Prenatal participation in WIC: impact on breastfeeding initiation and duration and on infant weight gain

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PRENATAL PARTICIPATION IN WIC: IMPACT ON BREASTFEEDING INITIATION AND DURATION AND ON INFANT WEIGHT GAIN

by

Lynn S. Edmunds

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ABSTRACT

Background: The Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) is one of the most studied federal food assistance programs. However, few studies have examined the association between maternal WIC participation and breastfeeding or weight gain during infancy. Prenatal WIC participation provides an important window of influence on birth outcomes but also on early life risk factors for chronic disease. This study utilizes a cohort of WIC enrolled infants to assess the added effect of prenatal exposure to WIC on two specific outcomes – breastfeeding initiation and duration and rate of infant weight gain.

Methods: Utilizing data prepared for the Pediatric and Pregnancy Nutrition Surveillance Systems, this study links a cohort of WIC enrolled infants born in 2008-2009 with maternal WIC records. Infants whose mothers enrolled prenatally are compared to those whose mothers delayed enrollment until postpartum. Multiple logistic regression analyses test the association of prenatal WIC participation with initiation and duration of breastfeeding and with rapid infant weight gain.

Results: The final study cohorts included more than 160,000 infant/mother pairs. Both studies demonstrate that prenatal WIC participation imparts added benefits beyond those of postpartum participation. Initiation of breastfeeding was high among the prenatal and postpartum groups, 79% and 77%, respectively. Prenatal participants were more likely to continue to breastfeed at 3, 6, and 12 months. Odds of breastfeeding varied by
race/ethnicity and parity; Hispanic mothers had higher odds of breastfeeding at each time assessed compared to non-Hispanic white or black participants. Prenatal participation was associated with reduced odds of rapid infant weight gain; birth weight-for-gestational age and breastfeeding duration mediated the relationship.

**Conclusions:** The results of these studies of mother-infant pairs enrolled in WIC in NYS demonstrates that WIC enrollment during the prenatal period increases the initiation and duration of breastfeeding and reduces the risk of rapid infant weight gain. A strength of this study is the use of a comparison group of women enrolled in WIC during the postpartum period, minimizing the bias inherent in studies that use as the control group eligible non-participants. Future research should examine how long the protective effect of prenatal participation extends.
CHAPTER 1

INTRODUCTION

In 1972, the United States congress established the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) to help prevent adverse health outcomes during periods of critical growth and development (1). WIC does this by providing supplemental foods, nutrition education and health care referrals to low-income families (< 185% Federal poverty level) for nutritionally at risk infants, children and pregnant, postpartum and breastfeeding women (2).

WIC is the nation’s third largest food assistance program, surpassed only by the Supplemental Nutrition Assistance Program (formerly called the Food Stamp Program) and the School Lunch program (2). WIC differs from other Federal programs in that it is not an entitlement program, in other words, not all eligible individuals are guaranteed participation. In the event of funding shortages, a priority system establishes which category of eligible individuals are given preference (2).

At that time the WIC program was founded the major nutritional concern, particularly affecting pregnant women and children living in low-income households, was that nutritional intake was inadequate to support optimal growth and development. In the ensuing decades since the program’s inception, the increasing prevalence of obesity among children and adults in the US has become a significant public health concern. Thus, in recent years, the WIC program has been challenged with not only addressing inadequate nutritional intake among eligible participants but also with promoting a more
healthful and active lifestyle for the prevention of obesity. Recently, numerous changes have been made to the WIC program to address these emerging challenges and issues and to reduce the burden of enrolling in the program to encourage families to continue participation as long as they are eligible.

**WIC Program Operations**

At the Federal level, the Food and Nutrition Services of the United States Department of Agriculture, administers the WIC program through grants to state agencies. The WIC program was administered by 50 state health departments, 34 Indian Tribal Organizations, five US territories, and the District of Columbia, and in 2010 served over 10 million individuals at a cost of $6.7 billion dollars (3, 4). Nationally, in 2009 WIC served more than 60% of eligible individuals (3). In New York State, the Division of Nutrition of the New York State Department of Health oversees the program and services are delivered through 97 contracting agencies, including county health departments, hospitals, and other community agencies. In 2010, the New York WIC program served 5.7% of US WIC participants, making it the fourth largest WIC program in the nation (4).

To participate in the WIC program one must meet specific eligibility requirements. Women must be pregnant, non-breastfeeding within 6 months postpartum, or breastfeeding within one year postpartum. Infants are eligible up to their first birthday and children up to the age of five years. In addition, they must meet specific income guidelines, generally at or below 185% of the federal poverty level, live in the state in which they are applying, and demonstrate nutritional risk. Participants are certified as
WIC eligible by providing evidence that they meet the income guidelines and are nutritionally at risk. Nutritional risk is defined by Federal regulation and must be established by a health professional (4). Height and weight are measured at approximately six-month intervals.

Certified participants visit the WIC clinic every 3 months to pick up vouchers for food and to receive nutrition counseling. Eligible pregnant women are enrolled in WIC through 6 weeks postpartum. Postpartum women who are not breastfeeding can be certified for up to 6 months following birth and breast-feeding women can be certified up to one year following birth as long as they continue to breast-feed. Infants are certified until one year of age. At the time of this study, children, over the age of one year, were certified at 6-month intervals and may continue to participate until their fifth birthday as long as they continue to be income eligible. The Healthy, Hunger-free Kids Act of 2010 gave states the option of certifying children for 12 months rather than 6 months (5).

The supplemental foods provided to program participants are specific to the category of eligibility (i.e. Pregnant, postpartum, breastfeeding woman, infant, or child). Historically, the supplemental foods provided are to meet specific nutritional needs during these critical periods of critical growth and development (i.e. calcium, iron, vitamins A and C, and protein).

Nutrition education is another core benefit provided by the WIC program. WIC regulations require that WIC local agency staff offer participants or their caregivers at least two nutrition education sessions during each certification period, approximately every three months. These nutrition education sessions aim to increase the participants’
knowledge, attitudes, behaviors, and self-efficacy with respect to healthy lifestyles, including choices surrounding food and dietary behaviors and physical activity. The WIC program has a strong commitment to promote and support breastfeeding as the best possible source of infant nutrition. In addition to incorporating messages surrounding breastfeeding into nutrition counseling the WIC program further supports and promotes breastfeeding by providing peer counselors, training staff as lactation consultants, distributing breast pumps, and providing an enhanced food package to breastfeeding mothers.

WIC research

The WIC program is one of the most studied federal food assistance programs. However, the most comprehensive studies of the program were conducted decades ago. In 1998, Rush and colleagues published results of the National WIC Evaluation (6). These studies focused on the effects of prenatal WIC participation on maternal and infant/child outcomes. WIC participation during pregnancy was associated with increased early prenatal care, longer gestation, decreased pre-term birth, increased birth weight, and reduced fetal mortality (7). Prenatal enrollment in WIC was also associated with improved dietary intake including increased intake of protein, iron, calcium, and vitamin C. The primary association with WIC among preschool children was enhanced dietary intake specifically for iron, vitamins A and C.

Of the published studies since the National WIC Evaluation, the majority focuses on prenatal participation and the effect on birth outcomes (8). Research into the impact of the WIC program on child participants, however, is limited, though greater than 50% of
participants are between the ages of 1 and 5 years. The majority of the studies assessing outcomes among child participants focused their evaluation on improvements in nutritional intake or reduction in iron-deficiency anemia (8). Of the few studies that have examined the association between WIC participation and child growth most have focused on participation of the infant or child in relation to growth outcomes during early childhood (8). One of those studies found that WIC eligible infants not enrolled in the program were more likely to be underweight or short compared to infants who received WIC benefits during the first year of life (9). No published studies have evaluated the effect of mothers’ prenatal participation in the WIC program on physical growth of children.

The WIC program has been criticized for promoting the use of formula and for lower rates of breastfeeding among participants compared to non-participants (10, 11). One study comparing WIC mothers to non-WIC mothers found that non-WIC mothers were twice as likely to breastfeed their infant for at least 6 months (11). Others have noted racial/ethnic differences or regional variation in initiation and duration of breastfeeding among WIC eligible mothers (12, 13). However, what most studies of breastfeeding behavior among WIC mothers fail to account for is the bias produced both by mothers’ self-selection into the WIC program and self-selection of breastfeeding (14).

After several decades of rising prevalence of obesity among all children (15), and particularly among low-income pre-school age children participating in the WIC program (16, 17) the prevalence appears to be stabilizing (15, 18). Among preschool age children
enrolled in WIC in New York State, prevalence of obesity peaked at 16.7% in 2003, declined through 2005, before stabilizing at 14.7% in 2007 (18). Nationally, obesity prevalence among low-income preschool aged children participating in maternal and child health programs also appeared to stabilize at just under 15% in 2008 (19).

**Risk factors for child obesity**

Well-established risk factors for child obesity include dietary patterns, physical inactivity, and television viewing behaviors but increasingly research is focusing on early life factors, including prenatal and perinatal factors (20-23). In 1994, Dietz identified gestation and early infancy as critical periods in the development of obesity, citing studies indicating that both under- and over-nutrition during pregnancy are associated with later childhood obesity (20). It is hypothesized that it is during this critical period that the foundation is laid for a life-long predisposition for body composition and that conditions experienced in utero may play an important role (24).

Parental obesity (25), maternal prenatal smoking (26, 27), and gestational diabetes (28, 29) have all been linked with development of obesity during childhood. Whitaker, et al. found that obese children at 1 – 2 years of age had a non-significant odds ratio for obesity in adulthood (OR=1.3; 95% CI, 0.7-2.5) but the odds ratio increased to 3.6 (95% CI, 2.1-5.9) if the mother was obese (25). Maternal pre-pregnancy body mass index (BMI) has been associated with both weight and weight-for-length among infants at 6 months of age (30). Infants of mothers who were overweight or obese prior to pregnancy had higher weight and weight-for-length at 6 months of age compared to mothers who were of normal weight pre-pregnancy (30). Pre-pregnancy weight status is of particular public
health importance as surveillance data estimate that greater than a third of women are overweight or obese prior to pregnancy, 13% overweight (BMI of 26.0-29.0), and 22% obese (BMI 29.0 or greater) (31).

