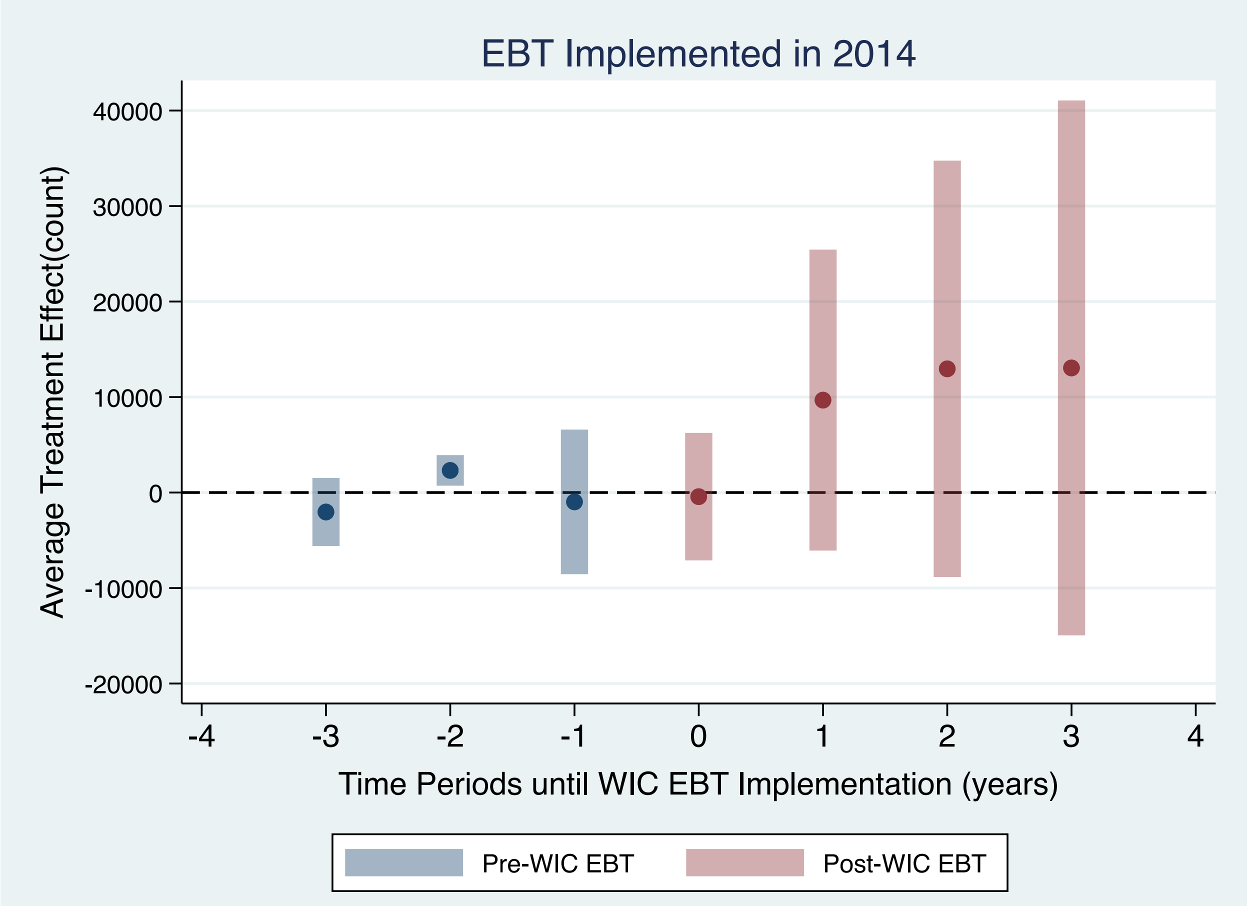
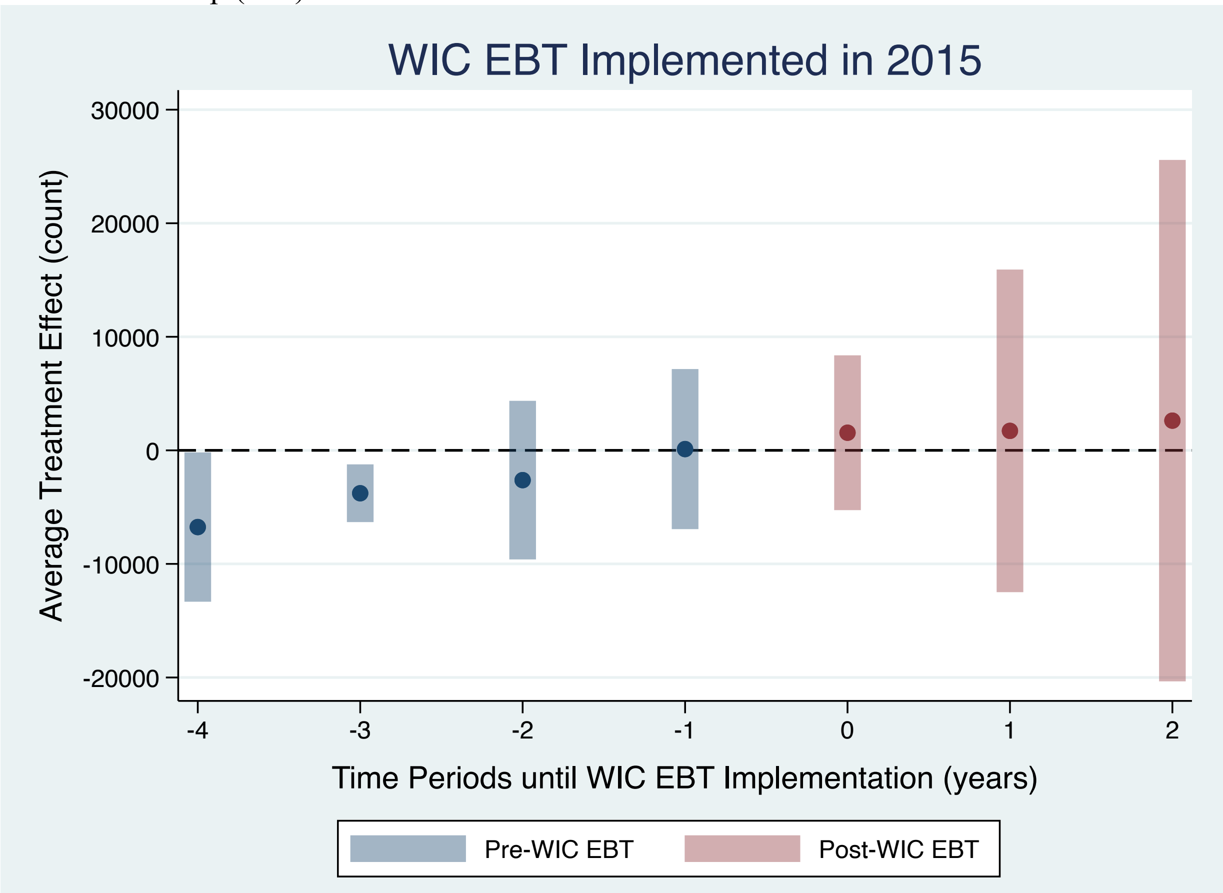
Figure 4.13 Average Treatment Effect in Number of WIC Participants by Year for the 2014 WIC EBT Time Group (n=3)



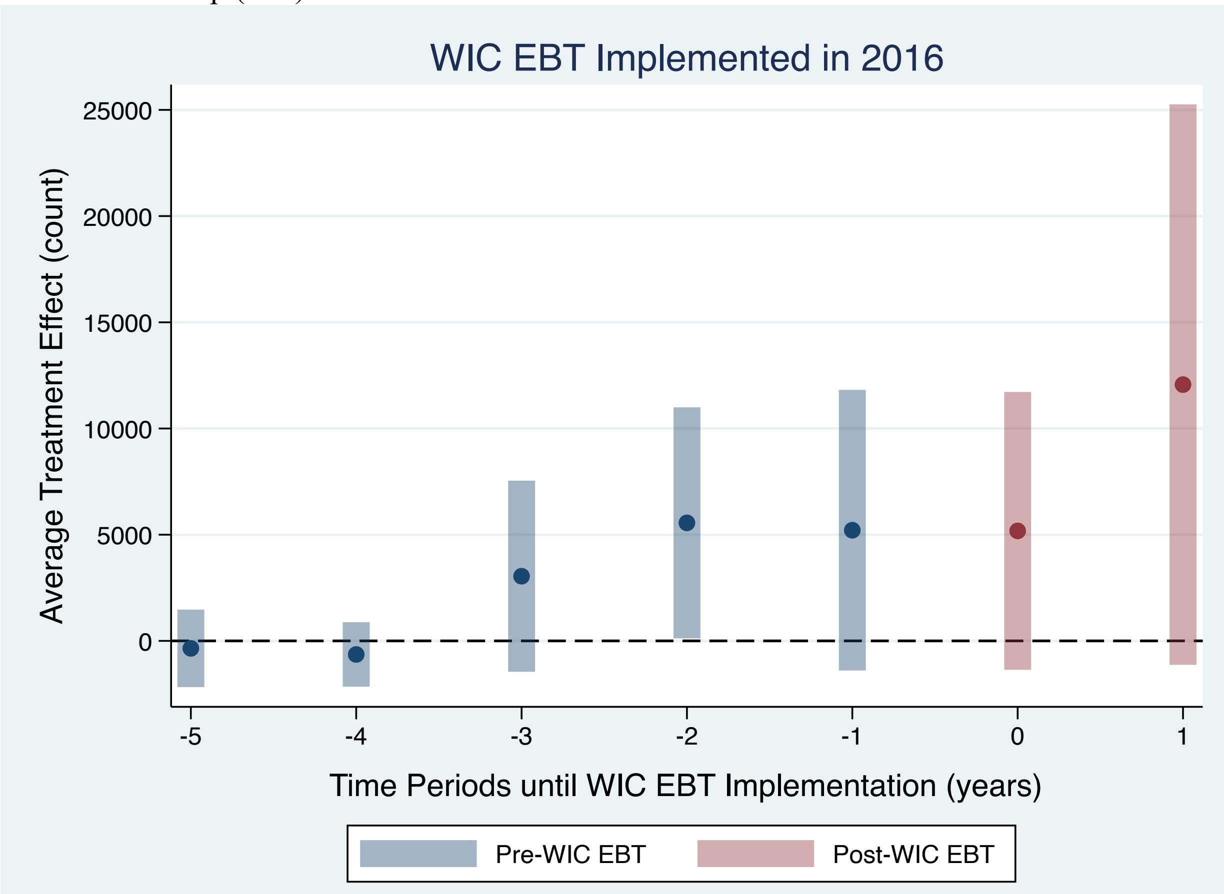
Data Sources: U.S. Department of Agriculture. (2023). *WIC EBT Activities*. U.S. Department of Agriculture, Food and Nutrition Services. Retrieved April 3, 2023 from https://www.fns.usda.gov/wic/wic-ebt-activities. Johnson, et al. (2017). *National- and State-Level Estimates of Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) Eligibles and Program Reach in 2014, and Updated Estimates for 2005–2013.* U.S. Department of Agriculture, Food and Nutrition Service, Office of Policy Support. Trippe, et al. (2018). *National- and State-Level Estimates of Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) Eligibles and Program Reach in 2015*. Alexandria, VA: U.S. Department of Agriculture, Food and Nutrition Service, Office of Policy Support. Trippe, et al. (2019). *National- and State-Level Estimates of Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) Eligibles and Program Reach in 2016*. Alexandria, VA: U.S. Department of Agriculture, Food and Nutrition Service, Office of Policy Support. Gray, et al. *National- and State-Level Estimates of WIC Eligibility and WIC Program Reach in 2017.* Alexandria, VA: U.S. Department of Agriculture, Food and Nutrition Service, Office of Policy Support. Rios-Avila, F., Callaway, B., & Sant'Anna, P. H. C. (2021). csdid: Difference-in-Differences with Multiple Time Periods in Stata [PowerPoint Slides]. Stata Conference, Virtual.

Figure 4.14 Average Treatment Effect in Number of WIC Participants by Year for the 2015 WIC EBT Time Group (n=2)



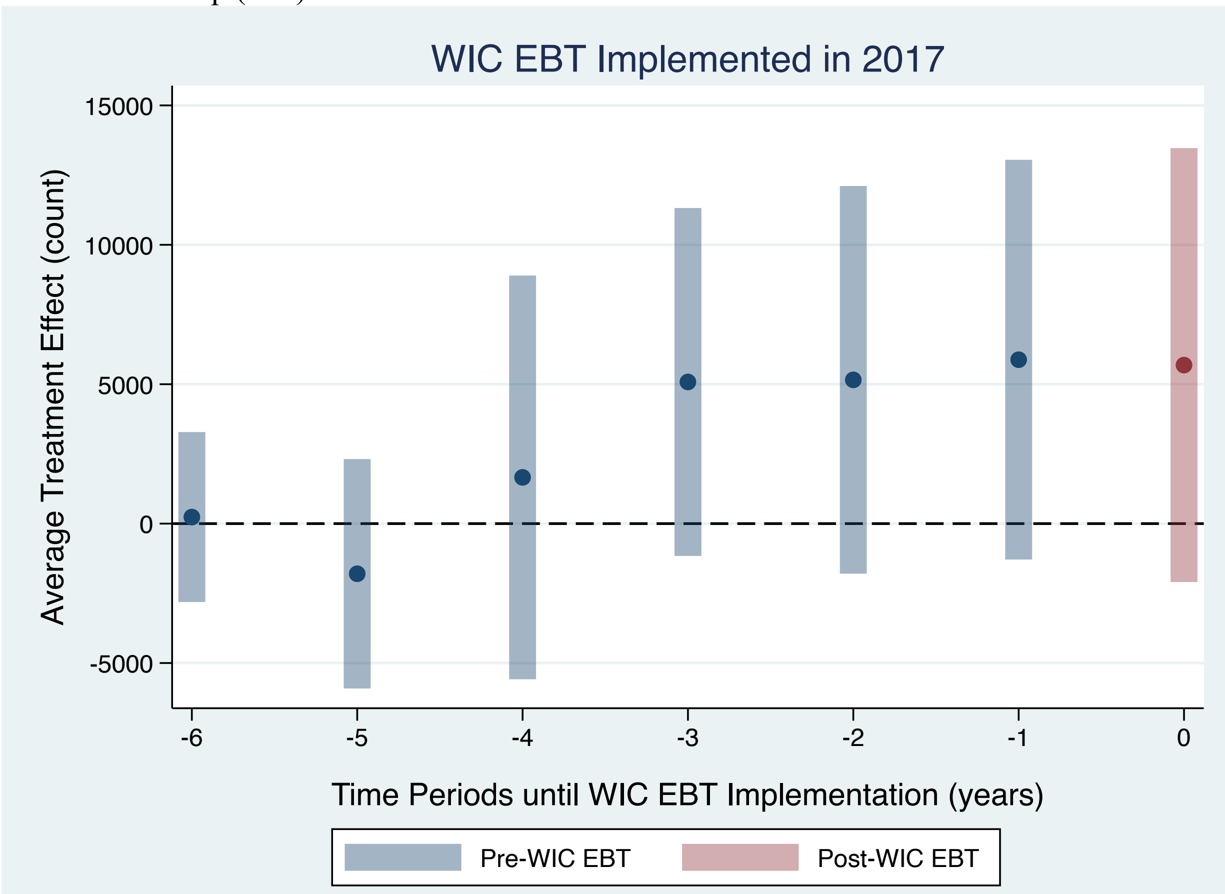
Data Sources: U.S. Department of Agriculture. (2023). *WIC EBT Activities*. U.S. Department of Agriculture, Food and Nutrition Services. Retrieved April 3, 2023 from https://www.fns.usda.gov/wic/wic-ebt-activities. Johnson, et al. (2017). *National- and State-Level Estimates of Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) Eligibles and Program Reach in 2014, and Updated Estimates for 2005–2013.* U.S. Department of Agriculture, Food and Nutrition Service, Office of Policy Support. Trippe, et al. (2018). *National- and State-Level Estimates of Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) Eligibles and Program Reach in 2015*. Alexandria, VA: U.S. Department of Agriculture, Food and Nutrition Service, Office of Policy Support. Trippe, et al. (2019). *National- and State-Level Estimates of Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) Eligibles and Program Reach in 2016*. Alexandria, VA: U.S. Department of Agriculture, Food and Nutrition Service, Office of Policy Support. Gray, et al. *National- and State-Level Estimates of WIC Eligibility and WIC Program Reach in 2017.* Alexandria, VA: U.S. Department of Agriculture, Food and Nutrition Service, Office of Policy Support. Rios-Avila, F., Callaway, B., & Sant'Anna, P. H. C. (2021). csdid: Difference-in-Differences with Multiple Time Periods in Stata [PowerPoint Slides]. Stata Conference, Virtual.