It is well understood that appropriate maternal weight gain during pregnancy is an important factor for optimal birth outcomes and that gestational weight gain is associated with infant birth weight (32). Recent research, however, has suggested that gestational weight gain may be directly associated with high BMI of the child (30, 33, 34). A large prospective study of mother and child pairs enrolled in Project Viva found that gestational weight gain was directly associated with child adiposity at three years of age (33). However, in that study, even children of mothers with adequate gestational weight gain according to the 1990 IOM guidelines had higher BMI z-scores and an increased risk of obesity. A second prospective cohort study identified excessive gestational weight gain as a risk factor for high weight, length, and weight-for-length of offspring at 6 months of age (30). Another study found excess weight gain during pregnancy and prepregnancy body mass index to be associated with child overweight at 3 years of age (34). The study authors reported that the impact of excess weight gain during pregnancy was greater among women who began their pregnancy overweight with nearly half of their offspring overweight at 3 years of age.

Birth weight is a well-studied outcome of pregnancy, largely because it is easily measured, but birth weight has also been shown to be associated with child and adult weight status. In a review of the prenatal environment and the development of obesity Whitaker and Dietz found seven studies that showed a positive association between birth
weight and adult weight status (23). A large prospective study of children showed that both birth weight and weight gain during the first 12 months of life were associated with increased odds of obesity at 7 years of age (22). A study of WIC enrolled children in New York State reported that rate of infant weight gain during the first 6 months of life was associated with obesity at 4 years of age (35). The role of birth weight in the development of later obesity may be due to the rapid catch-up growth that occurs during the first 6 to 12 months of life among low birth weight infants (36). Though some suggest that the effects of rapid infant weight gain on later obesity are similar for infants born small for gestational age and those of normal birth weights (37).

Studies suggest that breastfeeding may play a role in prevention of childhood obesity (38-40). A clear dose response protective effect of breastfeeding has been noted with respect to prevalence of obesity at school entry (41). And a large meta-analysis concluded that each additional month of breastfeeding was associated with a 4% reduction in risk of overweight (39).

**Public Health Significance**

As a major food assistance and nutrition education program, WIC is in a position to play an important role in the prevention of childhood obesity. Both at the national and state levels the WIC program has responded to the challenge and has taken steps to incorporate obesity prevention into program operations. To support these efforts, it is essential to gain a thorough understanding of the role that WIC plays in the development or remission of obesity among child participants as well as to identify those at greatest risk for development of obesity. WIC is a large public health nutrition program that
enrolls nearly half of all U.S. newborns. Thus, answering these questions has important implications for effective prevention strategies and program policy.

Few studies, to date, have attempted to evaluate the effect of mother’s prenatal and/or postpartum participation in the WIC program on infant health including physical growth over time or on initiation or duration of breastfeeding. Significant gaps in the literature exist with respect to the effects of maternal participation in WIC beyond the impact on birth outcomes.

The specific aims of this study

There is little evidence of the effect of maternal participation in WIC beyond that of the effect on birth outcomes, more specifically on birth weight. What is lacking is evidence that maternal participation in WIC during the prenatal period leads to improved child health outcomes during the first year of life and beyond. The proposed study aims to expand the knowledge base on the association of maternal prenatal participation in WIC beyond that of the association with birth outcomes. Through a linkage of child WIC participants with information regarding their mothers’ participation in WIC, this study aims to assess whether maternal prenatal participation in WIC is associated with improved health outcomes for their children, specifically, increased duration of breastfeeding and a reduced risk of rapid infant weight gain during infancy.

The research questions, hypotheses, and specific aims addressed through this study are:

1) **Research question** – What is the association of maternal prenatal WIC participation with infant health outcomes?
a. **Hypothesis** – Breastfeeding initiation and duration are greater among infants whose mothers enrolled participated in WIC prenatally vs. postpartum.
   
i. **Specific Aim** – Conduct a cohort analysis of WIC enrolled infants testing the association maternal prenatal vs. postpartum WIC enrollment with breastfeeding initiation and duration.

b. **Hypothesis** – Infants of mothers who enrolled in WIC have a reduced risk of excess weight gain during the first year of life compared to infants of mothers who enrolled in WIC during the postpartum period only.
   
i. **Specific Aim** – Conduct a cohort analysis of WIC enrolled infants testing the association of maternal prenatal vs. postpartum WIC enrollment with infant weight gain during the first year of life.

**Conceptual framework**

Figure 1.1 depicts a conceptual framework for the potential intervention effects of WIC in mediating the relationship between maternal and perinatal factors and child weight status between birth and one year of age. The prenatal period and the infant’s first year of life provides an important potential widow of influence that is not fully realized as approximately one-third of infants enrolled in WIC during infancy do not continue to participate beyond their first birthday.

This study tests the hypothesis that early and continued participation in the WIC program exposes the mother to the maximum benefits provided by the program through nutritious foods, nutrition education, and referral to medical and social services. Gestational weight gain, and the infant feeding decisions that the mother makes during
the prenatal period each impact a risk for excess infant weight gain and development of obesity.

The obesity epidemic and new research led the Institute of Medicine in 2009 to revise their guidelines for weight gain during pregnancy based on pre-pregnancy BMI (32). During pregnancy WIC provides supplemental foods and nutritional counseling including guidance on optimal weight gain. Nutrition counseling is provided by a Competent Professional Authority, generally a Registered Dietitian, nutritionist, or nurse, in one-on-one or groups sessions. Women are also offered the support of Breastfeeding Peer Counselors and Certified Lactation Consultants during the prenatal period as this a critical time when the infant feeding decisions are being made. Women are also counseled regarding smoking and alcohol use during pregnancy and referred to appropriate programs as necessary.

During the postpartum period the breastfeeding mother receives the continued support of Breastfeeding Peer Counselors and Certified Lactation Consultants in addition to an enhanced food package. Postpartum enrolled women who are not breastfeeding do not receive the enhanced food package although they do receive the benefits of nutrition counseling which address issues such as appropriate infant feeding and introduction of foods other than formula.
Figure 1.1 Conceptual framework for the role of WIC in moderating risk factors for child obesity
Description of study

This prospective, longitudinal study includes infants who were born during 2008 or 2009 and enrolled in the NYS WIC program during the first six months of life. Data were obtained by linking data generated from the NYS WIC information system for inclusion in two national surveillance systems sponsored by the Centers for Disease Control and Prevention; the Pediatric Nutrition Surveillance System (PedNSS) and the Pregnancy Nutrition Surveillance System (PNSS). Data contributed to PedNSS and PNSS are routinely collected during WIC clinic visits. For all participants, data were collected at the initial enrollment, and for infants at approximately one year of age, and for children, over 1 year of age, at 6-month intervals as long as they remain eligible and the family chooses to participate.

PedNSS provided information on breastfeeding initiation and duration and infants length and weight, collected at time of infant enrollment in WIC and at approximately 1 year of age. Infant data were linked to their mother’s data if a record existed. PNSS provides information on maternal factors such as timing of enrollment in WIC, timing of initiation of prenatal care, pre-pregnancy weight, gestational weight gain, presence of gestational diabetes, and smoking prior to pregnancy.

Two novel approaches were used to assess infant and child weight status. First, a birth weight-for-gestational age reference developed by Oken, et al (42) provides a more precise estimate of weight status at birth than would birth weight alone. Second, following recommendations of the Centers for Disease Control and Prevention (43), the USDA recently mandated that state WIC programs use the new child growth standards developed by the World Health Organization (44) for assessment of anthropometry in children up to 2
years of age. These new standards are utilized to assess weight status during the first year of life.

**Preparation of data**

Addressing the research questions requires a linkage of infants and children in PedNSS with their mothers in the PNSS. This is made possible by matching an infant/child with the corresponding unique identifier on the mother’s record if one exists. The process used to prepare and link the data in Figure 1.2. The first step in the process of creating the linked cohort was to merge monthly PedNSS files beginning with January 2008 through March 2011 into one data file. Second, a subset of children born January 1, 2008, through December 31, 2009, is selected as the birth cohort. It is advantageous to limit to children born 2008 and later for two main reasons. First, changes to the WIC Statewide Information System in 2008 improved the integrity of some PNSS data items. Second, selecting children born in 2008 and 2009 ensures that a sufficient sample of children who will continue participation beyond one year of age will be available. Child records were then linked to their mothers’ records.
Figure 1.2 Preparation of linked data set

1. **Merged PedNSS**
   - Jan 1 2008 - Mar 31 2011
   - N=2,271,920

2. **Selected records for children**
   - born 01-Jan-08 – 31-Dec-09
   - N=762,963
   - max records per child = 8

3. **Merged all records for each child to yield one record per child**
   - N=309,456

4. **Merged PNSS 2007-2010**
   - Jan 1 2007 – Sep 30 2010
   - N=534,417

5. **Infant in PNSS?**
   - No
     - Records of children not in PNSS
     - N=57,066
   - Yes
     - Match merge with PNSS
     - N=259,072

6. **Eliminate duplicate records**
   - (n=122)
   - N=258,950

7. **Merged unmatched PedNSS with matched PedNSS/PNSS**
   - N=316,016 unique child records
Research design

The main exposure variable, prenatal participation in WIC was operationalized according to the mother’s enrollment in WIC while pregnant with this child. (Figure 1-3) To isolate the contribution of maternal prenatal enrollment in WIC on infant and child health outcomes, the study population was limited to two groups: 1) those children whose mothers participated both prenatally and during the postpartum period; and 2) those whose mothers participated during the postpartum period only.

Selection of control group

This study design compares outcomes among infants whose mothers enrolled in WIC prenatally to those who delayed enrollment until the postpartum period. Several problems arise when attempting to compare WIC to non-WIC participants. First, program coverage is very high among infants from income-eligible families making it difficult to find a “true” control group of children never exposed to the WIC program. Second, as with all studies attempting to compare WIC participants to non-participants, selection bias is a concern, specifically that WIC participants and non-participants might differ on important but unmeasured characteristics (8). Researchers have tried to control for differences between WIC and non-WIC participants by employing techniques such as multivariate regression or propensity score analysis. Such techniques, however, are limited unless all relevant covariates are included in the analyses (8). This study employed a similar design to Joyce and colleagues (45) to address selection bias by comparing women who first enrolled during the prenatal period and continued to participate during the postpartum period to women who enrolled later during the postpartum period, thus creating two groups of women who were eligible and who
participated in WIC (but for differing intervals) (45). In this way, the exposure and comparison groups are similar in ways that often differ when researches attempt to compare WIC participants to income eligible non-participants.

Figure 1.3 Study design for assessment of association of prenatal WIC participation on with excess infant weight gain during first year and with initiation and duration of breastfeeding.
CHAPTER 2

Prenatal enrollment in NYS WIC is associated with increased breastfeeding initiation and duration
ABSTRACT

Introduction: Breastfeeding is widely accepted as the optimal method of infant feeding conveying benefits to both the mother and infant and is considered the normative standard worldwide. Reportedly, the prevalence of initiation and particularly duration are lower among participants of the Special Supplemental Nutrition Program for Women, Infants, and Children. The New York State Department of Health and the New York State WIC program have put considerable time and effort into the promotion of breastfeeding as the optimal means of infant feeding. The primary objective of this study is to assess whether breastfeeding initiation and duration are influenced by maternal prenatal WIC participation.

Methods: This prospective cohort study includes infants who were born during 2008 or 2009 and enrolled in the NYS WIC program during the first six months of life. Infant records were linked to maternal WIC participation records. Two groups of infants/mother pairs comprised the exposed and unexposed groups; mothers who enrolled in WIC during the prenatal period and those who delayed enrollment until the postpartum period. The main outcome variables were breastfeeding initiation, and at 3, 6, and 12 months of age. Prevalence estimates were generated for each time period and multiple logistic regression assessed the association of prenatal enrollment and each outcome, expressed as odds ratios.

Results: Initiation of breastfeeding was high among the prenatal and postpartum groups, 79% and 77%, respectively. The prevalence of women/infants continuing to breastfeed at 3, 6, and 12 months was higher among prenatal participants vs. postpartum participants.
and was highest among Hispanic women compared to black or white women. Breastfeeding outcomes varied by maternal gravid status. Among non-Hispanic black or white women, those enrolled prenatally had lower odds ratios of breastfeeding for each outcome. Among multigravida women, prenatal enrollees had higher odds of breastfeeding at all time points compared to postpartum women.

**Conclusions:** In NYS WIC high rates of breastfeeding initiation were noted for women who enrolled prenatally or postpartum. Higher rates of continued breastfeeding were seen at all time points (3, 6, and 12 months) among women who enrolled in WIC prenatally vs. the postpartum period suggesting that prenatal participation has a positive effect on initiation and duration of breastfeeding. Most women make the decision to breastfeed or not prior to delivery. These findings highlight the important role that WIC participation, particularly during the prenatal period plays in promoting initiation and duration of breastfeeding.
INTRODUCTION

Breastfeeding is widely accepted as the optimal method of infant feeding conveying benefits to both the mother and infant and is considered to be the normative standard worldwide (46-48). Breastfeeding protects both the mother and infant against a range of adverse health outcomes (47). Breastfed infants have lower incidence of ear, respiratory, and gastrointestinal infections and a reduced risk of childhood obesity (49). The U.S. Surgeon General and the American Academy of Pediatrics (AAP) recommend exclusively breastfeeding until 6 months of age with continued breastfeeding to one year or beyond along with the introduction of complementary foods (46, 47). Despite progress made toward meeting recommendations for breastfeeding, disparities continue to exist particularly regarding continuation beyond the early postpartum period (50). Nationally, estimates of breastfeeding initiation and duration vary by race and ethnicity, education, and income status (51). The prevalence of initiation of breastfeeding is well below the HP2010 target of 75% among non-Hispanic black women, and women who are younger, less educated, and lower income, or who participate in the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) are also less likely to initiate breastfeeding (50, 52).

The New York State Department of Health and the New York State WIC program have put considerable time and effort into promotion of breastfeeding as the optimal means of infant feeding. The WIC program promotes and supports breastfeeding by providing peer counselors, training staff as lactation consultants, distributing breast pumps, and providing an enhanced food package to breastfeeding mothers. Mothers who are not exclusively breastfeeding, however, receive infant formula from WIC. Critics
suggest that by providing formula, WIC discourages breastfeeding, a claim that has been demonstrated in studies comparing WIC to eligible non-WIC participants (10, 11). One study comparing WIC mothers to non-WIC mothers found that non-WIC mothers were twice as likely to breastfeed their infant for at least 6 months than were WIC enrolled mothers (11). Others have noted racial/ethnic differences or regional variation in initiation and duration of breastfeeding among WIC eligible mothers (12, 13). However, what most studies of breastfeeding behavior among WIC mothers fail to account for is the bias produced both by mothers’ self-selection into the WIC program and self–selection of breastfeeding (8, 14).

The WIC program is one of the most studied federal food assistance programs. Significant gaps in the literature exist with respect to the effects of maternal participation in WIC beyond the impact on birth outcomes. A recent review of studies examining participation in WIC identified five studies that investigated the association of prenatal WIC participation with infant feeding practices (8). Only one reported a positive association between WIC enrollment and breastfeeding initiation (53). Through a comparison of early prenatal enrollees to those enrolling in the second or third trimester of pregnancy the authors observed a positive association between first trimester enrollment and initiation of breastfeeding (53). Another study compared prenatal participants to non-participants and found no difference in initiation of breastfeeding (54). A study of women who enrolled in WIC postpartum compared to non-participants found that postpartum participants were more likely to initiate breastfeeding than prenatal participants (55).
No studies to date have examined, among a large population of WIC participants, whether women who enroll in WIC prior to birth, when the decision to breastfeed is most likely made, are more likely to initiate breastfeeding and breastfeed longer than women who delay enrollment until after birth.

The primary objective of this study is to assess whether breastfeeding initiation and duration are influenced by maternal prenatal WIC participation. This is made possible through a linkage of WIC enrolled infants and their mothers by comparing those whose mothers enrolled during the prenatal period to those who delayed enrollment to the postpartum period. Specifically, we hypothesize that the breastfeeding support and counseling that women receive during the prenatal period increases the likelihood of initiation and duration of breastfeeding.

METHODS

Study design

This prospective cohort study used New York State WIC administrative data extracted for inclusion in two national surveillance systems sponsored by the Centers for Disease Control and Prevention; the Pediatric Nutrition Surveillance System (PedNSS) and the Pregnancy Nutrition Surveillance System (PNSS). Data contributed to PedNSS and PNSS are routinely collected during WIC clinic visits. For all participants, data are collected at the initial enrollment, and for infants at approximately one year of age. Infant’s PedNSS records were linked to their mother’s PNSS record if one existed.

Study population
The study population includes infants who were born during 2008 or 2009, enrolled in the NYS WIC program during the first six months of life, and included in PedNSS. For each child, all subsequent records associated with re-certification visits through 2011 were combined to create one longitudinal record per child. To observe all breastfeeding outcomes, only children remaining in WIC at one year of age were included. Multiple births and foster children were excluded. Infant data were then linked to their mother’s data if a record existed in PNSS, indicating that the mother herself enrolled in WIC at some time, prenatally or postpartum. To examine the added effect of prenatal participation, the data analysis was restricted to two groups of infants – the exposed group, comprised of infants whose mothers participated in WIC during both the prenatal and postpartum periods (hereafter referred to as prenatal participants), and the unexposed group, consisting of infants whose mothers did not enroll prenatally but did enroll during the postpartum period (postpartum participants). Thus, we excluded infants whose mothers participated only during the prenatal period and those whose mothers did not themselves enroll in WIC either prenatally or postpartum.

The main exposure variable, an indicator of maternal WIC participation was dichotomized to indicate whether the infant’s mother participated in WIC both prenatally and postpartum or only during the postpartum period. The primary outcomes were indicators of breastfeeding initiation and duration coded as dichotomous variables (0=No, 1=Yes) to indicate initiation, and breastfeeding at 3, 6, and 12 months. Covariates include household size and income, reported at the time of infant enrollment, and coded as a percent of the 2008 Federal poverty guidelines, participation in Medicaid, and self-reported maternal race and ethnicity (restricted to Hispanic, non-Hispanic black, and non-
Hispanic white). Hispanic was defined as any race of Hispanic ethnicity. Mothers also reported their highest level of education attained (categorized as < HS graduate, HS graduate/GED or beyond). Mother’s age was computed as the difference between her date of birth and the child’s date of birth. Other variables include parity – number of previous pregnancies of at least 20 weeks gestation (categorized as first primigravida or multigravida), smoking during pregnancy and self-reported pre-pregnancy height and weight. Pre-pregnancy BMI was calculated as weight (kg) divided by the square of the height (meters) and categorized according to the 2009 Institute of Medicine (IOM) recommendations for pre-pregnancy body mass index as underweight, BMI < 18.5; normal, BMI 18.5 ≤ BMI < 25; overweight, 25 ≤ BMI < 30; and obese, BMI ≥ 30 (32) for the purpose of assessing adequacy of weight gain. For analytic purposes weight status was coded as overweight or obese (BMI < 25) vs. not overweight or obese (BMI ≥ 25).

Weight gain during pregnancy was categorized as below the recommended range, within the recommended range, or greater than the recommended range for a given pre-pregnancy BMI according to current IOM recommendations (32). As part of the WIC protocol, trained staff measure infant length and weight according to standard protocols at approximately 6-month intervals. Length of children less than 24 months of age is measured with a recumbent board to the nearest quarter inch. Weight is measured using a balance beam scale to the nearest quarter pound or a digital scale to the nearest tenth of a pound. Anthropometric measures may also be obtained from medical referral records. Birth weight is reported by the mother or obtained by medical referral. Birth weight was converted to the gestational age, (calculated as the difference between last menstrual period and date of birth) and sex-specific z-score (birth weight-for-gestational age z-
score) using a national reference (42); for descriptive purposes birth weight was also
categorized as low (<2500 g) or not low ( ≥ 2500 g).

**Statistical analysis**

Differences in characteristics between the prenatal/postpartum versus postpartum
groups were examined using chi-square tests for categorical variables or t-test analyses
for continuous variables. Multiple logistic regression estimated odds ratios for each
breastfeeding outcome by category of maternal WIC participation with interaction terms
included as appropriate. Odds ratios across comparison groups are presented graphically.

Statistical significance was established at p < 0.05. All analyses were conducted
using SAS 9.3 (SAS Institute, Cary, NC).