Figure 4.15 Average Treatment Effect in Number of WIC Participants by Year for the 2016 WIC EBT Time Group (n=9)



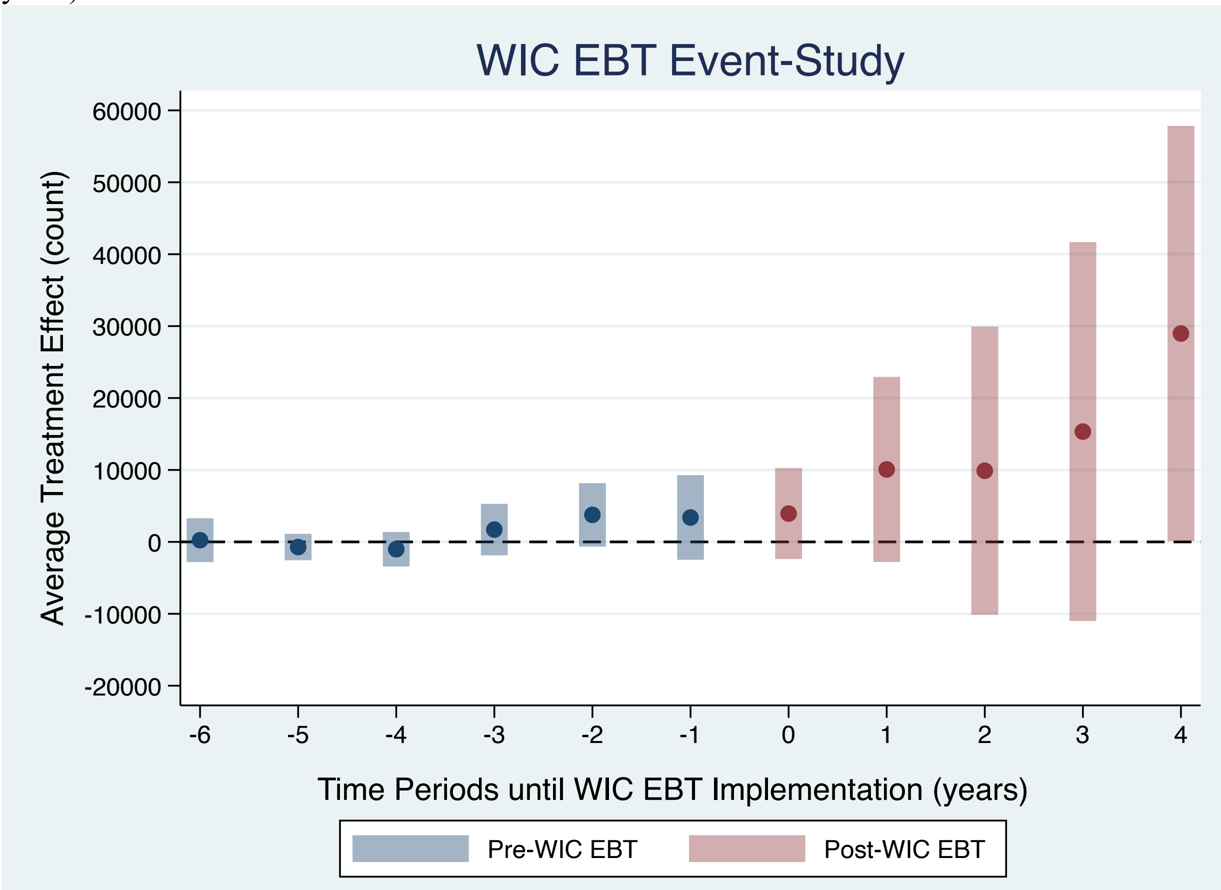
Data Sources: U.S. Department of Agriculture. (2023). *WIC EBT Activities*. U.S. Department of Agriculture, Food and Nutrition Services. Retrieved April 3, 2023 from https://www.fns.usda.gov/wic/wic-ebt-activities. Johnson, et al. (2017). *National- and State-Level Estimates of Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) Eligibles and Program Reach in 2014, and Updated Estimates for 2005–2013.* U.S. Department of Agriculture, Food and Nutrition Service, Office of Policy Support. Trippe, et al. (2018). *National- and State-Level Estimates of Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) Eligibles and Program Reach in 2015*. Alexandria, VA: U.S. Department of Agriculture, Food and Nutrition Service, Office of Policy Support. Trippe, et al. (2019). *National- and State-Level Estimates of Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) Eligibles and Program Reach in 2016.* Alexandria, VA: U.S. Department of Agriculture, Food and Nutrition Service, Office of Policy Support. Gray, et al. *National- and State-Level Estimates of WIC Eligibility and WIC Program Reach in 2017.* Alexandria, VA: U.S. Department of Agriculture, Food and Nutrition Service, Office of Policy Support. Rios-Avila, F., Callaway, B., & Sant'Anna, P. H. C. (2021). csdid: Difference-in-Differences with Multiple Time Periods in Stata [PowerPoint Slides]. Stata Conference, Virtual.

Figure 4.16 Average Treatment Effect in Number of WIC Participants by Year for the 2017 WIC EBT Time Group (n=3)



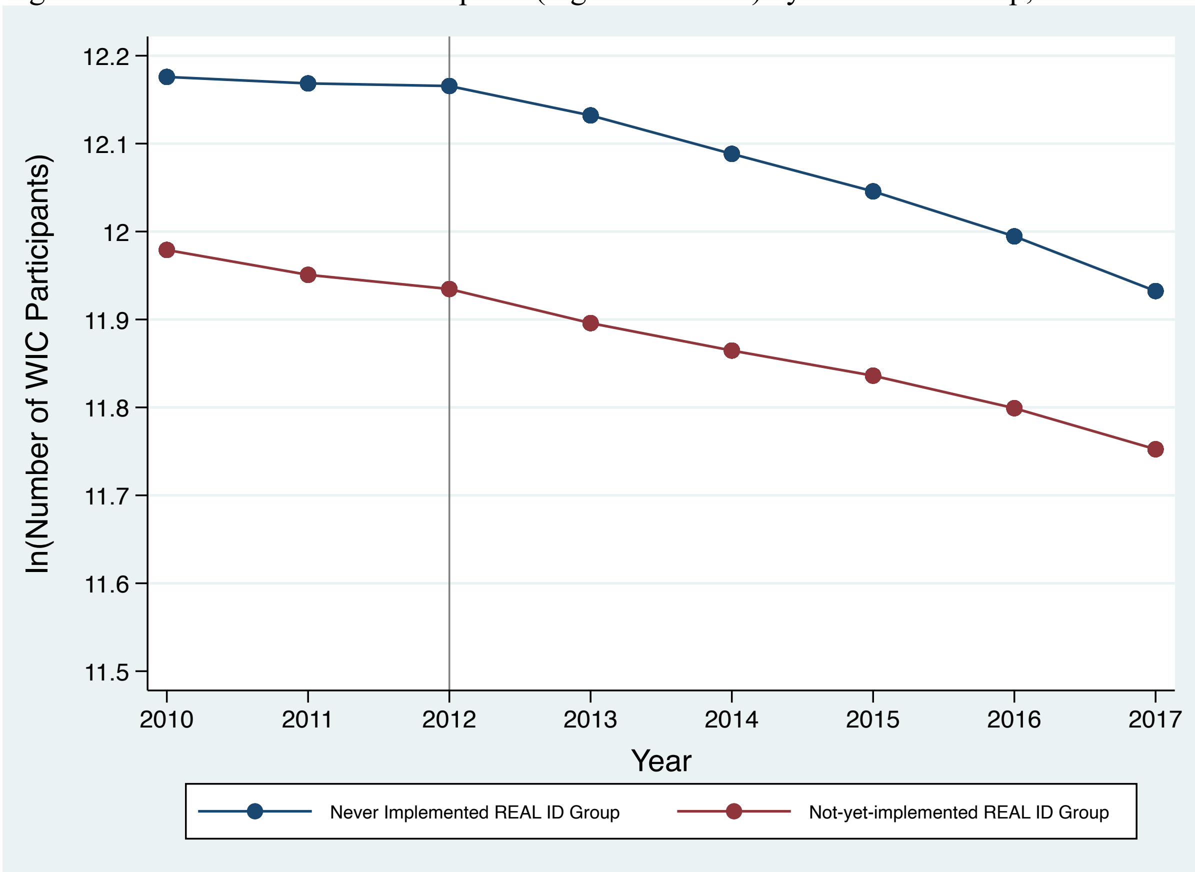
Data Sources: U.S. Department of Agriculture. (2023). *WIC EBT Activities*. U.S. Department of Agriculture, Food and Nutrition Services. Retrieved April 3, 2023 from https://www.fns.usda.gov/wic/wic-ebt-activities. Johnson, et al. (2017). *National- and State-Level Estimates of Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) Eligibles and Program Reach in 2014, and Updated Estimates for 2005–2013.* U.S. Department of Agriculture, Food and Nutrition Service, Office of Policy Support. Trippe, et al. (2018). *National- and State-Level Estimates of Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) Eligibles and Program Reach in 2015*. Alexandria, VA: U.S. Department of Agriculture, Food and Nutrition Service, Office of Policy Support. Trippe, et al. (2019). *National- and State-Level Estimates of Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) Eligibles and Program Reach in 2016*. Alexandria, VA: U.S. Department of Agriculture, Food and Nutrition Service, Office of Policy Support. Gray, et al. *National- and State-Level Estimates of WIC Eligibility and WIC Program Reach in 2017.* Alexandria, VA: U.S. Department of Agriculture, Food and Nutrition Service, Office of Policy Support. Rios-Avila, F., Callaway, B., & Sant'Anna, P. H. C. (2021). csdid: Difference-in-Differences with Multiple Time Periods in Stata [PowerPoint Slides]. Stata Conference, Virtual.

Figure 4.17 Average Treatment Effect in Number of WIC Participants by Exposure Time (in years) to WIC EBT



Data Sources: U.S. Department of Agriculture. (2023). *WIC EBT Activities*. U.S. Department of Agriculture, Food and Nutrition Services. Retrieved April 3, 2023 from https://www.fns.usda.gov/wic/wic-ebt-activities. Johnson, et al. (2017). *National- and State-Level Estimates of Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) Eligibles and Program Reach in 2014, and Updated Estimates for 2005–2013.* U.S. Department of Agriculture, Food and Nutrition Service, Office of Policy Support. Trippe, et al. (2018). *National- and State-Level Estimates of Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) Eligibles and Program Reach in 2015*. Alexandria, VA: U.S. Department of Agriculture, Food and Nutrition Service, Office of Policy Support. Trippe, et al. (2019). *National- and State-Level Estimates of Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) Eligibles and Program Reach in 2016.* Alexandria, VA: U.S. Department of Agriculture, Food and Nutrition Service, Office of Policy Support. Gray, et al. *National- and State-Level Estimates of WIC Eligibility and WIC Program Reach in 2017.* Alexandria, VA: U.S. Department of Agriculture, Food and Nutrition Service, Office of Policy Support. Rios-Avila, F., Callaway, B., & Sant'Anna, P. H. C. (2021). csdid: Difference-in-Differences with Multiple Time Periods in Stata [PowerPoint Slides]. Stata Conference, Virtual.

Figure 4.18 Number of WIC Participants (log-transformed) by REAL ID Group, 2010-2017



Data Sources: U.S. Department of Homeland Security. (2021). REAL ID Act: Federal Enforcement; State Compliance, Extensions and Implementation. Retrieved on April 1, 2021 from https://www.dhs.gov/real-id. Johnson, et al. (2017). *National- and State-Level Estimates of Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) Eligibles and Program Reach in 2014, and Updated Estimates for 2005–2013.* U.S. Department of Agriculture, Food and Nutrition Service, Office of Policy Support. Trippe, et al. (2018). *National- and State-Level Estimates of Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) Eligibles and Program Reach in 2015*. Alexandria, VA: U.S. Department of Agriculture, Food and Nutrition Service, Office of Policy Support. Trippe, et al. (2019). *National- and State-Level Estimates of Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) Eligibles and Program Reach in 2016*. Alexandria, VA: U.S. Department of Agriculture, Food and Nutrition Service, Office of Policy Support. Gray, et al. *National- and State-Level Estimates of WIC Eligibility and WIC Program Reach in 2017.* Alexandria, VA: U.S. Department of Agriculture, Food and Nutrition Service, Office of Policy Support.

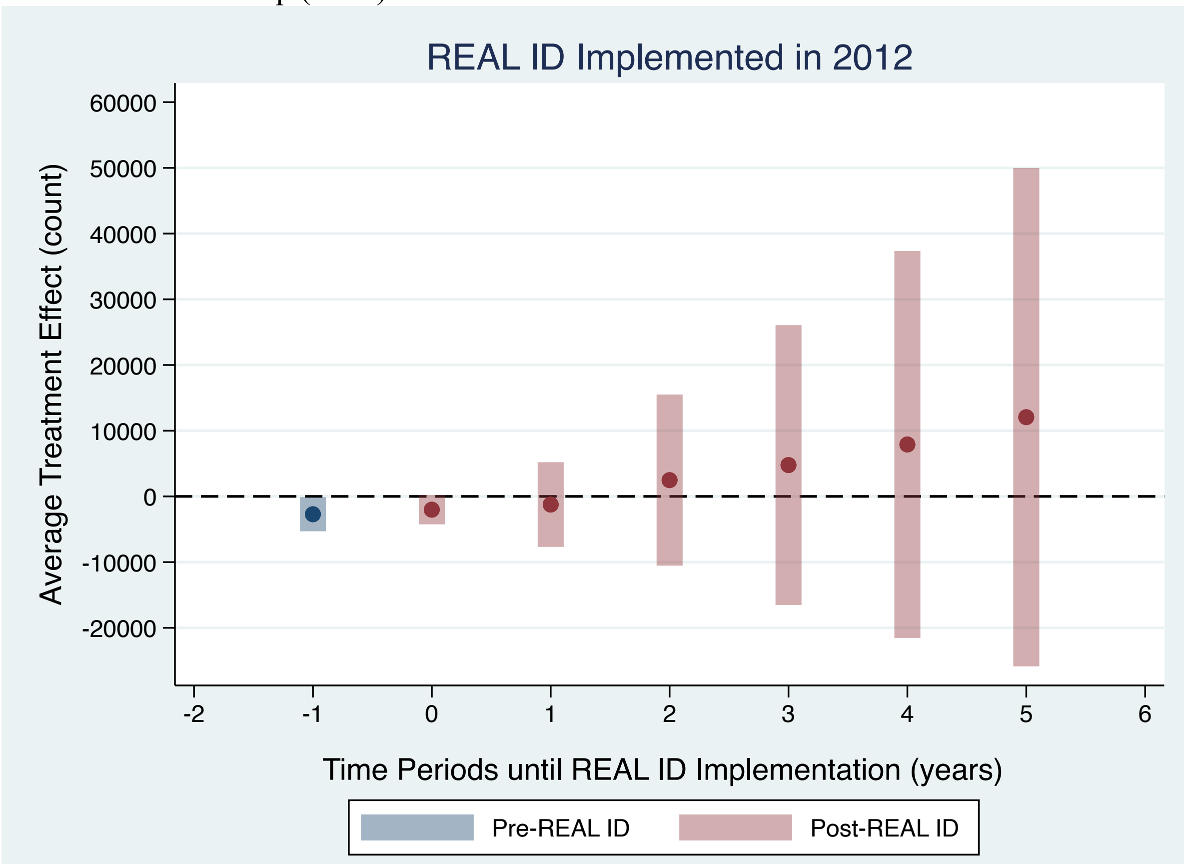
Figure 4.19 Null Difference-in-differences Two-way Fixed Effects Model for REAL ID (Dettmann et al., 2021; Goodman-Bacon, 2018, 2021; Wing et al., 2018)

$Y_{gt} = a_g + b_t + \delta D_{gt} + \varepsilon_{gt}$

Y: The number of WIC participants in group *g* at time *t*
g: Group
t: Time period
D_{gt}: REAL ID policy implementation status of group *g* at time *t*
α_g: Group-fixed effect
b_t: Time-fixed effect
δ: Global treatment effect
ε_{gt}: Error term

Data Sources: Dettmann, et al. (2021). flexpaneldid: A Stata toolbox for causal analysis with varying treatment time and duration. https://doi.org/http://dx.doi.org/10.2139/ssrn.3692458. Goodman-Bacon, A. (2018). Difference-in-Differences With Variation in Treatment Timing. Working Paper 25018. *NBER WORKING PAPER SERIES*. http://www.nber.org/papers/w25018. Goodman-Bacon, A. (2021). Difference-in-differences with variation in treatment timing. *Journal of Econometrics*, 225(2), 254-277. https://doi.org/10.1016/j.jeconom.2021.03.014. Wing, et al. (2018). Designing Difference in Difference Studies: Best Practices for Public Health Policy Research. *Annu Rev Public Health*, *39*, 453-469. https://doi.org/10.1146/annurev-publhealth-U.S. Department of Homeland Security. (2021). REAL ID Act: Federal Enforcement; State Compliance, Extensions and Implementation. Retrieved April 1, 2021 from https://www.dhs.gov/real-id.