**RESULTS**

Descriptive characteristics of the study population are presented for mothers who
enrolled in WIC prenatally and postpartum versus postpartum (Table 1). Mothers who
enrolled in WIC prenatally were more likely to be Hispanic while mothers who enrolled
during the postpartum period only were more likely to be non-Hispanic white. Women
enrolling during the prenatal period were less educated, had a lower income to poverty
ratio, and were more likely to receive Medicaid benefits than those enrolling postpartum.
Women who did not enroll in WIC until postpartum were slightly more likely to be first
time mothers than prenatal enrollees and slightly less likely to have smoked during
pregnancy. Though statistically significant, pre-pregnancy BMI and adequacy of
pregnancy weight gain were similar across groups. Infants born to the prenatal mothers
were less likely to be low birth weight and had, on average, birth weight for gestational age z-scores closer to the median of the reference population.

Prevalence of breastfeeding initiation was similar across WIC participation groups but the prevalence of continued breastfeeding at 3, 6, and 12 months was higher among prenatal participants than postpartum participants. Prevalence estimates for breastfeeding at each milestone – initiation, 3 months, 6 months, and 12 months, were higher among Hispanic participants compared to non-Hispanic white or non-Hispanic black participants for both the prenatal and postpartum groups. Among Hispanic participants, breastfeeding prevalences at 3, 6, and 12 months, were higher among those participating prenatally compared to postpartum. Among non-Hispanic black or non-Hispanic white participants, however, breastfeeding prevalence did not vary appreciably by category of maternal WIC participation (Figure 1).

Estimated odds ratios (OR) and 95% confidence intervals (CI) for breastfeeding at each of four time points – at birth, 3 months, 6 months, and 12 months of age are presented for prenatal compared to postpartum only mothers (Figure 2). A significant three-way interaction was present for WIC participation, race/ethnicity, and parity in each model; thus, odds ratios are presented at each level for each outcome. Models also were adjusted for mother’s age, educational attainment, weight status prior to pregnancy, pregnancy weight gain, smoking during pregnancy, child’s sex and birth weight for gestational age z-score. For Hispanic women with no prior pregnancies (primigravida), prenatal participation was associated with higher odds of breastfeeding, at each time point, compared to the postpartum group; OR (95% CI): 1.38 (1.23,1.56) for initiation; 1.28 (1.17,1.40) at 3 months; 1.33 (1.21,1.46) at 6 months; and 1.41 (1.26, 1.59) at 12 months.
months. Conversely, among non-Hispanic white primigravida women, prenatal participation was associated with lower odds of breastfeeding compared to postpartum participants. The odds of breastfeeding, among non-Hispanic black, primigravida women, however, did not differ by time of WIC participation. Among multigravida mothers in each race/ethnic group, prenatal participation compared to postpartum was associated with higher odds ratios for breastfeeding. The odds ratios were also generally higher among Hispanic mothers than non-Hispanic black or non-Hispanic white mothers.

DISCUSSION

This study shows relatively high levels of initiation of breastfeeding among WIC enrolled mothers in New York State. We observed high rates of breastfeeding initiation for both prenatal and postpartum WIC participants with higher rates of breastfeeding at 3, 6, and 12 months among women who participated in WIC during the prenatal period suggesting that prenatal participation has a positive effect on initiation and duration of breastfeeding. At each time assessed - initiation, 3, 6, or 12 months, prevalence of breastfeeding was highest among children whose mothers participated in WIC during the prenatal period, compared to mothers who did not enroll until the postpartum period.

The prevalence of breastfeeding initiation among all women in this study who participated in WIC during the postpartum period, whether prenatally or not, was similar to that reported for a representative sample of U.S. children in 2009 (77-79% vs. 77%, respectively) (56), exceeding the Healthy People 2010 goal of 75% and approaching the HP2020 objective of 82% (57). Overall, among infants enrolled in the New York WIC
program, prevalence of breastfeeding initiation has steadily increased from 60% in 2001 to 77% in 2010 (58).

The results of this study are consistent with another study showing that women who enroll in WIC prenatally had a higher prevalence of breastfeeding initiation than postpartum enrollees (45). This study demonstrates that overall, prenatal participants were 1.6% points more likely to initiate breastfeeding than were postpartum participants. This is less than the 2.6 percentage point difference seen in the earlier study by Joyce and colleagues (45). Similar to the study of Joyce and colleagues, this study shows that Hispanic women were more likely to initiate breastfeeding and to breastfeed longer when enrolled prenatally compared to postpartum (45). In addition, in this study of primigravida compared to multigravida mothers, among mothers who had given birth previously, in each race/ethnic group, prenatal participation was associated with higher rates of initiation and duration. Other studies of WIC and WIC eligible women have also found that being Hispanic and having experience breastfeeding are associated with a reduced risk of breastfeeding cessation (12, 59) and these results indicate that prenatal participation may enhance the effects.

These findings that prenatal women were more likely to continue to breastfeed until at least 6 and 12 months differs from a study in California that found no difference in breastfeeding duration between prenatal and postpartum WIC enrolled mothers (60). The differences in our findings may be due to the very high proportion (91%) of Hispanic women in the California study. This study also differs from previous studies reporting lower rates of breastfeeding among WIC participants compared to eligible non-participants (10, 11, 51). The study’s design differs in that all women were eligible for
and in fact did participate in WIC at some point, minimizing the bias associated with self-selection to participate in the WIC program. It does appear that WIC participation during the critical prenatal period, when infant feeding decisions are being made, may reduce the risk of early breast feeding cessation.

This study is subject to several limitations. First, only infants re-certifying in WIC at one year of age were included. This is an inherent limitation to the use of these surveillance data. To allow time to observe all outcomes an infant must return for a one-year certification visit. Thus, there is no information on the breastfeeding behaviors of infants/mothers who do not return at one year. However, by their ongoing participation, these families continue to be income-eligible putting them at increased risk for early breastfeeding cessation. Additionally, the length of time women were enrolled prenatally was not assessed, thus those entering WIC toward the end of pregnancy are treated the same as those entering early in pregnancy. If prenatal WIC participation were associated with improved breastfeeding outcomes, the inclusion of those enrolling late would tend to introduce bias that would minimize the results. Second, exclusivity of breastfeeding was not assessed. The proportion of mothers exclusively breastfeeding in WIC, however, is low.

No information on mother’s country of origin, primary language, or length of time in the U.S. was measured to assess acculturation. Studies show that newly acculturated Hispanic immigrants tend to breastfeed longer than their more acculturated counterparts (61, 62). If prenatal participation were associated with acculturation the results would be biased upwards if recent immigrants were more likely to enroll prenatally but they would be biased downward if the opposite were true. Information on social support was also
lacking, which is associated with longer duration of breastfeeding (59), introducing bias if women with strong social support were more (or less) likely to enroll in WIC prenatally.

Despite these limitations this study has several strengths. The study examines a large cohort of infant and mother pairs enrolled in the NYS WIC program, which comprised both the exposure and control groups. Including a comparison group of mothers and infants also enrolled in WIC minimizes the bias generally present in studies attempting to compare WIC participants to non-participants, as the comparison group is not an advantaged group. Although the postpartum only group had a slightly higher poverty ratio all women lived in families below the Federal poverty level. Second, this study included a racially and ethnically diverse population from across New York State. The high participation rate in WIC by eligible women and infants (> 90%) indicates that a large portion of low-income women and infants are included in the study. Finally, because women report breastfeeding status at each clinic visit to determine eligibility for specific food packages, the chance that the outcome is misclassified is minimized.

Most women make the decision to breastfeed, or not, prior to delivery (63). WIC has a long-standing commitment to promotion of breastfeeding including training staff as lactation counselors, providing peer counseling services, distributing breast pumps, and working with primary care providers and hospitals to improve breastfeeding promotion. These findings highlight the important role that WIC participation, particularly during the prenatal period plays in promoting initiation and duration of breastfeeding. WIC provides an environment that is conducive and supportive of breastfeeding. Health care providers
can work with prenatal mothers to facilitate participation in WIC during this critical period when infant feeding choices are established.

Table 3.1 Descriptive characteristics of mother/child pairs enrolled in the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) by category of maternal enrollment in WIC, New York State, 2008-2010

<table>
<thead>
<tr>
<th>Mother/child characteristics</th>
<th>Maternal WIC participation</th>
<th></th>
<th></th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Prenatal &amp; Postpartum</td>
<td>Postpartum Only</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(N = 130,959)</td>
<td>(N = 17,583)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maternal race/ethnicity</td>
<td></td>
<td></td>
<td></td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Hispanic</td>
<td>44.1</td>
<td>31.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-Hispanic black</td>
<td>24.4</td>
<td>28.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-Hispanic white</td>
<td>31.6</td>
<td>40.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maternal age, years, mean (SD)</td>
<td>26.4 (6.2)</td>
<td>26.9 (6.3)</td>
<td></td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Education</td>
<td></td>
<td></td>
<td></td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>&lt; High School</td>
<td>30.0</td>
<td>21.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>≥ High School graduate or General</td>
<td>54.7</td>
<td>61.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Poverty ratio, mean (SD)</td>
<td>0.73 (0.50)</td>
<td>0.86 (0.58)</td>
<td></td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Medicaid</td>
<td>77.6</td>
<td>54.0</td>
<td></td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Birth year 2009</td>
<td>49.9</td>
<td>47.2</td>
<td></td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Parity (1st pregnancy)</td>
<td>39.9</td>
<td>41.9</td>
<td></td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Smoking during pregnancy</td>
<td>9.4</td>
<td>8.7</td>
<td></td>
<td>0.003</td>
</tr>
<tr>
<td>Pre-pregnancy overweight/obese</td>
<td>53.7</td>
<td>52.0</td>
<td></td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Adequacy of gestational weight gain</td>
<td>22.1</td>
<td>23.2</td>
<td></td>
<td>0.0004</td>
</tr>
<tr>
<td>&lt; Recommended range</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Within recommended range</td>
<td>35.1</td>
<td>33.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt; Recommended range</td>
<td>42.9</td>
<td>43.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low birth weight (&lt;2500 g)</td>
<td>6.8</td>
<td>10.4</td>
<td></td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Birth weight for gestational age z-score, mean (SD)</td>
<td>-0.14 (0.97)</td>
<td>-0.30 (0.98)</td>
<td></td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Breastfeeding</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Initiation</td>
<td>78.8</td>
<td>77.2</td>
<td></td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>At 3 months</td>
<td>53.1</td>
<td>50.4</td>
<td></td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>At 6 months</td>
<td>42.1</td>
<td>38.4</td>
<td></td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>At 12 months</td>
<td>23.1</td>
<td>19.6</td>
<td></td>
<td>&lt;0.0001</td>
</tr>
</tbody>
</table>
Figure 3.1 Prevalence of breastfeeding initiation and at 3, 6, and 12 months by category of maternal WIC participation and race/ethnicity.
Figure 2.3 Odds ratios for breastfeeding at initiation, 3 months, 6 months, and 12 months among women who enrolled prenatally vs. postpartum. Stratified by parity (primigravida vs. multigravida) and race/ethnicity.
CHAPTER 3

The association between prenatal participation in WIC and rapid infant weight gain is mediated by breastfeeding duration and by birth weight for gestational age.
ABSTRACT

**Background:** The Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) is one of the most studied federal food assistance programs. Research to date has predominantly focused on prenatal participation and the beneficial effects on birth outcomes, particularly low birth weight. Fewer studies have examined the association between WIC participation and child weight status. Maternal prenatal participation in the WIC program provides an important widow of influence. The objective of this study was to assess the relationship between mothers’ prenatal enrollment in WIC and rate of infant weight gain from birth through 12 months of age.

**Methods:** This prospective cohort study included infants born during 2008 or 2009 and enrolled in the NYS WIC program during the first six months of life. Infants were linked to maternal WIC participation records. Outcomes were compared for infants of mothers who enrolled in WIC prenatally (early enrollees) to the infants of women who delayed enrollment until the postpartum period (late enrollees). Multiple logistic regressions assessed the association of early enrollment with rapid infant weight gain expressed as odds ratios.

**Results:** Logistic regression analysis, adjusted for infant and maternal demographics, showed a reduced odds of rapid weight gain (OR: 0.85; 95% CI: 0.82, 0.87) among infants of the early vs. late WIC enrollees. The addition of birth weight-for-gestational age and breastfeeding for at least 6 months to the model provided evidence of nearly complete mediation.

**Conclusions:** The results of this large longitudinal cohort of mother-infant pairs enrolled in the NYS WIC program demonstrated that early WIC enrollment, i.e. enrollment during
the prenatal period, may reduce the risk of rapid infant weight gain between birth and one year of age. Furthermore, the study provided evidence that both birth weight-for-gestational age and breastfeeding for at least 6 months mediate the relationship between early enrollment and rapid infant weight gain. The results of this study confirm that among women and infants enrolled in NYS WIC, early WIC enrollment reduced the risk of low birth weight-for-gestational age, and was associated with higher prevalence of breastfeeding at 6 months. In addition, both were associated with reduced risk of excess infant weight gain from birth through one year. These findings suggest that by improving birth outcomes, an established effect of prenatal WIC participation, the benefit extends to protecting infants from experiencing rapid weight gain during the first year of life.
INTRODUCTION

Childhood obesity is a well-documented public health concern. After increasing for several decades, the prevalence of obesity appears to be decreasing among all children (15), including preschool-age children from low-income families who participate in the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC ) (15, 18, 19). The prevalence of obesity among children, aged 2 through 4 years, participating in the New York State (NYS) WIC program peaked at 16.7% in 2003, declined through 2005, and stabilized at 14.7% in 2007 (18). Nationally, obesity prevalence among preschool-aged children participating in public maternal and child health and nutrition programs appears to have leveled off just under 15% in 2008 (19).

Well-established risk factors for child obesity include dietary patterns, physical inactivity, and television viewing behaviors, but increasingly research has focused on early life factors, including prenatal and perinatal factors (20-22, 64). Gestation and early infancy have been identified as critical periods in the development of obesity (20), suggesting that it is during this critical period that the foundation is laid for a life-long predisposition for body composition, and that conditions experienced in utero may play an important role later in life (20, 24). Additionally, rapid infant weight gain during the first 6-12 month of life is a well-documented risk factor for obesity, increasing the risk of obesity 40-100% during childhood, and nearly 25% during adulthood (35, 65).

WIC is a public health nutrition program designed to help prevent adverse health outcomes during periods of critical growth and development (2). More than half of all infants born in the U.S. and in NYS enroll in WIC, highlighting the broad reach and public health significance of the program. In an era fraught with cuts to federal support
for public programs, research documenting potential benefits of maternal prenatal WIC participation on child outcomes is necessary to ensure informed decision-making.

When the WIC program was founded, in 1972, the major nutritional concern, particularly affecting pregnant women and children living in low-income households, was that nutritional intake was inadequate to support optimal growth and development. In the ensuing decades since the program’s inception, the increasing prevalence of obesity among children and adults in the US has become a significant public health concern. Thus, in recent years, the WIC program has been challenged with not only addressing inadequate nutritional intake among eligible participants but also with promoting a more healthful and active lifestyle to aid in the prevention of obesity.

The WIC program is one of the most studied federal food assistance programs. Research to date has predominantly focused on prenatal participation and the beneficial effects on birth outcomes, particularly low birth weight (2, 8, 66-68). Fewer studies have examined the association between WIC participation and child weight status, and the few existing studies have mixed results (8). A recent review of the literature identified only five published studies that evaluated the association between WIC participation and infant or child weight status (8), however, all but one examined child WIC participants compared to non-participants (69-72).

Maternal prenatal participation in the WIC program provides an important window of influence. Prenatal participation in WIC was hypothesized as protective against rapid infant weight gain in two primary ways; by improving birth outcomes, specifically increased birth weight and increased gestational age, and through support for initiation and continuation of breastfeeding. Prenatal WIC participation has been consistently and
positively associated with gestational age and birth weight (8). Early and continued participation in the WIC program exposes the mother to the maximum benefits provided by the program through nutritious foods, nutrition education, and referral to medical and social services. Gestational weight gain and infant feeding decision are factors that may be influenced by a mother’s participation in the WIC program during pregnancy. During the prenatal period, in addition to the benefit of supplemental foods, women receive nutritional counseling and referral to social and health care services as needed, and are offered the support of Breastfeeding Peer Counselors and Certified Lactation Consultants at a critical time when the infant feeding decisions are being made. Women also are counseled regarding smoking and alcohol use during pregnancy and referred to appropriate programs as necessary. During the postpartum period, lactating women continue to receive the support of Breastfeeding Peer Counselors and Certified Lactation Consultants in addition to an enhanced food package. Postpartum-enrolled women who are not breastfeeding do not receive the enhanced food package, but all postpartum women receive the benefits of nutrition counseling which address issues such as infant feeding practices including the appropriate introduction of complimentary foods.

Despite the potential benefits of prenatal maternal enrollment in WIC on child health outcomes, no studies to our knowledge have examined the link between prenatal WIC enrollment and infant growth during the first year of life. The objective of this study was to do that - assess the relationship between mothers’ prenatal enrollment in WIC and rate of infant weight gain from birth through 12 months of age by comparing infants of mothers who enrolled in NYS WIC prenatally and who continued to participate during
the postpartum period to the infants of women who did not enroll in WIC prenatally, i.e.,
the group who participated in NYS WIC only during the postpartum period.

METHODS

Study Population

This prospective, longitudinal study includes infants who were born during 2008 or
2009 and enrolled in the NYS WIC program during the first six months of life. Data
were obtained by linking data generated from the NYS WIC information system for
inclusion in two national surveillance systems sponsored by the Centers for Disease
Control and Prevention; the Pediatric Nutrition Surveillance System (PedNSS) and the
Pregnancy Nutrition Surveillance System (PNSS). Data contributed to PedNSS and PNSS
are routinely collected during WIC clinic visits. For all participants, data were collected at
the initial enrollment; for infants at approximately one year of age; and for children, over 1
year of age, at 6-month intervals as long as they remain eligible and the family chooses to
participate.

For each child, all subsequent records associated with re-certification visits
through 2011 were combined to create one longitudinal record per child. To observe the
primary outcomes of interest, only infants who continued to participate at least until one
year of age were included (Figure 1). Infant data were then linked, using the unique WIC
identification number, to their mother’s data if a record existed in PNSS, indicating that
the mother herself enrolled in WIC at some time, prenatally or postpartum. To examine
the added effect of prenatal participation on child outcomes, the data analysis was
restricted to two groups of infants – the exposed group, comprised of infants whose
mothers participated in WIC both during the prenatal and postpartum periods (early WIC
enrollees), and the unexposed group, consisting of infants whose mothers did not enroll prenatally but did enroll during the postpartum period (late WIC enrollees).

**Main exposure variable**

The main exposure variable, the mothers’ participation in WIC, was operationalized as a dichotomous variable indicating whether the mother was an early or late WIC enrollee.

**Outcome measures**

The primary outcome of interest was rapid infant weight gain during the first year of life. As part of the WIC protocol, trained staff measure infant length and weight according to standard protocols at approximately 6-month intervals. Length of children less than 24 months of age is measured with a recumbent board to the nearest quarter inch. Weight is measured using a balance beam scale to the nearest quarter pound or a digital scale to the nearest tenth of a pound. Anthropometric measures may also be obtained from medical referral records.

Birth weight is reported by the mother or obtained by medical referral and gestational age is calculated as the difference between last menstrual period and date of birth. Birth weight was converted to gestational age and sex-specific z-score using a national reference (42) and weight at one year of age was converted to sex-specific weight-for-age percentile and z-score using the 2006 World Health Organization child growth standards (44). Change in weight z-score during the first year of life was calculated as the difference between the weight-for-age z-score at one year of age minus the birth weight-for-gestational age z-score. An infant who had a 12-month change in z-score > 0.67 was defined as having a “rapid weight gain” as this cut point approximately
corresponds to crossing a growth chart percentile and has been used in prior studies to define rapid weight gain (30, 36, 37).

**Covariates**

PedNSS provides information from the child’s WIC records and self-reported by the mother; specifically child sex, birth weight, age at WIC enrollment as infant and as a child, breastfeeding status and duration (categorized as never, < 3 months, 3-< 6 months, 6-<12months, and 12 months or more), infant’s enrollment in Medicaid (yes or no), and household income as a percent of the 2008 Federal poverty guidelines (73). PNSS data were collected at initial prenatal enrollment and again at postpartum enrollment. Mothers self-reported their race and ethnicity. Hispanic was defined as any race of Hispanic ethnicity. Because the “other” race/ethnic group was small and diverse, analyses were limited to non-Hispanic white, non-Hispanic black, Hispanic, and non-Hispanic Asian mothers. Mother’s educational attainment (categorized as < HS graduate, HS graduate/GED or beyond), age, when prenatal care began (none, 1st, 2nd, or 3rd trimester of pregnancy), parity – number of previous pregnancies of at least 20 weeks gestation (categorized as first pregnancy, yes or no), and pre-pregnancy weight were self-reported. Pre-pregnancy body mass index (BMI) was calculated as weight (kg) divided by the square of the height (meters) and categorized according to the 2009 Institute of Medicine (IOM) recommendations for pre-pregnancy body mass index as underweight, BMI < 18.5 kg/m²; normal, BMI 18.5 kg/m² ≤ BMI < 25 kg/m²; overweight, 25 kg/m² ≤ BMI < 30 kg/m²; and obese, BMI ≥ 30 kg/m² (32). Weight gain during pregnancy was categorized as below the recommended range, within the recommended range, or greater than the
recommended range for a given pre-pregnancy BMI according to current IOM recommendations (32).