Figure 4.20 Average Treatment Effect in Number of WIC Participants by Year for the 2012 REAL ID Time Group (n=13)



Data Sources: U.S. Department of Homeland Security. (2021). REAL ID Act: Federal Enforcement; State Compliance, Extensions and Implementation. Retrieved on April 1, 2021 from https://www.dhs.gov/real-id. Johnson, et al. (2017). *National- and State-Level Estimates of Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) Eligibles and Program Reach in 2014, and Updated Estimates for 2005–2013.* U.S. Department of Agriculture, Food and Nutrition Service, Office of Policy Support. Trippe, et al. (2018). *National- and State-Level Estimates of Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) Eligibles and Program Reach in 2015*. Alexandria, VA: U.S. Department of Agriculture, Food and Nutrition Service, Office of Policy Support. Trippe, et al. (2019). *National- and State-Level Estimates of Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) Eligibles and Program Reach in 2016*. Alexandria, VA: U.S. Department of Agriculture, Food and Nutrition Service, Office of Policy Support. Gray, et al. *National- and State-Level Estimates of WIC Eligibility and WIC Program Reach in 2017.* Alexandria, VA: U.S. Department of Agriculture, Food and Nutrition Service, Office of Policy Support. Rios-Avila, F., Callaway, B., & Sant'Anna, P. H. C. (2021). csdid: Difference-in-Differences with Multiple Time Periods in Stata [PowerPoint Slides]. Stata Conference, Virtual.

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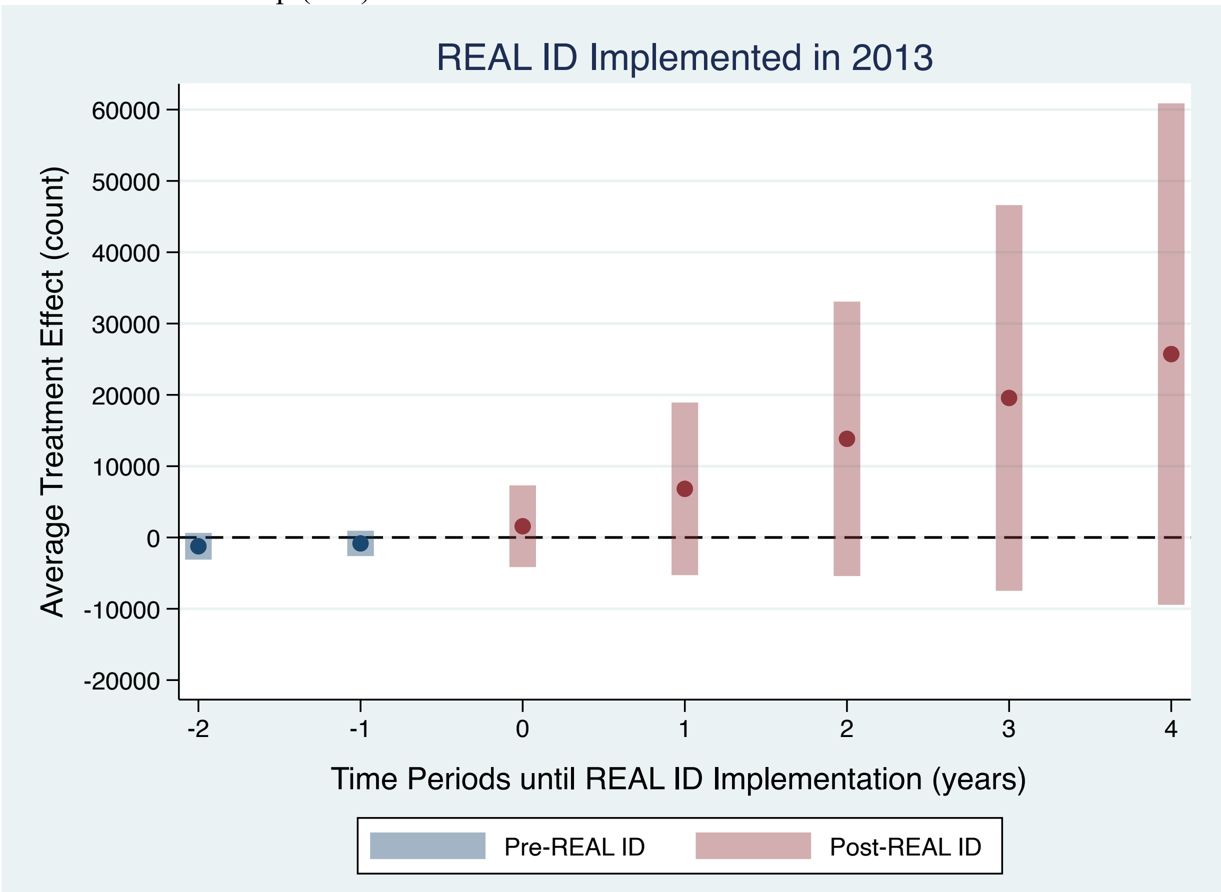
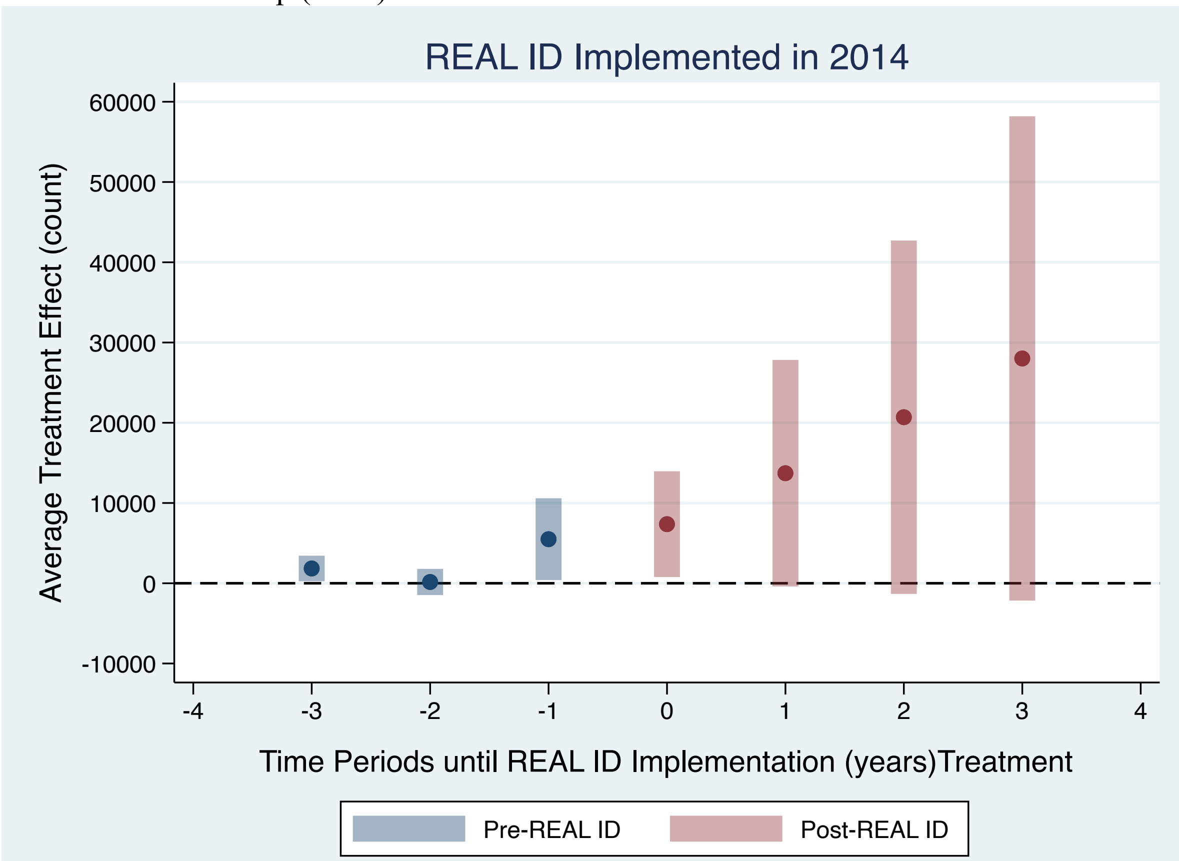
Figure 4.21 Average Treatment Effect in Number of WIC Participants by Year for the 2013 REAL ID Time Group (n=8)



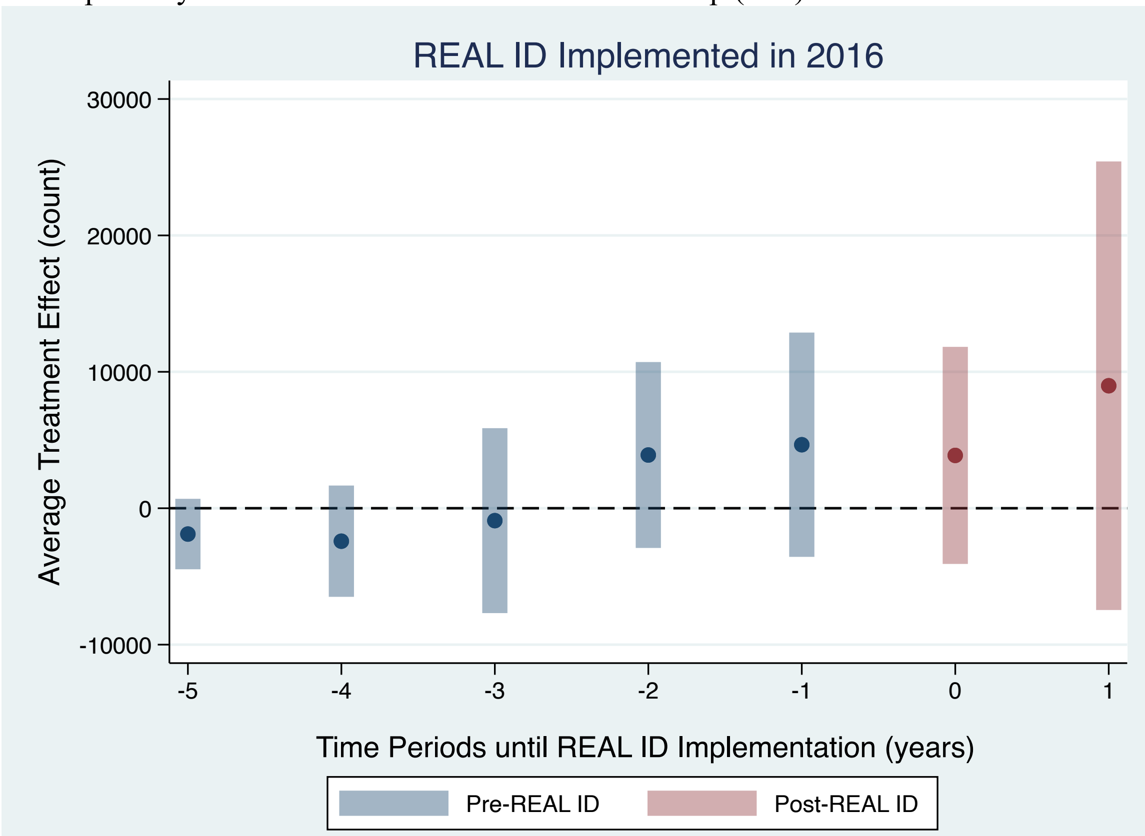
Data Sources: U.S. Department of Homeland Security. (2021). REAL ID Act: Federal Enforcement; State Compliance, Extensions and Implementation. Retrieved on April 1, 2021 from https://www.dhs.gov/real-id. Johnson, et al. (2017). *National- and State-Level Estimates of Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) Eligibles and Program Reach in 2014, and Updated Estimates for 2005–2013.* U.S. Department of Agriculture, Food and Nutrition Service, Office of Policy Support. Trippe, et al. (2018). *National- and State-Level Estimates of Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) Eligibles and Program Reach in 2015*. Alexandria, VA: U.S. Department of Agriculture, Food and Nutrition Service, Office of Policy Support. Trippe, et al. (2019). *National- and State-Level Estimates of Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) Eligibles and Program Reach in 2016*. Alexandria, VA: U.S. Department of Agriculture, Food and Nutrition Service, Office of Policy Support. Gray, et al. *National- and State-Level Estimates of WIC Eligibility and WIC Program Reach in 2017.* Alexandria, VA: U.S. Department of Agriculture, Food and Nutrition Service, Office of Policy Support. Rios-Avila, F., Callaway, B., & Sant'Anna, P. H. C. (2021). csdid: Difference-in-Differences with Multiple Time Periods in Stata [PowerPoint Slides]. Stata Conference, Virtual.

Figure 4.22. Average Treatment Effect in Number of WIC Participants by Year for the 2014 REAL ID Time Group (n=12)



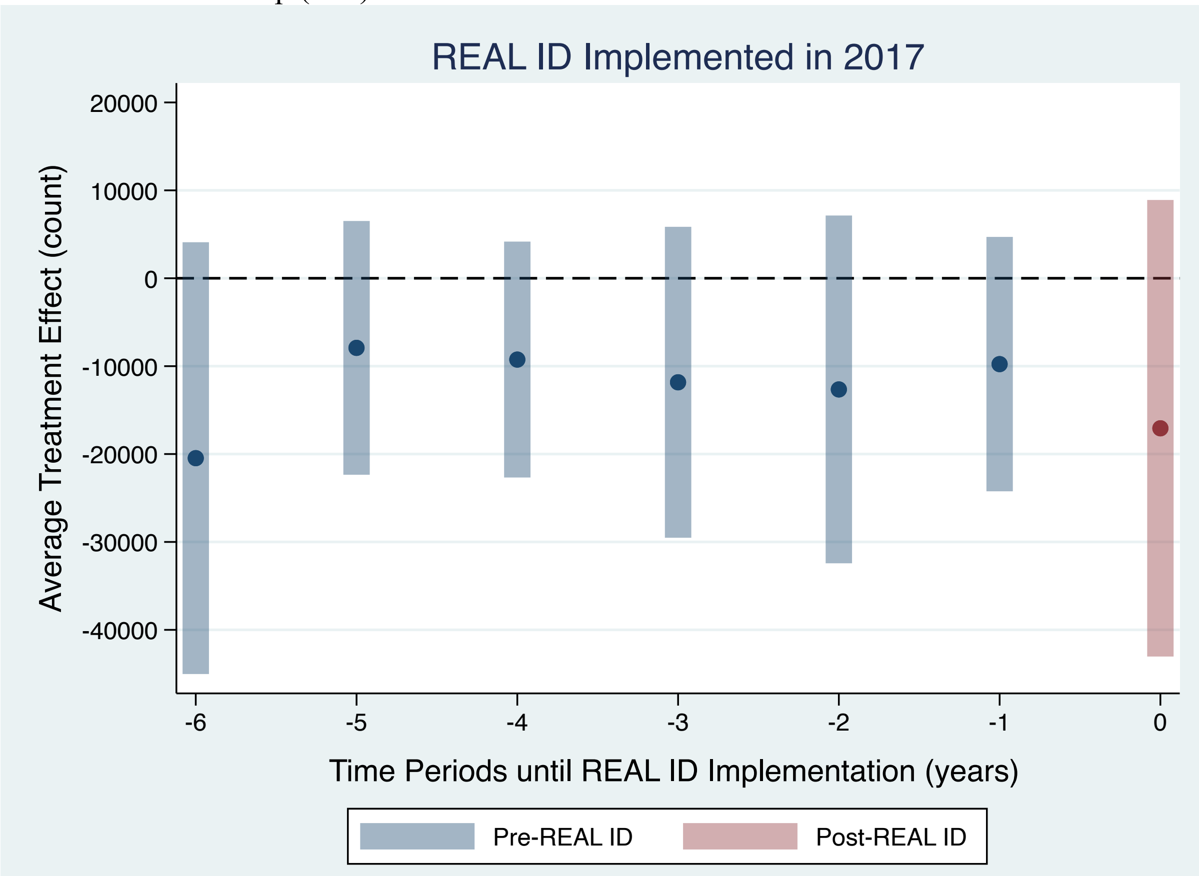
Data Sources: U.S. Department of Homeland Security. (2021). REAL ID Act: Federal Enforcement; State Compliance, Extensions and Implementation. Retrieved on April 1, 2021 from https://www.dhs.gov/real-id. Johnson, et al. (2017). *National- and State-Level Estimates of Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) Eligibles and Program Reach in 2014, and Updated Estimates for 2005–2013.* U.S. Department of Agriculture, Food and Nutrition Service, Office of Policy Support. Trippe, et al. (2018). *National- and State-Level Estimates of Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) Eligibles and Program Reach in 2015*. Alexandria, VA: U.S. Department of Agriculture, Food and Nutrition Service, Office of Policy Support. Trippe, et al. (2019). *National- and State-Level Estimates of Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) Eligibles and Program Reach in 2016*. Alexandria, VA: U.S. Department of Agriculture, Food and Nutrition Service, Office of Policy Support. Gray, et al. *National- and State-Level Estimates of WIC Eligibility and WIC Program Reach in 2017.* Alexandria, VA: U.S. Department of Agriculture, Food and Nutrition Service, Office of Policy Support. Rios-Avila, F., Callaway, B., & Sant'Anna, P. H. C. (2021). csdid: Difference-in-Differences with Multiple Time Periods in Stata [PowerPoint Slides]. Stata Conference, Virtual.

Figure 4.23 Average Treatment Effect in Number of WIC Participants in Number of WIC Participants by Year for the 2016 REAL ID Time Group (n=3)



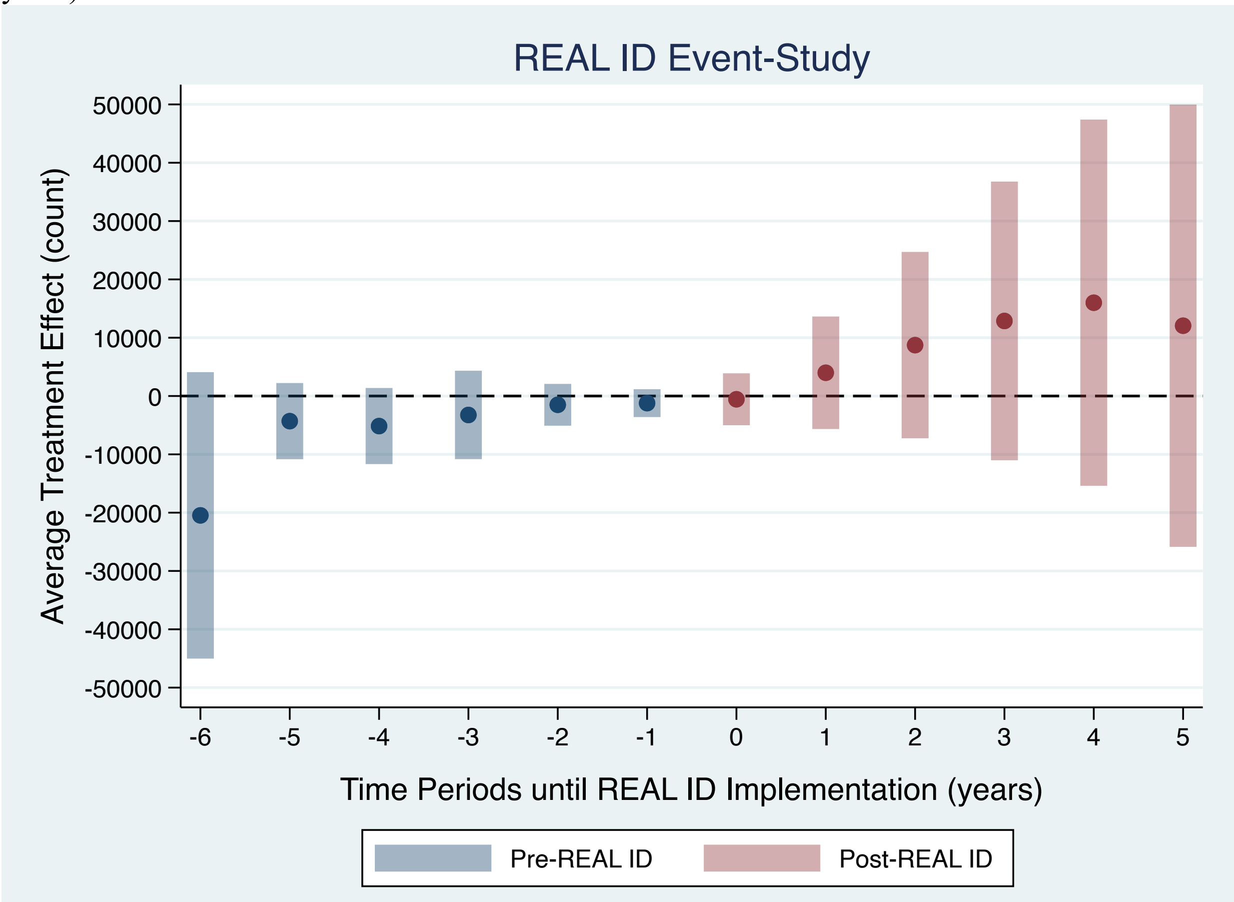
Data Sources: U.S. Department of Homeland Security. (2021). REAL ID Act: Federal Enforcement; State Compliance, Extensions and Implementation. Retrieved on April 1, 2021 from https://www.dhs.gov/real-id. Johnson, et al. (2017). *National- and State-Level Estimates of Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) Eligibles and Program Reach in 2014, and Updated Estimates for 2005–2013.* U.S. Department of Agriculture, Food and Nutrition Service, Office of Policy Support. Trippe, et al. (2018). *National- and State-Level Estimates of Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) Eligibles and Program Reach in 2015*. Alexandria, VA: U.S. Department of Agriculture, Food and Nutrition Service, Office of Policy Support. Trippe, et al. (2019). *National- and State-Level Estimates of Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) Eligibles and Program Reach in 2016*. Alexandria, VA: U.S. Department of Agriculture, Food and Nutrition Service, Office of Policy Support. Gray, et al. *National- and State-Level Estimates of WIC Eligibility and WIC Program Reach in 2017.* Alexandria, VA: U.S. Department of Agriculture, Food and Nutrition Service, Office of Policy Support. Rios-Avila, F., Callaway, B., & Sant'Anna, P. H. C. (2021). csdid: Difference-in-Differences with Multiple Time Periods in Stata [PowerPoint Slides]. Stata Conference, Virtual.

Figure 4.24 Average Treatment Effect in Number of WIC Participants by Year for the 2017 REAL ID Time Group (n=2)



Data Sources: U.S. Department of Homeland Security. (2021). REAL ID Act: Federal Enforcement; State Compliance, Extensions and Implementation. Retrieved on April 1, 2021 from https://www.dhs.gov/real-id. Johnson, et al. (2017). *National- and State-Level Estimates of Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) Eligibles and Program Reach in 2014, and Updated Estimates for 2005–2013.* U.S. Department of Agriculture, Food and Nutrition Service, Office of Policy Support. Trippe, et al. (2018). *National- and State-Level Estimates of Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) Eligibles and Program Reach in 2015*. Alexandria, VA: U.S. Department of Agriculture, Food and Nutrition Service, Office of Policy Support. Trippe, et al. (2019). *National- and State-Level Estimates of Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) Eligibles and Program Reach in 2016*. Alexandria, VA: U.S. Department of Agriculture, Food and Nutrition Service, Office of Policy Support. Gray, et al. *National- and State-Level Estimates of WIC Eligibility and WIC Program Reach in 2017.* Alexandria, VA: U.S. Department of Agriculture, Food and Nutrition Service, Office of Policy Support. Rios-Avila, F., Callaway, B., & Sant'Anna, P. H. C. (2021). csdid: Difference-in-Differences with Multiple Time Periods in Stata [PowerPoint Slides]. Stata Conference, Virtual.

Figure 4.25 Average Treatment Effect in Number of WIC Participants by Exposure Time (in years) to REAL ID



Data Sources: U.S. Department of Homeland Security. (2021). REAL ID Act: Federal Enforcement; State Compliance, Extensions and Implementation. Retrieved on April 1, 2021 from https://www.dhs.gov/real-id. Johnson, et al. (2017). *National- and State-Level Estimates of Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) Eligibles and Program Reach in 2014, and Updated Estimates for 2005–2013.* U.S. Department of Agriculture, Food and Nutrition Service, Office of Policy Support. Trippe, et al. (2018). *National- and State-Level Estimates of Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) Eligibles and Program Reach in 2015*. Alexandria, VA: U.S. Department of Agriculture, Food and Nutrition Service, Office of Policy Support. Trippe, et al. (2019). *National- and State-Level Estimates of Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) Eligibles and Program Reach in 2016*. Alexandria, VA: U.S. Department of Agriculture, Food and Nutrition Service, Office of Policy Support. Gray, et al. *National- and State-Level Estimates of WIC Eligibility and WIC Program Reach in 2017.* Alexandria, VA: U.S. Department of Agriculture, Food and Nutrition Service, Office of Policy Support. Rios-Avila, F., Callaway, B., & Sant'Anna, P. H. C. (2021). csdid: Difference-in-Differences with Multiple Time Periods in Stata [PowerPoint Slides]. Stata Conference, Virtual.

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Chapter 5. Discussion

5.1 Overview

This final chapter interprets aim specific results and offers possible explanations for these findings. Aim 1, Aim 2, and Aim 3 results are presented first. Subsequent sections discuss study strength and limitations, the public health implications of the study results, and lastly summarizing remarks.

The association of state implementation of three policies, the 2009 WIC Food Packages Changes, WIC EBT, and REAL ID, and changes in state WIC participation was examined in this study. The 2009 WIC Food Package changes were associated with post-policy trends changes in WIC participation in the majority of states, but neither state implementation of WIC EBT nor REAL ID were significantly associated with WIC participation. The reasons for the observed results are likely due to a multitude of factors. States are afforded a varying degree of autonomy in implementing Federal policy. The constitutionally guaranteed policy flexibility acknowledges the diversity among the 50 states and the District of Columbia populations, needs, and spectrum of administrative capabilities (Toossi & Jones, 2023). In the most lenient case, states may elect whether or not to implement a policy, and in the strictest case, when a policy is federally mandated, certain optional provisions are left to the discretion of the state.

5.2 Aim 1 Discussion

The results of Aim 1 analysis revealed the majority of states did demonstrate a significant association between state implementation of the 2009 WIC Food Package Changes and state WIC participation changes immediately after the food package changes (level change) or over time (trend trend). Trend changes were more common. Aim 1 results were in line with the study hypothesis that state implementation of the 2009 WIC food package changes was not consistently associated with changes in state WIC participation. The results may reflect the intentions behind the 2009 WIC Food Package Changes, different implementation strategies, and other state-specific policy factors.

The intention of the WIC Food Package Changes were intended to increase the acceptability of WIC foods and promote healthy behaviors; however, the features of the 2009 WIC Food Package changes were perceived differently by participant category (Ritchie et al., 2014; Weber et al., 2018; Weber et al., 2019). The increased breastfeeding support, longer certification periods, and enhanced food packages for breastfeeding women appeared to have a positive impact on participation by breastfeeding women (Joyce & Reeder, 2015; Langellier et al., 2014; Li et al., 2019; Weber et al., 2019; Wilde et al., 2012). Evidence suggests that pregnant women, non-breastfeeding women, and caregivers of infants perceived the WIC food packages changes as less beneficial. Households with participating infants disclosed dissatisfaction with the new food packages due to the removal of infant juice, the decrease in the amount of formula, and delayed introduction of solid foods to 6 months. Infant caregivers also expressed a preference for a fruit and vegetable cash voucher, a benefit afforded to all participating women and children, over receiving jarred baby food (Hurley & Black, 2010; Kim et al., 2013; Weber et al., 2018). Although the new foods may have provided an incentive for eligible families to participate in WIC, the main goal of the 2009 WIC Food Package Changes was to improve the nutrition of WIC participants, not to increase WIC participation. The main goal did appear to be achieved (Caulfield et al., 2022).

Different implementation months, policy options adopted, and state decisions regarding WIC vendor requirements, are some of the state-varying factors that may partially explain the inconsistent associations observed among state 2009 WIC Food Package Change implementation and state WIC participation. All states were required to implement the 2009 Food Package Changes by October 2009, the first month of the 2010 Federal Fiscal Year, but states introduced the changes throughout the 2009 calendar year (Joyce & Reeder, 2015). (Table 5.1). Thirteen states implemented in the months prior to the deadline; Delaware and New York were the earliest states to implement, beginning in January 2009. Montana was the last state to implement, in November 2009, and quite notably, was the only state that exhibited an average increase in the number of WIC participants per year in the post-policy period from 2010-2013, in both the null and extended ITS models. In comparison, a negative trend change was observed in all other states and was significant in 84% of states' null ITS models (42/50) and 76% (38/50) of states extended ITS models. The positive trend change observed in Montana was small and not statistically significant, and therefore it is less likely to be explained by an unknown third factor. If these findings are considered with the result that the majority of states did not exhibit immediate intervention effects, together they suggest that the overall effect of the WIC food package changes on WIC participation occurred over time and was likely negative.

States had numerous policy options within the 2009 WIC food package legislation, and implementation necessitated updated requirements for vendors in order to accept WIC benefits. Listed in Figure 5.1 are eleven policy options related to the new WIC foods. No policy options were universally adopted by all state agencies (Cole et al., 2011). To illustrate the variation among state agency adoption of policy options, if only the options related to the fruits and vegetable cash value voucher (CVV) are considered (1-4 in Figure 5.1), the percent of state agencies implementing each option varied from 22-80%. Specifically, 80% of state agencies allowed frozen, canned, and dried fruits and vegetables as alternatives to fresh; 44% allowed multiple cash value vouchers to be redeemed in one transaction; 71% permitted participants to pay the difference if their purchases exceeded the value of the CVV, and 22% allowed participants to redeem CVVs at local farmers' markets (Cole et al., 2011). Similar to the adoption of WIC Food Package change options, WIC vendor requirements vary remarkably across states and as a result disparities exist across states in the availability, accessibility, and acceptability of WIC products available to participants (Pelletier et al., 2017). Smaller stores and stores in rural areas authorized to accept WIC benefits experienced fewer positive effects in food availability and accessibility after the 2009 WIC food package changes compared to what was observed in larger stores (Lu et al., 2016). Many state agencies require vendors to meet more than the Federal minimum requirements in order to authorized to accept WIC benefits, which can be especially burdensome on small stores (Landry et al., 2021). Only 24 states have different requirements based on store size (Pelletier et al., 2017). Small stores may need additional support, in the form of technical assistance or loans for infrastructure improvements to meet minimum stocking requirements, especially when new requirements are introduced (Ayala et al., 2012).

The food package changes also were intended to increase the acceptability of WIC foods and promote healthy behaviors; however, the features of the 2009 WIC Food Package changes were perceived differently by participants and their families (Ritchie et al., 2014; Weber et al., 2018; Weber et al., 2019). The state level differences in the association of the 2009 WIC Food Package changes and state participation may be partially due to the different perceptions of the new WIC foods by participant category which could not be quantified because only total participation was examined in this study. The increased breastfeeding support, longer certification periods, and enhanced food packages for breastfeeding women appeared to have a positive impact on participation by breastfeeding women (Joyce & Reeder, 2015; Langellier et al., 2014; Li et al., 2019; Weber et al., 2019; Wilde et al., 2012). The increased variety of foods and expanded choice offered by the cash value fruit and vegetable voucher, were viewed favorably by caregivers of child WIC participants and participating women (Chauvenet et al., 2019; Okeke et al., 2017; Ritchie et al., 2014; Weber et al., 2019). Evidence suggests that pregnant women, non-breastfeeding women, and caregivers of infants and children older than one perceived the WIC food packages changes as less beneficial. The reduction in the amount of cheese and juice, and the requirement that participants over one year of age (children aged two years and older, and all women participants) only receive low-fat or skim milk, were viewed particularly unfavorably (Peck et al., 2013; Ritchie et al., 2014; Weber et al., 2018). Households with participating infants disclosed dissatisfaction with the removal of infant juice, the decrease in the amount of formula, and delayed introduction of solid foods to 6 months in the new infant food packages. Caregivers also expressed a preference for a fruit and vegetable cash voucher, a benefit afforded to all participating women and children, over receiving jarred baby food (Hurley & Black, 2010; Kim et al., 2013; Weber et al., 2018).

5.3 Aim 2 Discussion

The aggregate average treatment effect (ATT) of EBT implementation on WIC participation estimated in Aim 2 difference-in-differences (DID) modeling, was positive but not statistically significant ($p>0.05$). The ATT calculated from the null DID model was 8,447 WIC participants ($p=0.19$) and was 6,973 participants ($p=0.32$) in the extended model (after adjustment for the number of WIC-eligible individuals). Therefore, state implementation of WIC

EBT was not observed to be associated with changes in state WIC participation in this study. There are several potential reasons for the observed results.

Positive ATTs values were expected, indicating that state WIC EBT implementation was associated with increased WIC participation due to a growing body of qualitative research on participant views on WIC EBT. WIC participants perceive paper vouchers as a barrier to participation due to the arduous check-out process and stigma experienced at the register (Bai & Ciecierski, 2023; Chauvenet et al., 2019; Hanks et al., 2019; Phillips et al., 2014; Zimmer et al., 2021). Participants reported they prefered WIC EBT over paper vouchers, because the check-out process was more efficient, more private, and less stigmatizing. The increased flexibility of EBT which allowed for WIC foods to be purchased individually, instead of having to purchase all foods printed on a paper voucher at the same time, was another reason cited by participants for the preference for EBT (Bai & Ciecierski, 2023; Chauvenet et al., 2019; Hanks et al., 2019; Phillips et al., 2014; Zimmer et al., 2021).

Athough EBT may alleviate some barriers to participation, one policy alone is unlikely to close the gap between the number of WIC-eligible individuals and the number of participants. Qualitative studies of participants receiving WIC benefits via EBT in Tennessee, Texas, West Virginia, and New Jersey commented that they experienced the same difficulties identifying WIC foods at the store as they did with paper vouchers. Difficulties included unreliable WIC smartphone applications to determine eligible foods, confusion among WIC vendors about approved items, and transaction errors at checkout. As a result, clients reported they felt sitgmatized and treated poorly by employees and other customers (Andress & Fitch, 2016; Bai & Ciecierski, 2023; Chauvenet et al., 2019; Zimmer et al., 2021). A potentital consequence of EBT implementation is a decrease in WIC participation due to a disproportionate reduction in the number of small vendors authorized to accept WIC (Meckel, 2020). After EBT implementation in Texas, the small stores authorized to accept WIC benefits dropped by 10.7%, and the decline was even more pronounced in high poverty areas. Moreover, the likelihood of program drop-out even among chain stores increased, especially as local poverty increased. Participation among pregnant woman decreased by 5.2% after EBT in Texas. In Oklahoma, the total number of vendors decreased 10% during eWIC implementation, but researchers found no effect on program participation, although they did not examine participation by participant category (Li et al., 2022).