**Statistical Analyses**

Biologically implausible values were flagged according to standard criteria, or if no standard criteria existed then according to the data distributions. Specifically, weight-for-age, length-for-age, and weight-for-length were flagged using criteria updated by the WHO with the release of the international growth standards in 2006 (44, 74). Weight-for-age z-scores <-6 or >5, length-for-age z-scores <-6 or > 6, and weight-for-length z-scores <-5 or > 5 were flagged as biologically implausible values. If any one of the three were flagged, then weight-for-length measure was also flagged as implausible.

Standard criteria were used to flag implausible values for gestational age (42) and birth weight-for-gestational-age (42, 75). Mother’s height, weight, and pregnancy weight gain were examined for implausible values using PNSS edit criteria (76). For infant’s weight gain and mother’s pre-pregnancy BMI, the distributions were examined and the upper and lower 0.01% was trimmed. Records were excluded from analysis if any of the anthropometric measures were flagged as biologically implausible (n=4160, 2.6% of total).

The “other” race ethnic group consisted of 4,172 mother/child pairs, 2.9% of the original study population.

Differences in demographic and risk factor characteristics between the early versus late WIC were examined using chi-square tests for categorical variables or t-test analyses for continuous variables (Table 1). Demographic characteristics that differed significantly (p<0.05) across groups were included as covariates in multivariate analyses.
Potential risk factors and proposed mediators were assessed individually for association with rapid infant weight gain using bivariate analyses (Table 2). Due to the large sample size, statistical significance alone was not the only criteria for including factors in the multivariate analyses; rather the factors needed to be both significant (p<0.05) and plausibly associated with the outcome to be included.

Five logistic regression models with the late WIC enrollees as the referent group are shown (Table 3). Model one assessed the unadjusted effect of early WIC enrollment with rapid infant weight gain. Model 2 included the demographic characteristics -- household poverty ratio, infant’s sex; and maternal race/ethnicity, age, educational attainment, receipt of Medicaid, and trimester of pregnancy in which prenatal care began. Model 3 included all covariates in Model 2 plus the potential maternal risk factors: parity, smoking during pregnancy, pre-pregnancy BMI, gestational weight gain, adequacy of gestational weight gain, and gestational diabetes. To explore potential mediating effects, two additional models were generated. Model 4 included all covariates in Model 3 plus birth weight for gestational age z-score. Birth weight for gestational age was included as a measure of the prenatal environment. Model 5 included all covariates in Model 3 plus infant’s breastfeeding status at 6 months of age.

The presence of mediation was tested in five steps (77). In step 1, the direct path from X (WIC participation) to Y (rapid weight gain) was estimated in Model 3. In step 2, two additional regression models assessed the effect of WIC participation on each hypothesized mediating variable (M), birth weight for gestational age z-score and breastfeeding at 6 months of age, adjusted for potential confounders. These equations produce an estimate of the effect of X on M. Step 3 estimated the effect of each potential...
mediator on rapid weight gain adjusted for all covariates (Models 4 and 5). In step 4, standardized regression coefficients (each parameter divided by its standard error) were computed using the parameter estimates from step 2 (the effect of X on M) and step 3 (the effects of M on Y, models 4 and 5). Finally, a z-test for mediation was computed for each potential mediator using the product of the standardized estimates from step 4 divided by their collective standard errors. The test was considered significant at the alpha <0.05 if the z-value exceeded ±1.96 (77).

All analyses were conducted using SAS (version 9.3, SAS Institute, Inc. Cary, NC, USA)

RESULTS

Descriptive characteristics of the study population are presented for mothers who enrolled in WIC early versus late (Table 1). Mothers who enrolled early were more likely to be Hispanic, and less likely to be either non-Hispanic black or white, than late enrollees. Early WIC enrollees were less educated, younger, had a lower income to poverty ratio, and were more likely to receive Medicaid benefits than late WIC enrollees.

Early WIC enrollees were slightly less likely to be first time mothers. Though statistically significant, pre-pregnancy BMI and adequacy of pregnancy weight gain were similar across groups. The two groups differed minimally in prevalence of smoking during pregnancy.

With respect to the hypothesized mediators, breastfeeding and birth weight for gestational age, both groups had a high prevalence of any breastfeeding though women enrolling early showed longer duration of breastfeeding compared to the late WIC enrollees. Birth weight for gestational age z-core was significantly higher and prevalence
of infant rapid weight gain lower among the early WIC enrollees compared to the late WIC enrollees.

Table 2 presents univariate predictors of rapid infant weight gain. Parity is strongly associated with rapid infant weight gain in univariate analyses with prior pregnancies showing a protective effect (OR: 0.69; 95% CI: 0.68, 0.71). Women who were overweight or obese prior to pregnancy, gained more weight than recommended, or had gestational diabetes were less likely to have infants who gained weight rapidly. Smoking during pregnancy was strongly associated with rapid weight gain, with infants of mothers who smoked during pregnancy having more than a 50% greater odds (OR: 1.58; 95% CI 1.52, 1.64) of rapid weight gain than infants of mothers who reported no smoking during pregnancy. Breastfeeding for longer than at least 6 months shows a protective effect and being small for gestational age imparts considerable risk for rapid weight gain during infancy.

Table 3 compares the unadjusted and multivariable adjusted logistic regression models for the study outcome. Unadjusted logistic regression analyses revealed that the main exposure variable, early WIC enrollment was protective against rapid infant weight gain, (unadjusted OR: 0.87; 95% CI: 0.84, 0.90) Model 2, adjusted for infant and maternal demographics, showed a similar reduced odds of rapid weight gain (OR: 0.85; 95% CI: 0.82, 0.87) for the early WIC enrollees. Model 3, included the addition of known risk factors for rapid weight gain and continued to show a protective effect of early WIC (OR: 0.85; 95% CI 0.82, 0.88). The addition of birth weight for gestational age, Model 4, appears to mediate the relationship between early WIC enrollment and rapid weight gain by attenuating the protective effect of early WIC (OR: 0.98, 95% CI: 0.94, 1.01). The
addition of breastfeeding status at 6 months of age, Model 5, suggests that breastfeeding for 6 months provides an additional protective effect (OR: 0.82 (0.80,0.84).

The coefficients for the effect of WIC participation on the potential mediators were \( \beta \) (s.e.)=−0.086 (0.004), \( p<0.0001 \) and \( \beta \) (s.e.)=0.068(0.018), \( p=0.0002 \) for birth weight for gestational age z-score and breastfeeding status at 6 months, respectively. Results of the z-test for mediation (77) confirmed that birth weight for gestational age (\( z=21.68, p<0.0001 \)) and breastfeeding for 6 months (\( z=3.67, p<0.0001 \)) each mediate the relationship between WIC participation and rapid infant weight gain.

DISCUSSION

The results of this large longitudinal cohort of mother-infant pairs enrolled in the NYS WIC program demonstrates that early WIC enrollment, that is enrollment during the prenatal period, may reduce the risk of rapid infant weight gain between birth and one year of age. Furthermore, we provide evidence that birth weight for gestational age and breastfeeding for 6 months each mediate the relationship between early enrollment and rapid infant weight gain.

This study is the first to examine the association of prenatal WIC maternal enrollment with postnatal infant growth outcomes through a linkage of mother and infant pairs among WIC participants in New York State. Like Joyce, et al (45) this study used as a comparison group of mothers who did not enroll in WIC until the postpartum period. The earlier study, found that women who enrolled in WIC during the prenatal period were more likely to have better birth outcomes, than mothers who did not enroll until the postpartum period (45). Other studies have also shown that prenatal participation in WIC is associated with more favorable birth outcomes, particularly higher birth weight. (67,
This study shows that birth weight for gestational age, and breastfeeding at 6 months mediate the relationship between prenatal maternal WIC participation and rapid infant weight gain, a conclusion that builds on earlier findings that prenatal WIC participation is associated with improved birth weight. The combination of low birth weight and rapid weight gain or “catch up growth” is an established risk factor for adult cardio-vascular disease (80). These findings, that prenatal WIC participation is associated with a reduced likelihood of rapid weight gain and that the relationship is mediated by birth weight for gestational age, implies that improved birth outcomes, specifically increased birth weight, is a mechanism through which WIC reduces rapid infant weight gain and subsequent risk of child and adult morbidity.

One might hypothesize that women enrolling in WIC prenatally would be more likely to initiate breastfeeding and to breastfeed longer than women enrolling during the postpartum period due to the support for breastfeeding that begins during the prenatal period in WIC. A higher prevalence of breastfeeding at 6 months (41.5 vs. 38.6%) and at 12 months (22.6 vs. 19.8%) was observed among the prenatally enrolled group, and continued breastfeeding at 6 months reduced the odds gaining weight rapidly by nearly 20%. The finding that breastfeeding for 6 months reduces the odds of rapid weight gain is consistent with other research that also has shown a reduced odds of rapid weight gain with increased breastfeeding duration (81, 82). Our results are novel in that we also demonstrate that the increased likelihood of breastfeeding for 6 months among early WIC enrollees is one mechanism through which prenatal participation reduces the odds of rapid infant weight gain.
This study has several strengths. A large cohort of infant and mother pairs enrolled in the NYS WIC program comprised both the exposure and control groups. Including as comparison group of mothers and infants also enrolled in WIC minimizes the bias generally present is studies attempting to compare WIC participants to non-participants. All women choose to enroll in WIC at some point indicating income eligibility and similarity with respect to unmeasured characteristics that are often associated with the choice to enroll in WIC. A second strength is that infant’s length and weight is measured according to standard protocols by trained WIC staff or come from medical referral. Heights and weight measured by trained staff in WIC settings have been shown to be highly reliable and valid for research purposes with interclass correlation coefficients of 0.96 and 0.99 for height and weight respectively (83). Similarly, though birth weight may have been recalled by the mother a validation study of maternally reported birth weights in WIC indicated a high degree of accuracy when compared to birth certificate with 89% of recalled birth weights within one ounce of the birth certificate reported weight (59). Finally, the use of z-scores from a national reference (42) provides a more precise measure of birth-weight for gestational age than would the use of categorical definitions of small or large for gestational age.