The lack of significant results may also lie within state-level decisions made during the WIC EBT implementation process. State agencies had several policy options within WIC EBT implementation guidelines, and the policy choices may have influenced how EBT was perceived, and in turn, impacted WIC participation. (Figure 5.2). The type of EBT card acceptor device is an example of one policy decision state agencies must make and that influences the participant check-out experience (Phillips et al., 2014). State agencies may authorize integrated electronic cash registers (integrated systems), stand-beside devices, or a mix of both. Integrated systems, sometimes referred to as online systems, address the two most common complaints among WIC participants regarding paper vouchers, the long-time at check-out and the stigma experienced at the register (Bai & Ciecierski, 2023; Chauvenet et al., 2019; Hanks et al., 2019; Phillips et al., 2014; Zimmer et al., 2021). During checkout with an integrated system, participants do not need to separate their WIC and non-WIC items; they use the same card accepter device as one would use to pay with a debit or credit card, and if the state agency elects to authorize, participants can even use self-check-out lanes (Phillips et al., 2014). In contrast, the length of time to check-out with a stand beside device, also called an offline system, is similar to that of paper vouchers.

Participants must separate their WIC and non-WIC items, because the WIC items must be rung-up at the store cash register first, and then the stand-beside device (Phillips et al., 2014). Although the integrated system may appear to be a better choice, state agencies often authorize both card acceptor devices because many small stores either lack the infrastructure and funds to update to an integrated system or do not perceive the business they receive from WIC redemptions worth the investment (most large grocery stores already have integrated systems) (Li et al., 2022; Meckel, 2020; Phillips et al., 2014). Sensitivity analysis did not reveal that the type of card acceptor device, online or offline, was a significant confounder in the association of EBT implementation and WIC participation. However, the available data did not indicate which online states also authorized offline systems, and the sample size was small; only one state, Ohio, implemented an offline system during the study period (U.S.D.A., 2023b).

5.4 Aim 3 Discussion

State enactment of the REAL ID Act was not associated with changes in state WIC participation. The lack of association observed between state REAL ID implementation and WIC participation may reflect the truth, there truly is no relationship between REAL ID and WIC participation. The REAL ID Act was one measure in the post-9/11 omnibus of anti-terrorism legislation, that shared a common goal to strengthen national security and prevent future attacks. Participation in WIC or other public benefit programs was not a consideration. Alternatively, the null results may reflect state level differences in state ID policy.

Lack of personal identification, particularly among marginalized groups, has only recently been recognized as a public health problem (LeBron et al., 2018; Sanders et al., 2020). Identification cards or driver's licenses (ID) are required to access many health and community services such as WIC, Medicaid, and even food pantries. To date, no studies have examined if REAL ID implementation is associated with changes in state WIC participation. The results of this study may reflect how investigation into the effect of ID policy on health outcomes is in its infancy, rather than a true null association between REAL ID implementation and WIC participation.

State level differences in ID policy may explain the lack of association observed between state REAL ID implementation and state WIC participation. The pre-REAL ID renewal period for driver licenses and identification cards is established at the state-level. As of September 2023, Vermont requires IDs be renewed every 2-4 years, whereas Arizona and Montana residents' ID's do not expire until 12 years from the date of issue (Arizona DOT, 2023; Montana, 2021; Vermont DMV, 2023). States deemed REAL-ID compliant by the U.S. Department of Homeland Security, are permitted to issue official "non-REAL" IDs with less restrictive documentation requirements. The number of states that issued non-REAL IDs, however, was not reported by the U.S. Department of Homeland Security. The availability of State alternatives to REAL IDs was not considered in this study. Lastly, National REAL ID enforcement deadlines were delayed throughout the study period, and due to the COVID-19 pandemic, the deadline was extended to May 7, 2025. Individuals may not be required to renew their ID yet and may wait to replace their ID when the REAL ID deadline approaches, or they may elect to get a non-REAL ID, if offered in their state. If REAL ID implementation is associated with WIC participation, the effect may not be visible for years.

5.5 Study Strengths and Limitations

The data set quality, time series measures, lasso methods, and policy relevance constitute the four major strengths of this study. The first major strength is the dataset is comprised of the high-quality, reliable, routinely collected government data that are publicly available. A second study strength is inclusion of annual state-level measures from 2005-2017, creating robust time-series data. The availability of multiple measures pre and post policy for key variables, meets the assumptions for two quasi-observational approaches, interrupted time series (ITS) and difference-in-differences (DID), which increases the internal validity of this study. The use of a novel machine-learning statistical technique, lasso, as a tool in covariate selection is a third strength. Compared to traditional covariate selection methods such as backward or forward, lasso compares hundreds (or even thousands) of models with different ordering and grouping of covariates in seconds, which is not only efficient but minimizes research bias (Ahrens et al., 2020; Drukker & Liu, 2019). Lasso and other machine learning techniques are seldom used in public health research, and the use of this technique is especially innovative because only recently has it been adapted for use with time series data (Ahrens et al., 2020; Krishnamurti et al., 2019; McEligot et al., 2020). COVID-19 WIC policy waivers and deadline extensions for REAL ID are set to expire, and as U.S. government operations resume to their pre-pandemic state, WIC participation research prior to 2020 may be more applicable.

This study also has four major limitations. The first limitation is the observational nature of the study; causality cannot be determined because the study is not experimental. A second limitation is study results may be due to unknown or unmeasured factors other than the policy of interest (Linden, 2015, 2021; Wing et al., 2018). Efforts were made to minimize these two threats to internal validity in both study design and method decisions. First, as discussed in

Chapter 3, the aim-specific study periods were tailored to limit exposure to events shown to be associated with WIC participation, other than the independent variable. Second, in analysis, quasi-experimental methods were employed, and known confounders were included in the model. Sensitivity tests were also performed to determine if state Medicaid Expansion status, or type of EBT (i.e., offline vs online system) confounded results, and neither did. The third limitation is conclusions may not be generalizable to WIC programs administrated by Native American or American Indian Tribal Organizations within states, or WIC agencies in U.S. Territories. The fourth limitation is the limits of the data used in analyses. State-level data on the number of WIC eligible individuals by eligibility category (e.g., pregnant women, infants) was not available, even though FNS estimates the number of WIC eligible individuals by category, only the total number eligible by state is publicly accessible. Race categories has to be combined due to high degrees of multicollinearity and small sample sizes in some states. Evidence supports that participant category and race are important determinants of WIC participation, and both could potentially act as an effect modifier of the association between policy implementation and changes in WIC participation (i.e. the association between policy implementation and WIC participation may vary by participant category or race) (Gray et al., 2019; Pati et al., 2014).

5.6 Public Health Implications for Research and Policy

The widening gap between the number of WIC-eligible individuals and the number of WIC participants, provides evidence that WIC is not meeting the needs of the entire eligible population. Policy change is one avenue that may help close the gap. The observed results from the examination of state policy implementation of the 2009 WIC Food Packages Changes, WIC

EBT, and REAL ID, and changes in WIC participation conducted in this study, presents several public health implications for research and policy.

First, a deeper examination of the state policy adoption variations is needed. Evidence supports that state WIC policies that improve the accessibility, availability, and acceptability of WIC foods are associated with participation gains. Investigating the 2009 WIC Food Package changes options adopted by each state, and state WIC participation may provide a clearer picture as to why the association was observed in some states but not others. For WIC EBT, investigating the type of EBT card acceptor device(s) used by each state, and WIC participation is warranted. Especially since all states have now transitioned to WIC EBT. The state availability of alternatives to REAL IDs may provide more insight on REAL ID implementation and WIC participation.

The policy motivation needs to be considered when studying implementation and WIC program participation. WIC participation change was not the main outcome targeted by the 2009 WIC Food Package Changes, WIC EBT, or REAL ID. For the two-WIC related policies, an increase in WIC participation could be considered a potentially positive consequence. The REAL ID Act was legislated without consideration for participation in public benefit programs, including WIC. In contrast, the more recent COVID-19 policy waivers allowed government programs, like WIC, to pivot their usual operations from in-person to online from March 2020 until May 2023, and continue to provide benefits to program participants, minimizing the risk of COVID-19 infection. Unlike the three policies studied, the conversion to online service delivery intended to impact WIC participation. Policies should be evaluated based on their intended goals but the current decline in the percent of WIC-eligible individuals participating, indicates a large unmet need. Therefore, participation is an important metric in evaluation of policy implementation in the current environment.

The USDA reported WIC participation increased for the first time in over a decade in 2021, most notably in children, and preliminary data indicate that the trend continued in 2022 (Toossi & Jones, 2023; Whaley & Anderson, 2021). (Figure 5.3). New research attributed the recent increases in WIC participation to the COVID-19 program policy waivers. One study credited remote recertification/certification and benefit delivery to the increases in WIC participation observed during the pandemic (Vasan, Kenyon, Roberto, et al., 2021). WIC participants reported satisfaction with remote services in another pandemic policy waiver study (Ventura et al., 2022). Most states transitioned to WIC EBT prior to the onset of the pandemic, and the main difference became where participants received their benefits, in person at the WIC clinic or remotely (Jacobs & Adeniran, 2022). States that required participants to come in person to load benefits, experienced an 7.6% overall decline in WIC participation from February 2020 to February 2022. In contrast, states that issued benefits remotely saw a 3.9% increase in participation (Jacobs & Adeniran, 2022).

The increase in WIC participation observed during the pandemic was largely driven by an increase in the number of child participants, which suggests that the change to remote visits and benefit delivery was a policy change that appealed to families with young children (Jacobs & Adeniran, 2022). Nationwide, child participation in WIC increased 8.7% from February 2020 (right before the pandemic) to February 2022. During the same time period, participation by pregnant and post-partum women decreased 5.4% and infant participation declined by 7.7% (Jacobs & Adeniran, 2022). Although, there was a slight decrease in the birth rate in 2020, births increased by 1% from 2020 to 2021, therefore it is unlikely that birth rate alone explains the discrepancies in participation by category. The total number of eligible individuals was reported to have increased during the pandemic but to what extent has yet to be released by the USDA (Jacobs & Adeniran, 2022).

WIC programs administered by Native American and American Indian Tribal Organizations experienced a 7.6% decrease in WIC participation during the pandemic, which may suggest that the switch to remote service and benefit delivery was a barrier to participation among eligible individuals in Native American communities (Jacobs & Adeniran, 2022). Eligible individuals that reside in communities that are served by Tribal organization WIC agencies, faced numerous barriers to participation prior to the pandemic, such as long travel distances to WIC clinics and few stores that accept WIC benefits. These barriers were further compounded by the lack of access to the reliable phone and internet service required for remote visits during the pandemic. WIC programs administered by Native American and American Indian Tribal Organizations were included in the state in which the program was located in this study (e.g. Cherokee Nation WIC is located in Oklahoma, so it was included as part of Oklahoma in state-level analyses). The state with the largest decrease in WIC participation at 19.7% was New Mexico. New Mexico is home to seven Tribal Organization WIC Agencies, each of which experienced marked declines in participation from 2020-2022, ranging from 11.8% to 47.5% decrease (Jacobs & Adeniran, 2022).

In 2022, the U.S. Department of Agriculture Food and Nutrition Service announced four new initiatives funded by the American Rescue Plan Act of 2021 to target WIC participation: prioritization of outreach, improvement to the shopping experience, investment in the workforce, and modernization of technology and service delivery. Specific interventions included online shopping for WIC foods, nationwide outreach campaigns to increase awareness of WIC, grant monies to fund projects that aim to identify methods that increase participation among eligible non-participants, and investment in additional training for WIC employees on how to improve the participant experience. Additionally, new WIC food packages were proposed. All of these efforts may impact participation, overall and by participant category.

On May 11, 2023, the U.S. government declared that the COVID-19 pandemic was no longer considered a public health emergency (C.D.C., 2023). This action had direct consequences for government programs. The COVID policy waivers that permitted WIC to provide benefits to program participants remotely expired as result. (Figure 5.4). Similarly, Federal deadlines for state REAL ID implementation were no longer eligible for extensions. The return to pre-pandemic policy may make pre-pandemic research more applicable, and potentially provide a more complete picture of the impact of policy implementation on WIC participation.

5.7 Conclusions

For over a half of a century, WIC has contributed to improving maternal and child health in the U.S. The health and nutritional needs of low-income pregnant and post-partum women, infants, and young children have changed since the program's inception. Shifts in demographic, economic, and other characteristics of the U.S. have resulted in a progressively more culturally, ethnically, and racially diverse population. WIC has attempted to adapt as the WIC-eligible population became more diverse and faced different health challenges. As a government program, however, WIC is not immune to the political climate in which it is legislated and funded. The results of this study illustrate how complex the interplay of state policies, population characteristics, and the socio-cultural environment in which one resides contribute to individual health behaviors such as the decision to participate in WIC.

5.8 Tables

Table 5.1 Month of 2009 WIC Food Package Changes by State (Joyce & Reeder, 2015)

Month	**States**
January 2009 (n=2)	DE, NY
May 2009 (n=2)	KY, SC
June 2009 (n=1)	CO
July 2009 (n=1)	UT
August 2009 (n=6)	IL, KS, MI, OK, OR, WI
September 2009 (n=1)	SD
October 2009 (n=37)	AL, AK, AR, AZ, CA, CT, D.C., FL, GA, HI, ID, IN, IA, LA, ME, MD, MA, MN, MS, MO, NE, NV, NH, NJ, NM, NC, ND, OH, PA, RI, TN, TX, VT, VA, WA, WV, WY
November 2009 (n=1)	MT

Data Source: Joyce, T., & Reeder, J. (2015). Changes in breastfeeding among WIC participants following implementation of the new food package. *Matern Child Health J*, 19(4), 868-876. https://doi.org/10.1007/s10995-014-1588-7

Table 5.2 WIC EBT, REAL ID, and Medicaid Expansion Policies implemented by State, 2005-2017 (C.M.S., 2023; D.H.S., 2023; U.S.D.A., 2023b)

Implementation Status of WIC EBT, REAL ID, and Medicaid Expansion	**State**
No Policies Implemented (n=4)	ID, ME, MO, SC
WIC EBT Only (n=2)	OK, VA
REAL ID Only (n=8)	AL, GA, KS, MS, NC, NE, TN, UT
Medicaid Expansion Only (n=11)	AK, CA, LA, MN, ND, NH, NJ, PA, RI, WA
WIC EBT & REAL ID (n=5)	FL, SD, TX, WI, WY
WIC EBT & Medicaid Expansion (n=5)	KY, MA, MI, MT, OR
REAL ID & Medicaid Expansion (n=4)	AR, DC, HI, FL
WIC EBT, REAL ID, & Medicaid Expansion (n=12)	AZ, CO, CT, DE, IA, IN, MD, NM, NV, OH, VT, WV

Data Sources: C.M.S. (2023). Resources for States: State Medicaid and CHIP Profiles. Centers for Medicare and Medicaid. Retrieved August 28 from https://www.medicaid.gov/resources-for-states/index.html; U.S. Department of Homeland Security (2023). REAL ID Act: Federal Enforcement; State Compliance, Extensions and Implementation. U.S. Department of Homeland Security. Retrieved August 28 from https://www.dhs.gov/real-id; U.S. Department of Agriculture (2023). WIC EBT Activities. U.S.D.A. Food and Nutrition Services. Retrieved April 3 from https://www.fns.usda.gov/wic/wic-ebt-activities.

5.9 Figures

5.1 Examples of 2009 WIC Food Package Policy Options (Cole et al., 2011)

1. Allowing frozen, canned, and dried fruits and vegetables as alternatives to fresh
2. Redemption of multiple CVVs in a single transaction
3. Redemption of CVVs in a combination tender transaction whereby participants “pay the difference” when the fruits and/or vegetables exceed the value of the CVV
4. Redemption of CVVs at farmers’ markets
5. Allowing soy beverages and/or tofu as milk substitutes
6. Allowing specific Federally authorized whole grains (brown rice, bulgur, barley, oatmeal, and soft corn or whole-wheat tortillas) as alternatives to 100% whole-wheat bread
7. Allowing at least two different types of canned fish (SAs may can choose from tuna, salmon, sardines, and mackerel.
8. Package tailoring with different combinations of dry beans and peanut butter
9. Package tailoring with infant formula in the first month after birth
10. Food package adjustments to accommodate the special needs of homeless participants
11. “Rounding up” of infant formula and infant food container sizes.

Data Source: Cole, N., Jacobson, J., Nichols-Barrer, I., & Fox, M. K. (2011). WIC Food Packages Policy Options Study I. Alexandria, VA: U.S. Department of Agriculture, Food and Nutrition Service, Office of Research and Analysis

Figure 5.2 Examples of WIC EBT Policy Options (Phillips et al., 2014)

Integrated Systems and Stand-Beside Devices
Choice of Card Acceptor Devices for processing the WIC EBT card

- Integrated Electronic Cash Register (ECR) system Integrated POS systems identify the WIC allowable foods via the scanned UPC and carry out the appropriate match against the APL.
- Stand-beside device- Separate from the cash register system, he WIC purchase is first transacted in the cash register system and then entered into the stand-beside device

Mixed-Basket Purchases
Separating WIC and non-WIC items was required with paper vouchers.