This study is subject to several limitations. First, only infants who continued to participate in the WIC program beyond one year of age are included, possibly introducing self-selection bias if there are inherent differences between families who choose to stay beyond infancy and those who drop out prior to the infants first birthday. However, the exposure and comparison groups would be similarly affected. Furthermore, continued participation beyond one year of age indicates continued income eligibility, placing all
study participants at higher risk for adverse health outcomes. Additionally, we did not assess the length of time women were enrolled prenatally, thus those entering WIC toward the end of pregnancy are treated the same as those entering early in pregnancy. As other studies have shown a dose-response relationship with WIC prenatal participation and birth weight (16), our inclusion of those enrolling late would tend to introduce bias that would minimize our results. A second limitation is that there is no information on timing of introduction of complementary feeding or exclusivity of breastfeeding. A third limitation is that gestational age is computed from the mother’s self report of date of last menstrual period, however, last menstrual period has been shown to be clinically useful and reliable when used to estimate gestational age in a low-resource setting (84). Finally, one has to consider that there may be important, unmeasured factors that influence both the choice to participate prenatally or not and the outcome, rapid infant weight gain. For example, if mothers who intended to enroll prenatally but gave birth before they had an opportunity to enroll, gestational age bias would be present. The infants delivered prematurely would be expected to experience “catch up growth”. Though the women who delayed enrollment until the postpartum period had infants on average who were smaller for their gestational age than did the prenatal enrollees the average length of gestation was identical across groups at 39 weeks. Furthermore, the postpartum only group was slightly less likely to have smoked during pregnancy, which would bias the results in favor of the postpartum group.

WIC is a public health nutrition program charged with improving health outcomes among vulnerable populations during critical periods of growth and development. Findings that document program effectiveness in decreasing risk factors for adverse
health outcomes are critical for informing policy makers on progress toward national health objectives. The results of this study confirm that among women and infants enrolled in WIC in New York, early WIC enrollment reduces the risk of low birth weight for gestational age, and is associated with increased breast feeding at 6 months, which are both associated with reduced risk of excess infant weight gain from birth to one year. These finding suggest that by improving birth outcomes, an established effect of prenatal WIC participation, the benefit extends to protecting infants from experiencing rapid weight gain during the first year of life. Collaboration between health care providers and WIC programs could facilitate enrolling all eligible prenatal women as early as possible.
Figure 1. Flow chart of cohort selection and exclusions – mother/infant pairs participating in the WIC program in New York State.

PedNSS/PNSS cohort born 2008 - 2009 (N=316,016 WIC enrolled children)

Enrolled < 6 months of age (N = 279,553)

Outside of range (N=36,463)

Child certification between 10 and 16 mo. of age (n = 183,169)

Outside of range or no 1-year cert (n=96,384)

Singleton births (N=177,525)

Multiple births (N=5,644)

Not a foster child (household size > 1) (N=176,248)

Foster children (N=1,277)

Full study cohort (N=176,248)

Mother prenatal/postpartum or postpartum only (N=164,473 mother/child pairs)

Mother not on WIC or prenatal only (N=11,775)
Table 1. Characteristics of mother and infant pairs enrolled in WIC, by category of maternal WIC participation, New York State, 2008-2010

<table>
<thead>
<tr>
<th>Maternal/child characteristics</th>
<th>Prenatal &amp; Postpartum (N = 137,372)</th>
<th>Postpartum only (N = 18,229)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Demographics</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mother’s race/ethnicity, %</td>
<td></td>
<td></td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Non-Hispanic black</td>
<td>22.7</td>
<td>27.0</td>
<td></td>
</tr>
<tr>
<td>Non-Hispanic white</td>
<td>29.2</td>
<td>37.6</td>
<td></td>
</tr>
<tr>
<td>Hispanic</td>
<td>41.0</td>
<td>29.5</td>
<td></td>
</tr>
<tr>
<td>Asian</td>
<td>6.5</td>
<td>5.9</td>
<td></td>
</tr>
<tr>
<td>Age, years, mean ± SD</td>
<td>26.6 (6.2)</td>
<td>27.1 (6.3)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Education, %</td>
<td></td>
<td></td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>&lt; HS</td>
<td>30.3</td>
<td>21.8</td>
<td></td>
</tr>
<tr>
<td>HS grad/GED</td>
<td>54.4</td>
<td>61.4</td>
<td></td>
</tr>
<tr>
<td>Poverty ratio(^a), mean ± SD</td>
<td>0.73 (0.49)</td>
<td>0.86 (0.57)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Medicaid, %</td>
<td>78.2</td>
<td>54.6</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Prenatal care began, %</td>
<td></td>
<td></td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>None</td>
<td>2.1</td>
<td>1.3</td>
<td></td>
</tr>
<tr>
<td>1(^{st}) trimester</td>
<td>85.4</td>
<td>83.0</td>
<td></td>
</tr>
<tr>
<td>2(^{nd}) trimester</td>
<td>10.8</td>
<td>8.3</td>
<td></td>
</tr>
<tr>
<td>3(^{rd}) trimester</td>
<td>1.0</td>
<td>1.7</td>
<td></td>
</tr>
<tr>
<td><strong>Potential risk factors</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Parity, 1(^{st}) pregnancy, %</td>
<td>40.0</td>
<td>42.2</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Pre-pregnancy BMI, %</td>
<td></td>
<td></td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Underweight, &lt;18.5</td>
<td>4.2</td>
<td>3.9</td>
<td></td>
</tr>
<tr>
<td>Normal, 18.5 - &lt; 25</td>
<td>44.4</td>
<td>45.3</td>
<td></td>
</tr>
<tr>
<td>Overweight, 25 - &lt; 30</td>
<td>27.6</td>
<td>26.8</td>
<td></td>
</tr>
<tr>
<td>Obese, (&gt;= 30))</td>
<td>23.8</td>
<td>24.0</td>
<td></td>
</tr>
<tr>
<td>Adequate pregnancy weight gain, %</td>
<td></td>
<td></td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>&lt; Recommended range</td>
<td>22.4</td>
<td>23.4</td>
<td></td>
</tr>
<tr>
<td>Recommended range</td>
<td>36.0</td>
<td>34.4</td>
<td></td>
</tr>
<tr>
<td>&gt; Recommended range</td>
<td>41.6</td>
<td>42.2</td>
<td></td>
</tr>
<tr>
<td>Gestational Diabetes, %</td>
<td>5.0</td>
<td>5.2</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Smoking during pregnancy, %</td>
<td>8.8</td>
<td>8.2</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td><strong>Potential Mediators</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Breastfeeding, %</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Initiation</td>
<td>77.9</td>
<td>77.4</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>Age</td>
<td>Mean</td>
<td>SD</td>
<td>p-value</td>
</tr>
<tr>
<td>--------------</td>
<td>------</td>
<td>-----</td>
<td>---------</td>
</tr>
<tr>
<td>At 3 months</td>
<td>52.5</td>
<td>50.5</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>At 6 months</td>
<td>41.5</td>
<td>38.6</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>At 12 months</td>
<td>22.6</td>
<td>19.8</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Birth wt/gest age z-score(^b), mean ± SD</td>
<td>-0.15 (0.97)</td>
<td>-0.31 (0.97)</td>
<td>&lt;0.0001</td>
</tr>
</tbody>
</table>

**Anthropometric outcome – age 1 yr**

| Rapid weight gain, 1 centile\(^e\), % | 51.1 | 54.6 | <0.0001 |

Percents do not add to 100 due to missing or unknown values.

- \(^a\) Ratio of household income for household size to 2009 federal poverty level
- \(^b\) Birth weight for gestational age z-score – (42)
- \(^c\) Birth weight for gestational age <10\(\%\)ile (SGA) or >90\(\%\)ile (LGA) (42)
- \(^d\) High weight for length defined as a sex specific weight-for-length z-score >2 (WHO growth standard)
- \(^e\) Rapid weight gain defined as change in weight-for-age z-score >0.67 during first year of life (36)
Table 2.2 Association between infant and maternal risk factors or potential mediators and rapid infant weight gain birth to 12 months, among cohort of children enrolled in the Special Supplemental Nutrition Program for Women, Infants, and Children, 2008-2010

<table>
<thead>
<tr>
<th></th>
<th>Prevalence of rapid weight gain</th>
<th>Unadjusted odds ratio (95% CI)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Prenatal risk factors</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Parity, 1st pregnancy</td>
<td></td>
<td></td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>No</td>
<td>47.9</td>
<td>0.69 (0.68,0.71)</td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>57.1</td>
<td>1.00 (reference)</td>
<td></td>
</tr>
<tr>
<td>Pre-pregnancy BMI, %</td>
<td></td>
<td></td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Underweight, &lt;18.5</td>
<td>53.8</td>
<td>1.05 (1.00,1.10)</td>
<td></td>
</tr>
<tr>
<td>Normal, 18.5 - &lt; 25</td>
<td>52.3</td>
<td>1.00 (reference)</td>
<td></td>
</tr>
<tr>
<td>Overweight, 25 - &lt; 30</td>
<td>50.2</td>
<td>0.94 (0.91,0.96)</td>
<td></td>
</tr>
<tr>
<td>Obese, &gt;= 30</td>
<td>49.8</td>
<td>0.89 (0.87,0.92)</td>
<td></td>
</tr>
<tr>
<td>Adequate pregnancy</td>
<td></td>
<td></td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>&lt; Recommended range</td>
<td>54.6</td>
<td>1.12 (1.09,1.15)</td>
<td></td>
</tr>
<tr>
<td>Recommended range</td>
<td>51.7</td>
<td>1.00 (reference)</td>
<td></td>
</tr>
<tr>
<td>&gt; Recommended range</td>
<td>49.7</td>
<td>0.92 (0.90,0.94)</td>
<td></td>
</tr>
<tr>
<td>Gestational Diabetes</td>
<td></td>
<td></td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>No</td>
<td>52.1</td>
<td>1.00 (reference)</td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>42.2</td>
<td>0.67 (0.64,0.70)</td>
<td></td>
</tr>
<tr>
<td>Smoking during pregnancy</td>
<td></td>
<td></td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>No</td>
<td>50.6</td>
<td>1.00 (reference)</td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>61.8</td>
<td>1.58 (1.52,1.64)</td>
<td></td>
</tr>
<tr>
<td><strong>Postnatal Mediators</strong></td>
<td></td>
<td></td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Breastfeeding, %</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Never</td>
<td>54.4</td>
<td>1.00 (reference)</td>
<td></td>
</tr>
<tr>
<td>&lt; 3 months</td>
<td>54.2</td>
<td>0.99 (0.96,1.02)</td>
<td></td>
</tr>
<tr>
<td>3-&lt; 6 months</td>
<td>53.9</td>
<td>0.98 (0.94,1.01)</td>
<td></td>
</tr>
<tr>
<td>6+ months</td>
<td>47.7</td>
<td>0.76 (0.74,0.78)</td>
<td></td>
</tr>
<tr>
<td>Birth wt for gestational age</td>
<td></td>
<td></td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Small</td>
<td>84.0</td>
<td>5.19 (4.99,5.41)</td>
<td></td>
</tr>
<tr>
<td>Large</td>
<td>11.3</td>
<td>0.12 (0.12,0.13)</td>
<td></td>
</tr>
<tr>
<td>Normal</td>
<td>50.3</td>
<td>1.00 (reference)</td>
<td></td>
</tr>
</tbody>
</table>
Table 2.3 Logistic regression unadjusted and adjusted estimates of odds ratios for rapid weight gain birth to one year of age among WIC participating mother and child pairs according to category of maternal WIC participation, New York State, 2008 - 2010

<table>
<thead>
<tr>
<th></th>
<th>Rapid infant weight gain</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>β (s.e.)</td>
<td>OR (95% CI)</td>
</tr>
<tr>
<td><strong>Model 1 (unadjusted)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Postpartum only</td>
<td></td>
<td>Ref</td>
<td></td>
</tr>
<tr>
<td>Prenatal + postpartum</td>
<td>-0.14 (0.02)</td>
<td>0.87 (0.84,0.90)</td>
<td></td>
</tr>
<tr>
<td><strong>Model 2 (model 1 + demographics)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Postpartum only</td>
<td></td>
<td>Ref</td>
<td></td>
</tr>
<tr>
<td>Prenatal + postpartum</td>
<td>-0.17 (0.02)</td>
<td>0.85 (0.82,0.87)</td>
<td></td>
</tr>
<tr>
<td><strong>Model 3 (model 2 + confounders)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Postpartum only</td>
<td></td>
<td>Ref</td>
<td></td>
</tr>
<tr>
<td>Prenatal + postpartum</td>
<td>-0.17 (0.02)</td>
<td>0.85 (0.82,0.88)</td>
<td></td>
</tr>
<tr>
<td><strong>Model 4 (model 3 + mediator 1)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Postpartum only</td>
<td></td>
<td>Ref</td>
<td></td>
</tr>
<tr>
<td>Prenatal + postpartum</td>
<td>-0.02 (0.02)</td>
<td>0.98 (0.94,1.01)</td>
<td></td>
</tr>
<tr>
<td>Birth weight for gest age z-score</td>
<td>-1.12 (0.01)</td>
<td>0.33 (0.32, 0.33)</td>
<td></td>
</tr>
<tr>
<td><strong>Model 5 (model 4 + mediator 2)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Postpartum only</td>
<td></td>
<td>Ref</td>
<td></td>
</tr>
<tr>
<td>Prenatal + postpartum</td>
<td>-0.02 (0.02)</td>
<td>0.98 (0.94,1.02)</td>
<td></td>
</tr>
<tr>
<td>Birth weight for gest age z-score</td>
<td>-1.12 (0.01)</td>
<td>0.33 (0.32, 0.33)</td>
<td></td>
</tr>
<tr>
<td>BF never or &lt; 6 months</td>
<td></td>
<td>Ref</td>
<td></td>
</tr>
<tr>
<td>BF &gt;= 6 months</td>
<td></td>
<td>-0.19 (0.01)</td>
<td>0.82 (0.80,0.84)</td>
</tr>
</tbody>
</table>

*Rapid weight gain defined as change in weight-for-age z-score > 0.67 during first year of life
High weight for length defined as a sex specific weight-for-length z-score > 2 (WHO growth standard)

Model 1 – unadjusted
Model 2 – Rapid weight gain adjusted for covariates: child’s sex, mother’s race/ethnicity, age, education, poverty ratio, Medicaid, and trimester prenatal care began
Model 3 – Model 2 + risk factors: parity, smoking during pregnancy, pre-pregnancy BMI, pregnancy weight gain, adequacy of pregnancy weight gain
Model 4 – Model 3 + birth weight for gestational age z-score
Model 5 – Model 4 + any breast feeding for 6 months
The studies presented here add to the body of research into the effects of participation in the WIC program on health outcomes. The results of these studies indicate that participation in WIC during the prenatal period has a positive impact on infant health outcomes beyond that of improved birth outcomes. The specific contribution is that prenatal participation is linked with higher initiation and duration of breastfeeding and with reduced risk of rapid weight gain during infancy compared to infants of mothers enrolling during the postpartum period. Using a comparison group of women who enrolled in WIC during the postpartum period minimizes the bias inherent in studies that attempt to evaluate WIC outcomes among WIC participants compared to eligible non-participants.

The first study reports that women who enrolled in WIC prenatally (early WIC enrollees) compared to those who enrolled during the postpartum period (late WIC enrollees) were more likely to initiate breastfeeding and to continue to do so until 3, 6, and 12 months. These findings differ from other studies that have shown that WIC participants are less likely to initiate breastfeeding and more likely to cease breastfeeding compared to eligible non-participants (10-12). Consistent with other studies, this study also points to differences in breastfeeding initiation and duration by race and ethnicity and by parity. Hispanic mothers and those with previous births were more likely to breastfeed for longer as others have observed (12, 59-62). Unlike other studies, this study identified race and ethnic differences in odds of breastfeeding by parity for early vs. late
WIC enrollees. In other words early WIC enrollees who were first time mothers and were non-Hispanic black or white were less likely to initiate breastfeeding or continue to 3, 6, or 12 months than Hispanic first time mothers enrolled prenatally. Among multigravida mothers, all early WIC enrollees were more likely to breastfeed than were late WIC enrollees. Some of these differences might reflect the younger age of primigravida mothers compared to multigravida, but that does not explain the difference in early vs. late WIC enrollees, pointing to some unmeasured difference between the groups. Nonetheless, the policy implication is that there may be subgroups of mothers who for some reason are not benefiting from the prenatal breastfeeding counseling all mothers receive. On the other hand, perhaps they have already made a decision about infant feeding prior to enrolling in WIC. For example, the first time mothers may lack the social support needed to be successful at breastfeeding or they may not utilize services of peer counselors. Additionally, no information was available to assess acculturation, which is associated with breastfeeding behaviors (61, 62). Future research should examine social and cultural factors that might hinder a decision to breastfeed. Such information could provide valuable information to the WIC program so that initiatives could be targeted where most needed. For example, outreach efforts could target individuals early in pregnancy before they make a decision to formula feed. Furthermore, hospital polices that prohibit the routine distribution of formula discharge packs may benefit women who are at risk for choosing not to breastfeed or to discontinue breastfeeding early. Finally, though the NYS WIC program has a robust peer-counseling program in place there may be subgroups of women underrepresented by peer-counselors. For example, one such group might be very young mothers. It is encouraging that among a majority of
participants, prenatal participation is associated with improved breastfeeding as prenatal enrollees are likely to continue participation into the postpartum period and the early postpartum period is crucial to breastfeeding success.

The second study also demonstrates positive effects of prenatal participation on infant outcomes. Infants of women who enrolled early were less likely to gain weight rapidly during infancy than were the infants of women enrolling postpartum. Maternal prenatal participation in the WIC program provides an important widow of influence as this period of gestation and early infancy have been identified as critical periods in the development of obesity (20). Furthermore, it is during these periods that the foundation is laid for a life-long predisposition for body composition, and that conditions experienced in utero may play an important role later in life (24). Additionally, rapid weight gain during the first 6-12 month of life is a well-documented risk factor for obesity, increasing the risk of obesity 40-100% during childhood, and nearly 25% during adulthood (35, 65). This study provides evidence that early WIC enrollment is associated with reduced odds of excess infant weight gain but also that birth weight for gestational age and breastfeeding mediate the relationship; two factors known to be associated with rapid weight gain and subsequent obesity.

According to NYS WIC program policy, infants must be weighed and measured at the mid-point of the infant certification, at approximately 6 months of age with weights and lengths plotted on appropriate growth charts. Evaluation of the charted measures should extend beyond simply assessing whether the infant is below or above specific cuts points but should include whether growth chart percentiles are crossed. A protocol that could easily be implemented with training of appropriate staff. At the national level, the
USDA, which sets program policy, could define a specific nutritional risk as crossing a major percentile line between any two measurement points thus establishing rapid infant weight gain as a nutritional risk for certification purposes.

A strength of these studies is that infant and mother pairs enrolled in the NYS WIC program comprised both the exposure and control groups. Including as comparison group of mothers and infants also enrolled in WIC minimizes the bias generally present in studies attempting to compare WIC participants to non-participants. All women choose to enroll in WIC at some point indicating income eligibility and similarity with respect to unmeasured characteristics that are often associated with the choice to enroll in WIC.

The results of these large longitudinal cohort studies of mother-infant pairs enrolled in the NYS WIC program demonstrate that early WIC enrollment, that is enrollment during the prenatal period, may increase the initiation and duration of breastfeeding and reduce the risk of rapid infant weight gain between birth and one year of age. WIC is a public health nutrition program charged with improving health outcomes among vulnerable populations during critical periods of growth and development. Findings that document program effectiveness in decreasing risk factors for adverse health outcomes are critical for informing policy makers on progress toward national health objectives. Establishing this link between prenatal WIC and the intermediate outcomes of birth weight for gestational age and breastfeeding, two known risk factors for rapid infant weight gain, provides support for a causal relationship. Future research should examine whether the protective effect of prenatal participation extends beyond infancy to the preschool years by reducing the risk of child obesity.
REFERENCES