- With EBT, however, this separation is no longer necessary at vendors with an integrated system, allowing participants to place WIC and non-WIC food items alike on the checkout lane belt—referred to as a “mixed basket.”

Self-Checkout Lanes
Self-checkout stations are unattended, integrated POS systems in grocery stores where customers can scan and transact their purchases without the involvement of a cashier or clerk.

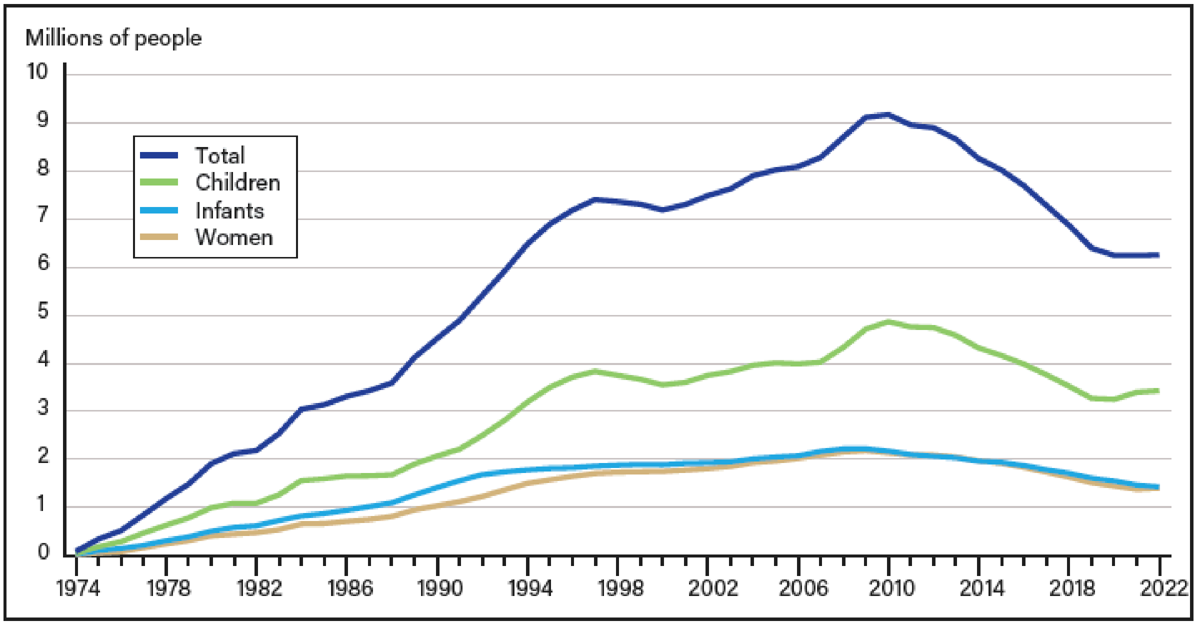
- Allow self-checkout service to WIC cardholders; at the WIC State Agency’s discretion.
- WIC State Agencies may also choose to certify WIC vendors for self-checkout separately from the standard EBT certification process.

Vendor Balance Inquiries
Without having the food benefit information printed on the FI itself, as was done with paper FIs, it may be more difficult for participants to track their remaining benefit balance and benefit expiration date.

- Require that authorized WIC vendors support balance inquiries prior to transactions.
- Balance inquiry capability can be supported either in a checkout lane, separate device in the store, websites, text messaging services, and smartphone applications.

Data Source: Phillips, D., Bell, L., Morgan, R., & Pooler, J. (2014). *Transition to EBT in WIC: Review of Impact and Examination of Participant Redemption Patterns, Final Report*. Altarum Institute. U.S. Department of Agriculture, Economic Research Service. Agreement # 59-5000-1-0032

Figure 5.3 Average Annual WIC Participation in Millions by Participant Category, 1974-2022 (Toossi & Jones, 2023)



Data Source: Toossi, Saied and Jordan W. Jones. June 2023. The Food and Nutrition Assistance Landscape: Fiscal Year 2022 Annual Report, EIB-255, U.S. Department of Agriculture, Economic Research Service.

Figure 5.4 Examples of WIC Program COVID-19 Waivers (Toossi & Jones, 2023)

Eligibility Criteria and Recertification
State agencies to conduct remote certifications for applicants and recertifications for WIC participants,
Defer medical documentation requirements for applicants who were unable to obtain documentation from their medical provider, and to
Extend certification periods for WIC participants by up to 3 months.

Benefits issuance (State option):
Suspend requirements that participants scheduled for nutrition education, or a recertification appointment pick up their food benefit in person.
State agencies with offline EBT card-based issuance systems to extend the supply of benefits that WIC participants received at one time to a maximum of 4 months.

Increase in the amount of the Cash-Value Voucher (CVV) for fruit and vegetable purchases (optional):
Increase the CVV for fruit and vegetable purchases from $9 (adults) and $11 (children) to an amount less than or equal to $35 per participant through September 30, 2021.
These benefit amounts were changed to $24 for children, $43 for pregnant and post-partum women, and $47 for breastfeeding women through FY 2022.

Food package substitutions (USDA Waiver): To accommodate pandemic-related supply chain issues, USDA waivers continued to temporarily allow participants to substitute specific food items in their food packages. Examples include allowing for milk of any fat content and flexibility with package sizes (e.g., different sizes of whole grain breads, cheeses, and juices).

Data Source: Toossi, Saied and Jordan W. Jones. June 2023. The Food and Nutrition Assistance Landscape: Fiscal Year 2022 Annual Report, EIB-255, U.S. Department of Agriculture, Economic Research Service.

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Appendices

Table A.1 Percent of U.S. Population Identifying with Each Race, Detailed, 2005-2017

Year	White (%)	Black (%)	American Indian & Alaska Native (%)	Asian (%)	Native Hawaiian & Other Pacific Islander (%)	Some Other (%)	Two or More (%)
2005	74.3	12.3	0.7	4.4	0.1	6.1	1.9
2006	73.6	12.5	0.7	4.4	0.1	6.4	2.0
2007	73.7	12.5	0.7	4.5	0.1	6.3	2.2
2008	74.8	12.5	0.8	4.5	0.1	5.0	2.3
2009	74.6	12.6	0.8	4.5	0.1	4.9	2.5
2010	74.2	12.6	0.8	4.8	0.2	4.8	2.7
2011	74.1	12.6	0.8	4.8	0.2	4.7	2.8
2012	73.9	12.6	0.8	5.0	0.2	4.6	2.9
2013	73.7	12.6	0.8	5.1	0.2	4.7	3.0
2014	73.4	12.7	0.8	5.2	0.2	4.7	3.0
2015	73.1	12.7	0.8	5.4	0.2	4.8	3.1
2016	72.6	12.7	0.8	5.4	0.2	5.1	3.2
2017	72.3	12.7	0.8	5.6	0.2	5.1	3.3

Data Sources: U.S. Census Bureau, U. S. (2023a). *American Community Survey Data. Demographic and Housing Estimates.* Retrieved Sept 6 from https://data.census.gov/table?q=DP05

Table A.2 Percent of U.S. Population Identifying with Each Race, Detailed, by State, 2005

State	White (%)	Black (%)	American Indian & Alaska Native (%)	Asian (%)	Native Hawaiian & Other Pacific Islander (%)	Some Other (%)	Two or More (%)
Alabama	70.5	26.1	0.5	4.4	0.1	6.1	1.9
Alaska	69.0	3.6	14.4	4.3	0.3	1.6	6.9
Arizona	76.4	3.1	4.6	2.1	0.1	11.2	2.4
Arkansas	78.7	15.6	0.7	0.9	0.2	2.4	1.5
California	60.8	6.1	0.7	12.4	0.3	16.4	3.1
Colorado	83.2	3.6	0.9	2.5	0.1	7.0	2.7
Connecticut	81.4	9.1	0.3	3.2	0.1	4.4	1.6
Delaware	73.7	20.2	0.2	2.2	0.0	2.3	1.4
District of Columbia	31.9	57.5	0.3	3.1	0.0	5.7	1.6
Florida	76.7	15.1	0.3	2.1	0.0	4.2	1.6
Georgia	62.6	29.1	0.3	2.7	0.0	3.9	1.4
Hawaii	24.6	1.8	0.3	42.4	8.4	1.3	21.4
Idaho	91.2	0.4	1.2	1.0	0.0	4.0	2.2
Illinois	72.2	14.4	0.2	4.1	0.0	7.5	1.5
Indiana	86.4	8.5	0.3	1.1	0.0	2.2	1.4
Iowa	94.1	2.0	0.3	1.4	0.0	1.2	1.0
Kansas	85.2	5.8	0.7	2.0	0.0	4.0	2.1
Kentucky	85.2	5.8	0.7	2.0	0.0	4.0	2.1
Louisiana	63.4	32.6	0.5	1.4	0.0	0.9	1.1
Maine	96.5	0.8	0.5	0.8	0.0	0.4	1.0
Maryland	61.2	28.8	0.3	4.7	0.1	3.2	1.8
Massachusetts	83.5	5.9	0.2	4.7	0.0	4.3	1.4
Michigan	79.8	14.2	0.5	2.4	0.1	1.5	1.5
Minnesota	87.9	4.1	1.1	3.6	0.1	1.8	1.3
Mississippi	60.6	36.5	0.5	0.8	0.0	0.8	0.9
Missouri	84.7	11.1	0.4	1.4	0.1	1.0	1.4
Montana	90.9	0.2	5.4	0.6	0.1	0.6	2.1
Nebraska	88.9	4.4	0.7	1.6	0.0	2.7	1.8
Nevada	76.0	7.1	1.1	5.8	0.5	6.4	3.2
New Hampshire	94.9	0.8	0.4	2.1	0.0	0.6	1.0
New Jersey	69.9	13.3	0.2	7.2	0.0	7.8	1.4
New Mexico	69.0	1.9	9.6	1.2	0.1	14.9	3.2
New York	67.2	15.4	0.4	6.6	0.0	8.9	1.5
North Carolina	71.3	21.0	1.3	1.7	0.0	3.1	1.6
North Dakota	90.6	0.8	4.9	1.2	0.1	0.8	1.7
Ohio	84.2	11.6	0.1	1.4	0.0	1.0	1.4
Oklahoma	75.7	7.0	7.3	1.6	0.1	2.6	5.7
Oregon	86.8	1.6	1.4	3.7	0.1	3.5	2.8
Pennsylvania	84.7	9.8	0.2	2.4	0.0	1.9	1.1
Rhode Island	83.3	4.9	0.6	2.5	0.0	6.9	1.9
South Carolina	67.3	28.8	0.3	1.0	0.0	1.4	1.1
South Dakota	88.3	0.8	8.3	0.6	0.0	0.4	1.5
Tennessee	79.6	16.5	0.3	1.2	0.0	1.2	1.1
Texas	71.8	11.0	0.5	3.2	0.1	11.6	1.7
Utah	89.8	0.9	1.2	2.0	0.5	3.9	1.6
Vermont	96.8	0.3	0.2	1.1	0.0	0.2	1.4
Virginia	71.9	19.0	0.3	4.7	0.1	2.2	1.8
Washington	81.0	3.3	1.4	6.6	0.5	3.9	3.3
West Virginia	94.9	3.0	0.1	0.5	0.1	0.2	1.1
Wisconsin	88.3	5.9	0.8	2.0	0.0	1.9	1.2
Wyoming	91.7	0.8	1.8	0.7	0.0	2.9	2.1

Data Sources: U.S. Census Bureau, U. S. (2023a). *American Community Survey Data. Demographic and Housing Estimates.* Retrieved Sept 6 from https://data.census.gov/table?q=DP05

Table A.3 Percent of U.S. Population Identifying with Each Race, Detailed, by State, 2010

State	White (%)	Black (%)	American Indian & Alaska Native (%)	Asian (%)	Native Hawaiian & Other Pacific Islander (%)	Some Other (%)	Two or More (%)
Alaska	67.4	3.5	14.6	5.5	1.1	0.9	7.0
Alabama	69.5	26.4	0.6	1.1	0.0	1.1	1.4
Arkansas	78.4	15.9	0.6	1.1	0.2	2.1	1.7
Arizona	79.4	4.1	4.5	2.7	0.2	6.4	2.6
California	62.4	6.0	0.8	13.1	0.4	13.1	4.2
Colorado	83.3	3.9	1.0	2.6	0.1	5.6	3.4
Connecticut	78.2	10.0	0.2	3.8	0.0	5.3	2.5
District of Columbia	40.2	51.2	0.3	3.6	0.0	2.8	2.0
Delaware	70.7	21.3	0.3	3.1	0.1	2.0	2.6
Florida	76.5	15.9	0.4	2.4	0.1	2.6	2.2
Georgia	60.7	30.6	0.2	3.3	0.0	3.3	1.8
Hawaii	24.6	1.5	0.2	38.9	9.9	1.1	23.8
Iowa	91.5	3.1	0.3	1.7	0.0	1.5	1.8
Idaho	92.2	0.6	1.4	1.2	0.1	2.2	2.3
Illinois	72.5	14.5	0.2	4.6	0.0	6.3	1.9
Indiana	85.1	9.0	0.3	1.6	0.0	2.0	2.0
Kansas	85.2	5.8	0.9	2.5	0.0	2.5	3.1
Kentucky	88.3	7.7	0.2	1.1	0.1	1.0	1.6
Louisiana	62.8	32.0	0.6	1.6	0.1	1.3	1.5
Massachusetts	81.1	6.8	0.2	5.4	0.0	3.7	2.8
Maryland	58.9	29.4	0.3	5.5	0.0	3.0	2.8
Maine	95.3	1.1	0.5	1.0	0.0	0.2	1.8
Michigan	79.3	14.0	0.6	2.4	0.0	1.2	2.4
Minnesota	86.1	5.2	1.1	4.0	0.0	1.3	2.4
Missouri	83.1	11.7	0.4	1.6	0.1	1.0	2.2
Mississippi	59.5	37.3	0.4	0.9	0.0	0.8	1.1
Montana	89.9	0.5	6.2	0.6	0.1	0.4	2.4
North Carolina	69.7	21.4	1.2	2.2	0.0	3.1	2.3
North Dakota	90.0	1.3	4.9	1.1	0.1	0.5	2.0
Nebraska	88.9	4.4	0.9	1.6	0.1	1.9	2.2
New Hampshire	94.1	1.2	0.2	2.1	0.0	0.8	1.6
New Jersey	69.3	13.5	0.2	8.2	0.0	6.1	2.6
New Mexico	73.4	2.0	9.4	1.2	0.1	11.1	2.9
Nevada	72.9	8.0	1.0	7.3	0.6	6.3	3.9
New York	65.9	15.5	0.4	7.4	0.0	8.1	2.6
Ohio	83.0	12.2	0.2	1.7	0.0	0.8	2.1
Oklahoma	73.5	7.2	7.0	1.7	0.1	2.6	7.9
Oregon	85.0	1.8	1.3	3.7	0.3	4.3	3.6
Pennsylvania	82.6	10.8	0.2	2.8	0.0	1.8	1.9
Rhode Island	81.4	6.0	0.3	2.9	0.1	6.5	2.7
South Carolina	67.1	28.1	0.3	1.2	0.0	1.5	1.8
South Dakota	86.0	1.3	9.0	1.0	0.0	0.7	2.0
Tennessee	78.4	16.8	0.3	1.5	0.0	1.4	1.7
Texas	74.1	11.8	0.5	3.8	0.1	7.5	2.2
Utah	88.8	1.0	1.2	1.9	0.9	3.7	2.4
Virginia	69.5	19.6	0.3	5.5	0.1	2.4	2.7
Vermont	95.4	1.0	0.2	1.2	0.4	0.4	1.6
Washington	78.7	3.5	1.5	7.2	0.6	4.0	4.5
Wisconsin	87.0	6.2	0.8	2.3	0.0	1.6	2.1
West Virginia	93.9	3.1	0.2	0.6	0.0	0.3	2.0
Wyoming	91.0	0.8	2.6	0.7	0.1	2.2	2.7

Data Sources: U.S. Census Bureau, U. S. (2023a). *American Community Survey Data. Demographic and Housing Estimates.* Retrieved Sept 6, 2023 from https://data.census.gov/table?q=DP05

Table A.4 Lasso Results for Extended Interrupted Time Series Models

Knot (1-8)	**ID** (1-66)	**Lambda**	**Extended Bayes Information Criteria**	**R-Squared**	**Variables**
3	46	3,255,414.9	9,665.8	0.979	Number of WIC Eligible Individuals, Percent Foreign-Born

Table A.5 Hausman Specification Tests for Interrupted Time Series Models

Statistic	**Value**
Chi-squared with 11 degrees of freedom	163.7
p-value	0.000

Table A.6. Lasso Results for Extended WIC EBT Difference-in-differences Model

Knot (1-8)	**ID** (1-64)	**Lambda**	**Extended Bayes Information Criteria**	**R-Squared**	**Variable(s)**
2	39	1,974,544.1	3,721.3	0.975	Number of WIC Eligible Individuals

Table A.7 Hausman Specification Test Results for WIC EBT Difference-in-differences Model

Statistic	**Value**
Chi-squared with 10 degrees of freedom	239.6
p-value	0.000

Table A.8 Lasso Results for Extended REAL ID Difference-in-differences Model

Knot (1-6)	**ID (1-64)**	**Lambda**	**Extended Bayes Information Criteria**	**R-Squared**	**Variables**
3	50	877,175.5	4,207.6	0.9805	Number of WIC Eligible Individuals, Percent Foreign-Born

Table A.9 Hausman Specification Test Results for REAL ID Difference-in-differences Model

Statistic	**Value**
Chi-squared with 10 degrees of freedom	259.3
p-value	0.000

Figure A.1 Institutional Review Board Determination Notice

FWA #00000287

JOHNS HOPKINS
BLOOMBERG SCHOOL
of PUBLIC HEALTH

Institutional Review Board Office

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Toll Free: 1-888-262-3242
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Email: jhsph.irboffice@jhu.edu
Website: www.jhsph.edu/irb

DETERMINATION NOTICE

STUDENT PROJECT

Date: September 1, 2021

To: Lauren Hosterman

Re: **PhD Dissertation Student Project Title:** "Special Supplemental Nutrition Program for Women, Infants and Children (WIC) Participation and State Implementation of Federal Policy"

The JHSPH IRB reviewed the IRB Office Determination Request Form Secondary Data Analysis on **September 1, 2021**. It determined that the proposed activity does not qualify as human subjects research as defined by DHHS regulations 45 CFR 46.102, and therefore does not require IRB oversight.

IRB Determination:

- ☐ **Not Engaged in Human Subjects Research**
  (See OHRP Guidance http://www.hhs.gov/ohrp/policy/engage08.html)
  While the project itself is human subjects research, JHSPH is not: the primary grantee of federal funding, consenting participants, collecting data/biospecimens or otherwise interacting with human subjects, or obtaining or using identifiable (or linkable) private information/biospecimens.

- ☒ **Research/Not Human Subjects Research**

  - ☐ Key Informant Research involving information from individuals about something other than themselves, disclosing no personal opinions, and not exposing respondents to employment or other risks.

  - ☒ Secondary Data Analysis involving the use of existing, de-identified data/specimens, including publicly available data.

- ☐ **Not Research/Public Health Practice** involving "program development or evaluation" in the delivery of public health practice services."

- ☐ **Not Research/Public Heath Surveillance** involving activities, including the collection and testing of information or biospecimens, conducted, supported, requested, ordered, required, or authorized by a public health authority.

Figure A.2 WIC EBT Average Treatment Effect Coefficients, Standard Errors, p-values, and 95% Confidence Intervals by WIC EBT Time, Calender Year, and by Event-study Time Period, Null Model

Average Treatment Effect on Treated

	Coefficient	Std. err.	z	P>|z|	[95% conf.	interval]
ATT	**8446.578**	**6426.82**	**1.31**	**0.189**	**-4149.758**	**21042.91**

ATT by group

	Coefficient	Std. err.	z	P>|z|	[95% conf.	interval]
GAverage	**7855.676**	**5592.158**	**1.40**	**0.160**	**-3104.753**	**18816.11**
G2013	**16363.91**	**8237.672**	**1.99**	**0.047**	**218.3704**	**32509.45**
G2014	**8814.667**	**9005.262**	**0.98**	**0.328**	**-8835.322**	**26464.66**
G2015	**1962.407**	**7441.678**	**0.26**	**0.792**	**-12623.01**	**16547.83**
G2016	**8623.333**	**5023.171**	**1.72**	**0.086**	**-1221.901**	**18468.57**
G2017	**5686.481**	**3970.261**	**1.43**	**0.152**	**-2095.086**	**13468.05**

ATT by Calendar Period

	Coefficient	Std. err.	z	P>|z|	[95% conf.	interval]
CAverage	**6787.124**	**5123.567**	**1.32**	**0.185**	**-3254.883**	**16829.13**
T2013	**5391.111**	**2164.699**	**2.49**	**0.013**	**1148.379**	**9633.844**
T2014	**2179.722**	**4257.465**	**0.51**	**0.609**	**-6164.755**	**10524.2**
T2015	**7900.352**	**6397.074**	**1.23**	**0.217**	**-4637.683**	**20438.39**
T2016	**7407.489**	**5777.363**	**1.28**	**0.200**	**-3915.935**	**18730.91**
T2017	**11056.94**	**8142.747**	**1.36**	**0.174**	**-4902.546**	**27016.44**

ATT by Periods Before and After treatment
Event Study:Dynamic effects

	Coefficient	Std. err.	z	P>|z|	[95% conf.	interval]
Pre_avg	**1226.487**	**1342.629**	**0.91**	**0.361**	**-1405.018**	**3857.991**
Post_avg	**13642.87**	**9388.186**	**1.45**	**0.146**	**-4757.633**	**32043.38**
Tm6	**235.9259**	**1555.297**	**0.15**	**0.879**	**-2812.4**	**3284.252**
Tm5	**-713.6944**	**937.051**	**-0.76**	**0.446**	**-2550.281**	**1122.892**
Tm4	**-1020.487**	**1226.198**	**-0.83**	**0.405**	**-3423.791**	**1382.817**
Tm3	**1705.118**	**1828.48**	**0.93**	**0.351**	**-1878.638**	**5288.873**
Tm2	**3758.644**	**2251.017**	**1.67**	**0.095**	**-653.2691**	**8170.557**
Tm1	**3393.414**	**3003.662**	**1.13**	**0.259**	**-2493.655**	**9280.482**
Tp0	**3938.294**	**3227.248**	**1.22**	**0.222**	**-2386.995**	**10263.58**
Tp1	**10071.89**	**6565.764**	**1.53**	**0.125**	**-2796.769**	**22940.55**
Tp2	**9893.358**	**10219.69**	**0.97**	**0.333**	**-10136.87**	**29923.58**
Tp3	**15336.94**	**13438.15**	**1.14**	**0.254**	**-11001.36**	**41675.23**
Tp4	**28973.89**	**14730.13**	**1.97**	**0.049**	**103.3612**	**57844.42**

Figure A.3 WIC EBT Average Treatment Effects Coefficients, Standard Errors, p-values, and 95% Confidence Intervals by WIC EBT Time group, Calender Year, and by Event-study Time Period for Extended model, Regular Method

Average Treatment Effect on Treated

	Coefficient	Std. err.	z	P>|z|	[95% conf.	interval]
ATT	**6973.15**	**7016.611**	**0.99**	**0.320**	**-6779.155**	**20725.46**

ATT by group

	Coefficient	Std. err.	z	P>|z|	[95% conf.	interval]
GAverage	**4358.947**	**3838.578**	**1.14**	**0.256**	**-3164.527**	**11882.42**
G2013	**-8574.859**	**2523.072**	**-3.40**	**0.001**	**-13519.99**	**-3629.729**
G2014	**26160.73**	**21209.04**	**1.23**	**0.217**	**-15408.22**	**67729.69**
G2015	**7436.227**	**5613.049**	**1.32**	**0.185**	**-3565.146**	**18437.6**
G2016	**-281.6135**	**1816.895**	**-0.15**	**0.877**	**-3842.662**	**3279.435**
G2017	**-1261.41**	**1779.447**	**-0.71**	**0.478**	**-4749.063**	**2226.242**

ATT by Calendar Period

	Coefficient	Std. err.	z	P>|z|	[95% conf.	interval]
CAverage	**5463.342**	**5920.951**	**0.92**	**0.356**	**-6141.509**	**17068.19**
T2013	**-1009.086**	**718.9219**	**-1.40**	**0.160**	**-2418.147**	**399.9755**
T2014	**3185.664**	**5867.195**	**0.54**	**0.587**	**-8313.827**	**14685.15**
T2015	**11491.46**	**10975.7**	**1.05**	**0.295**	**-10020.51**	**33003.43**
T2016	**6513.259**	**6605.56**	**0.99**	**0.324**	**-6433.401**	**19459.92**
T2017	**7135.41**	**6926.822**	**1.03**	**0.303**	**-6440.912**	**20711.73**

ATT by Periods Before and After treatment
Event Study:Dynamic effects

	Coefficient	Std. err.	z	P>|z|	[95% conf.	interval]
Pre_avg	**-388.5678**	**461.5721**	**-0.84**	**0.400**	**-1293.233**	**516.0969**
Post_avg	**7556.701**	**9544.485**	**0.79**	**0.429**	**-11150.14**	**26263.55**
Tm6	**616.0027**	**1749.103**	**0.35**	**0.725**	**-2812.177**	**4044.182**
Tm5	**-383.6727**	**936.8082**	**-0.41**	**0.682**	**-2219.783**	**1452.438**
Tm4	**-1821.187**	**936.8331**	**-1.94**	**0.052**	**-3657.346**	**14.97257**
Tm3	**-1405.286**	**761.0876**	**-1.85**	**0.065**	**-2896.99**	**86.41814**
Tm2	**290.9841**	**844.6599**	**0.34**	**0.730**	**-1364.519**	**1946.487**
Tm1	**371.7516**	**1105.566**	**0.34**	**0.737**	**-1795.118**	**2538.622**
Tp0	**838.4333**	**1644.469**	**0.51**	**0.610**	**-2384.666**	**4061.532**
Tp1	**5352.837**	**4927.516**	**1.09**	**0.277**	**-4304.917**	**15010.59**
Tp2	**19044.99**	**15163.67**	**1.26**	**0.209**	**-10675.25**	**48765.23**
Tp3	**28205.68**	**26848.01**	**1.05**	**0.293**	**-24415.45**	**80826.81**
Tp4	**-15658.44**	**4480.505**	**-3.49**	**0.000**	**-24440.07**	**-6876.81**

Figure A.4 WIC EBT Average Treatment Effect Coefficients, Standard Errors, p-values, and 95% Confidence Intervals by WIC EBT Time, Calender Year, and by Event-study Time Period for Extended Model, Robust Method

Average Treatment Effect on Treated

	Coefficient	Std. err.	z	P>|z|	[95% conf.	interval]
ATT	9090.245	7423.742	1.22	0.221	-5460.022	23640.51

ATT by group

	Coefficient	Std. err.	z	P>|z|	[95% conf.	interval]
GAverage	6170.47	4089.821	1.51	0.131	-1845.432	14186.37
G2013	-1055.488	351.9309	-3.00	0.003	-1745.26	-365.7157
G2014	27652.07	23844.75	1.16	0.246	-19082.77	74386.92
G2015	7689.074	6128.925	1.25	0.210	-4323.398	19701.55
G2016	1499.921	773.2042	1.94	0.052	-15.53146	3015.373
G2017	96.76427	304.568	0.32	0.751	-500.1781	693.7067

ATT by Calendar Period

	Coefficient	Std. err.	z	P>|z|	[95% conf.	interval]
CAverage	7315.498	6279.097	1.17	0.244	-4991.307	19622.3
T2013	497.2905	169.467	2.93	0.003	165.1413	829.4397
T2014	4565.243	6141.191	0.74	0.457	-7471.271	16601.76
T2015	13417.2	11678.44	1.15	0.251	-9472.121	36306.52
T2016	8350.092	7056.167	1.18	0.237	-5479.741	22179.93
T2017	9747.662	7306.197	1.33	0.182	-4572.221	24067.55

ATT by Periods Before and After treatment
Event Study:Dynamic effects

	Coefficient	Std. err.	z	P>|z|	[95% conf.	interval]
Pre_avg	-188.286	401.4505	-0.47	0.639	-975.1146	598.5426
Post_avg	12221.34	10281.71	1.19	0.235	-7930.429	32373.12
Tm6	54.84223	883.7478	0.06	0.951	-1677.272	1786.956
Tm5	-852.7615	718.8283	-1.19	0.235	-2261.639	556.116
Tm4	-1736.591	937.0148	-1.85	0.064	-3573.106	99.92415
Tm3	-867.8538	703.1316	-1.23	0.217	-2245.966	510.2587
Tm2	944.9498	462.195	2.04	0.041	39.06438	1850.835
Tm1	1327.698	758.5704	1.75	0.080	-159.0722	2814.469
Tp0	1836.954	1534.564	1.20	0.231	-1170.736	4844.644
Tp1	7317.927	4974.757	1.47	0.141	-2432.417	17068.27
Tp2	21400	16420.82	1.30	0.192	-10784.23	53584.22
Tp3	32728.29	29271.64	1.12	0.264	-24643.07	90099.64
Tp4	-2176.445	571.5541	-3.81	0.000	-3296.671	-1056.22

Figure A.5 REAL ID Average Treatment Effect Coefficients, Standard Errors, p-values, and 95% Confidence Intervals by REAL ID Time, Calender Year, and by Event-study Time Period, Null Model

Average Treatment Effect on Treated

	Coefficient	Std. err.	z	P>|z|	[95% conf.	interval]
ATT	**8019.808**	**9043.994**	**0.89**	**0.375**	**-9706.095**	**25745.71**

ATT by group

	Coefficient	Std. err.	z	P>|z|	[95% conf.	interval]
GAverage	**7000.101**	**8567.524**	**0.82**	**0.414**	**-9791.938**	**23792.14**
G2012	**3993.747**	**9178.716**	**0.44**	**0.663**	**-13996.21**	**21983.7**
G2013	**13503.52**	**10051.84**	**1.34**	**0.179**	**-6197.73**	**33204.77**
G2014	**17446.78**	**9257.052**	**1.88**	**0.059**	**-696.7049**	**35590.27**
G2016	**6428.053**	**6212.778**	**1.03**	**0.301**	**-5748.768**	**18604.87**
G2017	**-17067.5**	**13250.7**	**-1.29**	**0.198**	**-43038.39**	**8903.393**

ATT by Calendar Period

	Coefficient	Std. err.	z	P>|z|	[95% conf.	interval]
CAverage	**6713.265**	**7874.968**	**0.85**	**0.394**	**-8721.388**	**22147.92**
T2012	**-2018.598**	**1136.884**	**-1.78**	**0.076**	**-4246.849**	**209.6524**
T2013	**41.21901**	**2863.185**	**0.01**	**0.989**	**-5570.521**	**5652.959**
T2014	**4696.689**	**5911.283**	**0.79**	**0.427**	**-6889.213**	**16282.59**
T2015	**9294.534**	**9855.043**	**0.94**	**0.346**	**-10021**	**28610.06**
T2016	**12723.07**	**12775.05**	**1.00**	**0.319**	**-12315.56**	**37761.71**
T2017	**15542.67**	**16112.09**	**0.96**	**0.335**	**-16036.44**	**47121.78**

ATT by Periods Before and After treatment
Event Study:Dynamic effects

	Coefficient	Std. err.	z	P>|z|	[95% conf.	interval]
Pre_avg	**-5981.518**	**3896.563**	**-1.54**	**0.125**	**-13618.64**	**1655.605**
Post_avg	**8849.201**	**10311.29**	**0.86**	**0.391**	**-11360.56**	**29058.96**
Tm6	**-20466.23**	**12532.23**	**-1.63**	**0.102**	**-45028.95**	**4096.496**
Tm5	**-4303.009**	**3331.68**	**-1.29**	**0.197**	**-10832.98**	**2226.965**
Tm4	**-5149.627**	**3329.215**	**-1.55**	**0.122**	**-11674.77**	**1375.514**
Tm3	**-3244.909**	**3867.188**	**-0.84**	**0.401**	**-10824.46**	**4334.64**
Tm2	**-1504.663**	**1828.464**	**-0.82**	**0.411**	**-5088.387**	**2079.061**
Tm1	**-1220.671**	**1218.725**	**-1.00**	**0.317**	**-3609.329**	**1167.987**
Tp0	**-559.5172**	**2271.014**	**-0.25**	**0.805**	**-5010.623**	**3891.588**
Tp1	**3989.365**	**4920.978**	**0.81**	**0.418**	**-5655.575**	**13634.31**
Tp2	**8729.352**	**8154.063**	**1.07**	**0.284**	**-7252.318**	**24711.02**
Tp3	**12874.98**	**12191.01**	**1.06**	**0.291**	**-11018.95**	**36768.91**
Tp4	**16001.04**	**16021.06**	**1.00**	**0.318**	**-15399.67**	**47401.74**
Tp5	**12059.99**	**19347.24**	**0.62**	**0.533**	**-25859.89**	**49979.88**

Figure A.6 REAL ID Average Treatment Effect Coefficients, Standard Errors, p-values, and 95% Confidence Intervals by REAL ID Time, Calender Year, and by Event-study Time Period for Extended Model, Regular Method

Average Treatment Effect on Treated

	Coefficient	Std. err.	z	P>|z|	[95% conf.	interval]
ATT	923.9482	3619.943	0.26	0.799	-6171.009	8018.906

ATT by group

	Coefficient	Std. err.	z	P>|z|	[95% conf.	interval]
GAverage	1700.537	3408.209	0.50	0.618	-4979.429	8380.504
G2012	128.7218	3019.063	0.04	0.966	-5788.533	6045.976
G2013	3148.121	7796.223	0.40	0.686	-12132.2	18428.44
G2014	-9021.288	5950.513	-1.52	0.130	-20684.08	2641.503
G2016	-443.7098	2085.229	-0.21	0.831	-4530.683	3643.264
G2017	17831.71	7637.647	2.33	0.020	2862.196	32801.22

ATT by Calendar Period

	Coefficient	Std. err.	z	P>|z|	[95% conf.	interval]
CAverage	576.0194	3160.581	0.18	0.855	-5618.606	6770.645
T2012	-1449	1126.385	-1.29	0.198	-3656.674	758.6739
T2013	-1630.383	1131.016	-1.44	0.149	-3847.134	586.3672
T2014	98.78477	2238.369	0.04	0.965	-4288.338	4485.908
T2015	1042.145	4382.655	0.24	0.812	-7547.701	9631.991
T2016	1531.776	5377.455	0.28	0.776	-9007.841	12071.39
T2017	3862.793	6341.038	0.61	0.542	-8565.413	16291

ATT by Periods Before and After treatment
Event Study:Dynamic effects

	Coefficient	Std. err.	z	P>|z|	[95% conf.	interval]
Pre_avg	-3026.789	2393.929	-1.26	0.206	-7718.804	1665.225
Post_avg	1229.968	3855.514	0.32	0.750	-6326.701	8786.637
Tm6	-22555.6	13769.12	-1.64	0.101	-49542.59	4431.382
Tm5	-3736.982	3395.153	-1.10	0.271	-10391.36	2917.394
Tm4	3067.214	4314.896	0.71	0.477	-5389.826	11524.25
Tm3	3156.952	3457.005	0.91	0.361	-3618.653	9932.558
Tm2	1476.593	2153.246	0.69	0.493	-2743.692	5696.878
Tm1	431.0897	1666.537	0.26	0.796	-2835.262	3697.442
Tp0	172.8255	1274.339	0.14	0.892	-2324.833	2670.484
Tp1	-1196.368	1855.109	-0.64	0.519	-4832.315	2439.579
Tp2	345.6889	4111.345	0.08	0.933	-7712.4	8403.777
Tp3	856.3712	5692.697	0.15	0.880	-10301.11	12013.85
Tp4	3952.992	7461.056	0.53	0.596	-10670.41	18576.39
Tp5	3248.298	6476.189	0.50	0.616	-9444.799	15941.4

Figure A.7 REAL ID Average Treatment Effect Coefficients, Standard Errors, p-values, and 95% Confidence Intervals by REAL ID Time, Calender Year, and by Event-study Time Period for Extended Model, Robust Method

Average Treatment Effect on Treated

	Coefficient	Std. err.	z	P>|z|	[95% conf.	interval]
ATT	1908.065	3048.689	0.63	0.531	-4067.255	7883.385

ATT by group

	Coefficient	Std. err.	z	P>|z|	[95% conf.	interval]
GAverage	2842.87	2871.443	0.99	0.322	-2785.055	8470.794
G2012	175.8199	2689.467	0.07	0.948	-5095.439	5447.079
G2013	3836.779	6248.357	0.61	0.539	-8409.776	16083.33
G2014	3727.98	2480.609	1.50	0.133	-1133.925	8589.885
G2016	292.0065	1136.098	0.26	0.797	-1934.705	2518.718
G2017	17259.36	6429.61	2.68	0.007	4657.555	29861.16

ATT by Calendar Period

	Coefficient	Std. err.	z	P>|z|	[95% conf.	interval]
CAverage	1439.938	2682.858	0.54	0.591	-3818.366	6698.243
T2012	-1453.22	1123.173	-1.29	0.196	-3654.599	748.1588
T2013	-1528.358	1012.852	-1.51	0.131	-3513.511	456.7959
T2014	305.9415	1980.574	0.15	0.877	-3575.913	4187.795
T2015	2139.104	3788.879	0.56	0.572	-5286.962	9565.17
T2016	3212.693	4534.773	0.71	0.479	-5675.299	12100.69
T2017	5963.468	5300.265	1.13	0.261	-4424.861	16351.8

ATT by Periods Before and After treatment
Event Study:Dynamic effects

	Coefficient	Std. err.	z	P>|z|	[95% conf.	interval]
Pre_avg	-2913.967	2446.42	-1.19	0.234	-7708.863	1880.929
Post_avg	2149.023	3258.317	0.66	0.510	-4237.161	8535.207
Tm6	-22517.43	13707.3	-1.64	0.100	-49383.25	4348.382
Tm5	-3171.82	3320.538	-0.96	0.339	-9679.955	3336.314
Tm4	2543.238	3819.445	0.67	0.505	-4942.736	10029.21
Tm3	3050.217	4195.319	0.73	0.467	-5172.458	11272.89
Tm2	1984.992	1952.813	1.02	0.309	-1842.452	5812.436
Tm1	627.0021	1586.775	0.40	0.693	-2483.02	3737.024
Tp0	271.7734	1212.204	0.22	0.823	-2104.103	2647.65
Tp1	-343.5905	1505.82	-0.23	0.820	-3294.943	2607.762
Tp2	2001.831	3458.256	0.58	0.563	-4776.226	8779.888
Tp3	3096.76	4762.664	0.65	0.516	-6237.89	12431.41
Tp4	4532.841	6171.322	0.73	0.463	-7562.728	16628.41
Tp5	3334.523	5639.223	0.59	0.554	-7718.15	14387.2

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Vita

Lauren Hosterman MPH, RDN
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Education:

Doctor of Philosophy (PhD) Candidate Baltimore, MD 2016-Present
Department of Population, Family and Reproductive Health
Johns Hopkins Bloomberg School of Public Health
GPA: 3.69/4.00
Dissertation: Changes in State Special Supplemental Nutrition Program for Women, Infants, and Children Participation and State Implementation of Federal Policy. Expected Graduation 12/2023

Master of Public Health Baltimore, MD 2014-2016
Child and Adolescent Health Concentration
Johns Hopkins Bloomberg School of Public Health
GPA 4.00/4.00

Bachelor of Science in Nutritional Science University Park, PA 2003-2007
The Pennsylvania State University
College of Health and Human Development
GPA 3.44/4.00

Training and Certifications:

Registered Dietitian/Nutritionist (RDN) Nationwide 2010-Present
National Registration Number 10105426

Dietetic Internship Richmond, VA 2009-2010
Virginia Department of Health and Maryland WIC Dietetic Internship

Emerging Leaders in Maternal Child Health Nutrition Training Institute Birmingham, AL 2014-2015
Partnership of University of Alabama, Birmingham; Baylor College of Medicine, University of Minnesota, University of Tennessee, Knoxville and Health Resources and Services Administration's Maternal and Child Health Bureau

Professional Work Experience:

Mama, LLC Canton, MA 2018- 2022
Public Health and Nutrition Consultant

- Performed literature review on the use of comprehensive care practices in pelvic floor fistula repair, and publication method section.
- Organized and streamlined data coding for the mobile surgical outreach program for management of patients with genital fistula in the Democratic Republic of Congo. Analyzed a database of patient medical information and created summary tables for publication.
- Assisted in randomized control trial of a pelvic digital health medical device which included distribution of devices and provision of technical assistance to study participants, completed data collection transfers, and collaborated with the company's technology team.

Renovia, Inc Boston, MA 2020-2022
Medical Writing Consultant

- Supported Renovia staff in literature searches, library organization, data management, and consulted on study design and research methodology.
- Collaborated with app developers, aided in data collection, and compiled patient reports for the Renovia Digital Health Pilot study on a digital pelvic floor medical device (Leva).

Maryland WIC Program, Maryland Department of Health Baltimore, MD 2013-2017

Nutrition Specialist Supervisor, Nutrition Specialist

- Wrote Maryland WIC state policy regarding WIC food packages, infant formula, and medical foods in accordance with the Federal Register and Code of Federal Regulations.
- Interpreted new USDA FNS WIC regulations and state policies, incorporated into state WIC policy, and disseminated to state and local WIC employees.
- Composed memorandums, bulletins, and other formal correspondence regarding WIC related maternal-child nutrition, food packages, infant formulas, and medical foods.
- Coordinated monitoring and evaluation of the provision of nutrition services by local agencies for USDA and Maryland WIC policy and procedure compliance. Completed through direct clinic observations, record reviews and evaluation of employee's interaction with WIC participants.
- Analyzed food, infant formula, and medical food submissions from vendors for desired macro/micronutrient content per Federal and State regulations for consideration for inclusion in the WIC Authorized Product List and Authorized WIC Food List.
- Acted as a liaison between the commercial food companies, formula/ medical nutritional representatives, WIC-authorized vendors and the Maryland WIC program regarding changes in allowable products or policies. Advised the vendor unit on eligibility of WIC foods and policy changes.
- Started and managed local agency support formula line. Provided support to local agency nutritionists and coordinators regarding special formula/medical food issuance on designated phone line.
- Supervised Nutrition Service Unit staff; duties included staff performance evaluations, updating job descriptions, coordinating job responsibilities, managing staff schedules and timekeeping.
- Worked in partnership with WIC Staff on eWIC implementation through the eWIC vendor workgroup and the management of the Authorized Product List (APL) database.
- Addressed participant complaints or concerns regarding the provision of WIC food packages, formulas and medical foods.
- Created food packages in a WIC specific management information system, WOW, in collaboration with 3-Sigma Software programmers and developers.
- Trained new local agency employees, with training staff at the Maryland WIC Training and Temporary Services Center. Updated current staff through webinars and statewide meetings.
- Acted as a preceptor to Maryland WIC Dietetic Interns. Provided training and guidance during internship class days.
- Attended conferences, trainings and symposiums on breastfeeding, maternal-child health and nutrition.
- Designed social media content, and reviewed communication team member's posts for accuracy and consistency with WIC's nutrition messaging.
- Collaborated with communication team to establish an outreach work group to streamline messaging, incorporate branding and pursue meaningful evidence-based methods of outreach.

Harford County Health Department Aberdeen, MD 2008-2013

Harford/Cecil County WIC Program

Nutritionist II, Nutritionist I, Nutrition Program Trainee

- Determined program eligibility for WIC applicants and administered program benefits, nutrition education, high risk counseling, breastfeeding support, health screening and referrals
- Created lesson plans/activities for nutrition education, breastfeeding and participant-centered counseling and delineated material to staff and clients. Completed annual nutrition services plan.
- Orchestrated outreach activities throughout the Harford/Cecil community and participated on local roundtables regarding the WIC population. Managed social media accounts. Completed monthly and annual outreach reports.
- Administered high risk nutrition counseling and monitoring. Tailored WIC food packages for women, infants and children with special needs. Processed and approved requests for medical foods/exempt formulas from prescriptive authorities.
- Obtained grant funding from Share our Strength to implement Cooking Matters for adults and Shopping Matters for WIC participants. Planned, organized, taught classes and led grocery store tours.

- Engaged as a member of nutrition care plan workgroup to revise WIC nutritional screening, counseling, monitoring protocols and inclusion of more weight management and obesity prevention strategies.
- Managed nutrition program trainees and acted as a community preceptor for dietetic interns.

Catholic Charities Early Head Start, Harford County Aberdeen, MD 2011-2014
Consultant Dietitian

- Evaluated menu plans quarterly for the daycare center and home-based socialization groups.
- Advised the program on how to meet Head Start Nutrition Performance Standards and CACFP guidelines.
- Incorporated a wellness policy for EHS in accordance with Maryland State Department of Education grant guidelines.
- Planned and taught a four-day nutrition and cooking class during National Nutrition Month for EHS participants and their caregivers.
- Reviewed children's and pregnant women's nutritional assessments, height/weight growth charts, and medical records to provide recommendations for improving eating and health related behaviors.
- Provided nutrition resources and consultations for children, families and staff.

Academic Work Experience:

Nutrition and Growth in Maternal and Child Health Baltimore, MD 2017-2019
Johns Hopkins Bloomberg School of Public Health
Graduate Course Teaching Assistant

Nutrition Programs, Policy and Politics in the United States: The Impact on Maternal, Child and Family Health Baltimore, MD 2016-2019
Johns Hopkins Bloomberg School of Public Health
Graduate Course Teaching Assistant

Population, Health and Development Baltimore, MD 2017-2018
Johns Hopkins University
Undergraduate Course Teaching Assistant

The Identity Clinic Baltimore, MD 2017-2018
Johns Hopkins University Student Outreach Resource Center and Living Classrooms Foundations' Identity Clinic
Clinic Navigator Organizer, Research Assistant

- Received Johns Hopkins Urban Health Institute Community-Driven Research Grant to perform a program process evaluation of the Living Classrooms Identity Clinic. The Identity Clinic was formed to streamline the process of obtaining identity for Baltimore City residents.
- Assessed program fidelity, determined if target population was being served, and informed program improvements and/or expansion.
- Developed the "Identity Clinic Intake Form" to record client information, (e.g. demographics, incarceration history) for later entry into an administrative database.
- Revised the data collection and management policies; trained staff and volunteers on new procedures; distributed intake forms to clients.
- Analyzed client information recorded in the clinic's administrative database.

Women and Children Health Policy Center Baltimore, MD 2017-2018
Johns Hopkins Bloomberg School of Public Health
Research Assistant

- Performed a literature review of evidence-based strategies to reduce the percentage of women that smoke during pregnancy, as part of the Strengthen the Evidence Base for Maternal Child Health Programs project (Maternal and Child Health Bureau, Health Resources and Services Administration).
- A resource to assist State Title V MCH programs in developing evidence-based State Action Plans and in responding to the National Outcome Measures, National Performance Measures, and State Performance Measures.

Publications:

Keyser, L., McKinney, J., Hosterman, L., & Chen., G. (2021). Rehabilitative care practices in the management of childbirth-related pelvic fistula: A systematic review. *International urogynecology journal*, 10.1007/s00192-021-04845-4. Advance online publication. https://doi.org/10.1007/s00192-021-04845-4

Maroyi R, Keyser L, Hosterman L, Notia A, & D. Mukwege. (2020) The mobile surgical outreach program for management of patients with genital fistula in the Democratic Republic of Congo. Int J Gynaecol Obstet. 2020 Jan;148 Suppl 1:27-32.

McKinney, J., Keyser, L., Hosterman, L., & Chen, G. (2018) Conference Abstract: Postoperative Conservative Management of Fistula and Associated Comorbidities. FIGO: World Congress of Gynecology and Obstetrics. Rio de Janeiro, Brazil

Burbank, M., Hosterman, L., Evans, M., & Leung-Strle. P. (2015). Mandating Paid Maternity Leave for America's Working Mothers: Improving the Health and Economic Stability for Families. The Association of State Public Health Nutritionists (ASPHN). Emerging Leaders in MCH Training Institute Policy Briefs.

Unger, E. L., Jones, B. C., Hosterman, L., Bianco, L. E., & Beard, J. L. (2006). Early iron deficiency alters neurotransmitter levels and locomotor behavior in pre-and post-weaning rats. The FASEB Journal, 20(4), A193.

Scholarships and Awards:

Bernard and Jane Guyer Scholarship Fund Recipient 2020-2021
Johns Hopkins Bloomberg School of Public Health
- Supports an outstanding student in the Department of Population, Family and Reproductive Health whose primary focus is maternal and child health.

Willian Endowment for Excellence in Science 2020-2021
Johns Hopkins Bloomberg School of Public Health
- Supports an outstanding doctoral student in the field of Population, Family and Reproductive Health whose work focuses on issues of health policy and management for women and children

Lisa Paine Graduate Fellowship Recipient 2020-2021
Johns Hopkins Bloomberg School of Public Health
- Supports a continuing health care professional pursuing a graduate degree in the Department of Population, Family and Reproductive Health.

Student Outreach Resource Center Champion of the Month August 2017
Johns Hopkins Bloomberg School of Public Health
- Recognizes a student for their commitment to serving the Baltimore community.

Delta Omega Public Health Honor Society Alpha Chapter 2017-Present
Johns Hopkins Bloomberg School of Public Health
- Inducted into national public health honor society that recognizes leaders in public health.

Kappa Omicron Nu National Honor Society for the Human Sciences 2006-Present
The Pennsylvania State University
- Inducted into national honor society for collegiate students in the human sciences.

Ruth Pike Scholarship in Basic Nutrition Science Recipient 2005-2006
The Pennsylvania State University

Selected Conferences and Symposiums:

FIGO: World Congress of Gynecology and Obstetrics Rio de Janeiro, Brazil 2018
Abstract Contributor

Community Involvement: Dispelling Myths, Providing Tips. SOURCE, Johns Hopkins Bloomberg School of Public Health *Panelist*	Baltimore, MD	2017
Careers in Nutrition Course. The Pennsylvania State University *Guest Speaker*	University Park, PA	2017
National WIC Association Annual Education Conference *Guest Speaker*	Pittsburgh, PA	2014
Obesity in the Early Childhood Years: State of the Science and Implementation of Promising Solutions. Institute of Medicine Workshop. *Attendee*	Washington, DC	2015
Biennial National WIC Association Technology and Program Integrity Education Conference *Attendee*	St Louis, MI	2015
National WIC Association Annual Education Conference *Attendee*	Los Angeles, CA	2015